



17th Annual International
Conference on
Economics and Business
**CHALLENGES IN
THE CARPATHIAN BASIN**

Innovation: Bridging the Gap between
Urban Centers and Peripheries

**17th Annual International Conference on
Economics and Business
CHALLENGES IN THE CARPATHIAN BASIN**

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Economics and Business
CHALLENGES IN THE CARPATHIAN BASIN**

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Editor in Chief

Dr. Nagy Benedek

Director editură: GHEORGHE POP

Editor in Chief: Dr. Nagy Benedek

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CONTENTS

FOREWORD.....	10
FINANCIAL FRONTIERS — NAVIGATING CAPITAL MARKETS AND CORPORATE	12
<i>BÍBORKA ESZTER BÍRÓ– BORÓKA JÚLIA BÍRÓ:</i> THE RISE OF ARTIFICIAL INTELLIGENCE IN FINANCIAL MARKETS: RESHAPING INVESTMENT DECISION-MAKING	13
<i>HAMAD MIRJAM:</i> THE ROLE OF TRADITIONAL AND CASH-FLOW BASED PROFITABILITY INDICATORS IN DIVIDEND POLICY: AN EMPIRICAL STUDY OF US AND GERMAN LISTED COMPANIES (2019-2022).....	24
TACKLING CHALLENGES IN INTERNATIONAL TAXATION AND ACCOUNTING ...	31
<i>RITA KOROSZCZYNÉ PAVLIN:</i> HUMAN RESOURCE CONTROLLING BASED ON THE EXAMPLE OF A PUBLIC HEALTHCARE INSTITUTION.....	32
<i>ANTÓNIA ZAKARIÁS - RITA KOROSZCZYNÉ PAVLIN:</i> USAGE OF INTERNATIONAL STANDARDS IN ACCOUNTING AND FINANCIAL AUDIT OF LEASING OPERATIONS ...	49
<i>RITA KOROSZCZYNÉ PAVLIN - VERONIKA GÁL – IRÉN WICKERT:</i> THE IMPACT OF INDUSTRY 4.0 ON THE MANAGEMENT ACCOUNTING IN CASE OF CROPS	61
MARKETING STRATEGIES FOR THE DIGITAL AND EXPERIENCE-DRIVEN ERA...	69
<i>SZŰCS RÓBERT SÁNDOR - FÖLDI KATA:</i> POSSIBILITIES OF ARTIFICIAL INTELLIGENCE (AI) IN PRODUCT DEVELOPMENT: IMPLICATIONS FOR MARKETING, COMMERCE, AND ECONOMICS.....	70
<i>FÖLDI KATA - SZŰCS RÓBERT SÁNDOR:</i> LITERATURE REVIEW AND SECONDARY RESEARCH ON THE POSITIONING OF ELECTRONIC CIGARETTES IN HUNGARY	77
<i>SZŐCS ATTILA:</i> DETERMINANTS OF CONSUMER INTENTIONS TO ATTEND THEATRE PERFORMANCES: THE CASE OF CSÍKI JÁTEKSZÍN	85
<i>KINGA KATALIN SZÉKELY:</i> THE TOURISM APPEAL OF LOCAL FLAVOURS: AN ANALYSIS OF GASTRONOMIC FESTIVALS IN SZEKLERLAND	95
LEADING THE FUTURE: INNOVATIONS AND CHALLENGES IN MODERN MANAGEMENT	102
<i>NOÉMI LŐRINCZ, MÁRTA KISS, GERGELY BALÁZS:</i> BEYOND THE WHEEL: MANAGING INNOVATION AND CHALLENGES IN THE AUTOMOTIVE SECTOR	103
REDISCOVERING HORIZONS — INNOVATIONS IN SUSTAINABLE TOURISM	119
<i>MÁRTA KÓRÓDI – KATALIN VARGÁNÉ CSOBÁN:</i> TRAVEL DECISIONS IN THE TOURIST PROFILE OF GENERATION Z	120
<i>TELEGDY BALÁZS – NISTOR LAURA:</i> MINERAL WATER AS AN ASSET IN THE LAND OF WINE WATERS: RESULTS OF AN EXPLORATORY STUDY.....	133
<i>ÉVA DARABOS – TÜNDE ORSOLYA NAGY –ANITA KISS:</i> THE ROLE OF TOURISM IN THE HUNGARIAN ECONOMY IN INTERNATIONAL COMPARISON.....	142

ADDRESSING REGIONAL DISPARITIES AND TERRITORIAL CHALLENGES	150
KASSAY JÁNOS: ROMANIAN PUBLIC PROCUREMENT SYSTEM, BENEFITS AND PROBLEMS.....	163
KASSAY JÁNOS: MOTORWAYS CONSTRUCTION IN ROMANIA, A NEVER-ENDING STORY.....	176
TIBOR JELEN: THE UNIVERSITY KNOWLEDGE TRANSFER OFFICE (TTO) AS A SPECIFIC INTERMEDIARY FOR INNOVATION BETWEEN URBAN CENTRES AND PERIPHERIES.....	195
GYÖNGYVÉR BÁLINT – LAURA NISTOR: ENVIRONMENTAL WILLINGNESS TO PAY ACROSS EUROPE. COMPARING ISSP AND EVS SURVEY DATA	206
VARGA ORSOLYA – RITTER KRISZTIÁN: REGIONAL DISPARITIES IN ROMANIA AT NUTS 3 LEVEL: A MULTIVARIATE APPROACH WITH EMPHASIS ON HARGHITA COUNTY	218
MAROSI GYÖRGY CSONGOR: COMPARATIVE ANALYSIS AND FUTURE REFORM PROPOSALS FOR THE HUNGARIAN AND ROMANIAN LOCAL GOVERNMENT AND ADMINISTRATIVE SYSTEMS	229
ANDRÁS NÁHLIK– ANDRÁS POLGÁR– LAURA BERTALAN: SUSTAINABILITY APPROACH OF LOCAL GOVERNMENT LEADERS IN HUNGARIAN UNIVERSITY CITIES	238
BAGDI RÓBERT: INTERPRETATION OF DEBRECEN AND ITS CATCHMENT AREA BASED ON TOURISM ASPECTS.....	248
KOLTAI ZOLTÁN: VILLAGE CARETAKER SERVICE, THE WAY TO REDUCE ISOLATION	257
CULTIVATING PROSPERITY — INNOVATIONS IN AGRICULTURE AND RURAL ECONOMICS.....	265
PÉTER EMŐKE KATALIN – VARGA JÓZSEF: THE ROLE OF MIGRATION THEORIES IN FOREIGN EMPLOYMENT IN SZEKLERLAND.....	266
PÉTER EMŐKE KATALIN - SZABÓ ÁRPÁD: ENERGY POVERTY IN THE CENTRAL AND NORTH-WESTERN DEVELOPMENT REGIONS OF ROMANIA - LIVING CONDITIONS OF FAMILIES	274
MÁTYÁS LÁSZLÓ – PÉTER EMŐKE KATALIN: CEREAL PRICE TRENDS IN BALANCED ECONOMIC PERIODS.....	290
BALLA EMESE – NAGY KINCŐS – SÁNDOR TIHAMÉR: CHALLENGES AND DEVELOPMENT OPPORTUNITIES OF THE AGRICULTURAL SECTOR IN HARGHITA COUNTY FROM THE PERSPECTIVE OF FARMER ORGANIZATIONS AND AGRICULTURAL EXPERTS	301
REDEFINING COOPERATIVES IN A MODERN ECONOMY	315
PÉTER EMŐKE KATALIN - NAGY SZERÉNA: ROMANIAN COOPERATIVES AND THEIR OPPORTUNITIES.....	316
ADVANCING BUSINESS INFORMATICS AND OPERATIONAL RESEARCH.....	328

PIROSKA BIRÓ – ZSUZSANNA TIMEA NAGY – MÁRIA CSERNOCH: ASSESSMENT OF PRIOR KNOWLEDGE AND ALGORITHMIC SKILLS AMONG FIRST-YEAR COMPUTER SCIENCE STUDENTS.....	329
ANITA KISS - ÉVA DARABOS - TÜNDE ORSOLYA NAGY: PERFORMANCE ANALYSIS OF HUNGARIAN FOOD INDUSTRY COMPANIES USING THE DEA METHOD.....	339
CSONGOR KRISTÓ - LÁSZLÓ PÁL: APPLICATION OF CONSTRAINED OPTIMIZATION IN INDEX TRACKING PORTFOLIO CONSTRUCTION.....	351
ZOLTÁN MAKÓ – JÚLIA SALAMON: INTUITIONISTIC FUZZY CERTAINTY EQUIVALENCE IN PROSPECT THEORY.....	368
JÚLIA SALAMON - ZOLTÁN MAKÓ: SEARCHING FOR CORRELATED EQUILIBRIUMS IN INTERVAL VALUED GAMES	377
EDIT GARDA-MÁTYÁS: THE SOLUTION OF QUADRATIC AND CUBIC FUNCTIONS WITH ADDITIONAL CONDITIONS.....	388
LÁSZLÓ ILLYÉS: THE RELATIONAL MODEL OF THE LIBRARY DATABASE	397
INNOVATION, AGILITY, LEADING CHANGE IN THE TURBULENT 21ST CENTURY — POSTER SECTION.....	403
ISTVÁN MÁRK TÓTH: EXAMINING THE CONSCIOUS AND UNCONSCIOUS PRESENCE OF AGILITY AMONG HUNGARIAN UNIVERSITY STUDENTS.....	404
OSZKAR DOBOS: THE ROLE OF CRITICAL INFRASTRUCTURE INDUSTRIES IN THE RESEARCH, DEVELOPMENT AND INNOVATION (RDI) ECOSYSTEM: AN EMPIRICAL ANALYSIS OF INNOVATION ACTIVITIES IN THE CI INDUSTRIES	412
ANITA PLÖTZ - JÁNOS VARGA: FOOD INDUSTRY AS AN IMPORTANT PART OF CRITICAL INFRASTRUCTURE.....	420
JÁNOS VARGA - ANITA PLÖTZ: INNOVATION STRATEGIES OF THE DOMESTIC SME SECTOR: EXPERIENCES OF ACTIVE AND ADAPTIVE INNOVATORS	432
BERNADETT REVÁK - ÁGNES CSISZÁRIK-KOCSIR: TEACHERS' DIGITAL COMPETENCE IN ONLINE EDUCATION FROM A STUDENT PERSPECTIVE	443
GÁBOR STERCZL - ÁGNES CSISZÁRIK-KOCSIR: ASSESSING THE BASIC SKILLS OF AGILE WORKING THROUGH AN INTERCULTURAL LENS	454
STUDENT SPECIAL SECTION	463
BODA ZSÓFIA: THE FINANCIAL IMPACT OF ESG ON LARGE ENTERPRISES.....	464
ATTILA SZŐCS - TIMEA BENCZE: BUSINESS APPLICATION OF FRAMING.....	472
BECSEK BEATRIX-ERIKA: THE IMPACT OF GREEN MARKETING ON CONSUMER BEHAVIOUR IN THE COSMETICS INDUSTRY	484
BÁLINT ÁGOTA – KOROSZCZYNÉ DR. PAVLIN RITA: ANALYSIS OF HUNGARY'S AND ROMANIA'S EXTERNAL TRADE	499
ATTILA BOLDIZSÁR – BÍBORKA-ESZTER BÍRÓ: COMPARATIVE FINANCIAL ANALYSIS OF DOMESTIC, FOREIGN AND INTERNATIONAL OIL COMPANIES	510
CSONGOR KRISTÓ - LÁSZLÓ PÁL: A COMPARATIVE ANALYSIS OF COLLABORATIVE FILTERING AND CONTENT-BASED APPROACHES TOWARD HYBRID SOLUTIONS	522

OLTI KINGA- KOROSZCZŃ DR. PAVLIN RITA: EXAMINATION OF CORPORATE INCOME TAX BURDENS BASED ON THE ACCOUNTING REPORTS OF MULTINATIONAL COMPANIES OPERATING IN HUNGARY	538
GÁBOR SILVIA - DR. BÍRÓ BÍBORKA ESZTER: THE ECONOMIC IMPACTS OF ARTIFICIAL INTELLIGENCE.....	550
PORCZEL BARBARA-DR. PÉTER EMŐKE-KATALIN: DEVELOPMENT OF FAMILY FARMS - IN AND AROUND TÂRGU SECUIESC	558

FOREWORD

It is with great pride and anticipation that we present the volume of the 17th International Conference on Economics and Business, held under the theme: "Innovation: Bridging the Gap between Urban Centers and Peripheries".

This biannual event, hosted by Sapientia Hungarian University of Transylvania, brings together scholars, professionals, and students from across Hungary and Romania and beyond to explore the pressing challenges and transformative opportunities facing our region and the broader global economy.

In recent years, innovation has emerged as a defining force not only in economic growth, but also in addressing deep-rooted regional disparities. The Carpathian Basin, with its unique blend of vibrant metropolitan centers and underdeveloped peripheries, represents a critical case for understanding how technological change can foster inclusion, resilience, and regional balance.

One of the central themes running through this conference volume is the strategic role of innovation in regional development. While cities have often served as incubators of digital innovation, the question remains: How can digital transformation be extended to rural and peripheral regions? Contributions in this volume show that with the right policy mix, infrastructure investment, and capacity building, even the most remote areas can become active participants in the digital economy—whether through smart tourism, e-governance, digital entrepreneurship, or remote education.

In this light, we must also confront the realities of the digital divide, which continues to challenge equity and cohesion in our societies. This collection of papers examines not only the technological infrastructure required, but also the social and institutional dimensions of digital inclusion—underscoring the importance of digital literacy, multilingual accessibility, and localized innovation ecosystems.

Another key focus of this conference—and a fundamental pillar of our institution's mission—is internationalisation. In a time when global uncertainties and regional fragmentation risk stalling cross-border cooperation, we reaffirm the power of academic mobility, research collaboration, and international business partnerships. From comparative analyses of European economies to joint digital tourism projects and AI-driven investment models, the works in this volume reflect a deep commitment to bridging geographic, institutional, and disciplinary boundaries.

The conference would not have been possible without the tireless efforts of our organising committee, the editorial team, and the dedicated staff of Sapientia Hungarian University of Transylvania. Their attention to both academic quality and logistical excellence ensured an intellectually rich and welcoming environment for every participant. We are also immensely grateful to our authors and

presenters, whose diverse insights, methodological rigor, and future-oriented thinking shape the core of this volume.

Finally, a heartfelt thank you goes to our conference participants and guests, whose engagement—in person and virtually—made this event a truly collaborative and forward-thinking platform. Your questions, critiques, and shared experiences continue to inspire the academic and professional community long after the closing plenary.

As you explore the contributions within these pages, we invite you to reflect on the transformative potential of innovation, digitalisation, and international cooperation—not as abstract ideals, but as actionable strategies for shaping a more inclusive and sustainable future in the Carpathian Basin and beyond.

Dr. Nagy Benedek
Head of the Business Sciences Department
Editor-in-Chief
Sapientia Hungarian University of Transylvania
May 2025

THE RISE OF ARTIFICIAL INTELLIGENCE IN FINANCIAL MARKETS: RESHAPING INVESTMENT DECISION-MAKING

BÍBORKA ESZTER BÍRÓ– BORÓKA JÚLIA BÍRÓ

ABSTRACT

The growing influence of Artificial Intelligence (AI) in the financial sector marks a significant shift in investment decision-making paradigms. By integrating machine learning, big data analytics, and sentiment analysis, AI transforms both theoretical and practical dimensions of asset management. This paper compares AI-driven approaches with traditional human-led investing, explores their respective strengths and limitations, and reflects on the implications for market theory and investor behavior. The discussion also highlights future research avenues involving cognitive biases, performance metrics, and demographic preferences in financial decision-making.

KEYWORDS

Artificial intelligence, human-led investing, behavioral finance, market efficiency, investment decision-making

1. INTRODUCTION

The financial sector has entered a period of rapid digital transformation, largely driven by advancements in Artificial Intelligence. These technologies are increasingly embedded in the infrastructure of investment decision-making. From algorithmic trading to risk assessment and portfolio management, AI's influence is growing not just in volume, but in the strategic depth of financial operations.

Traditional investment approaches—anchored in human judgment, qualitative assessment, and macroeconomic forecasting—are now being complemented and, in some cases, replaced by AI-driven systems. These systems utilize massive datasets, machine learning (ML) algorithms, and real-time analytics to identify patterns and make decisions faster than any human could.

The objective of this paper is to evaluate the transformative role of AI in investment decision-making by comparing it with traditional human-led investing. It will analyze the benefits and challenges of both approaches and explore implications for theory and practice.

2. BACKGROUND AND METHODOLOGY

Artificial Intelligence in finance involves using algorithms and computational models to perform tasks that traditionally require human intelligence. Core AI methods include supervised and unsupervised learning, deep learning, and natural language processing (NLP). These methods are applied to diverse financial tasks such as asset pricing, fraud detection, and automated trading.

Heaton et al. (2017) describe AI's increasing role in empirical asset pricing, while Gu et al. (2020) apply machine learning models to outperform classical approaches like CAPM. Meanwhile, behavioral economists such as Kahneman and Tversky (1979) have shown that human investors are susceptible to biases that impair rational decision-making.

This review highlights the convergence of two strands of literature: one focused on cognitive limitations and biases, and the other on technological advancements that aim to overcome those limitations.

The methodology is based on a comparative qualitative analysis of traditional and AI-based investing approaches. The framework considers key dimensions, such as data handling capability, decision-making speed, susceptibility to bias, and explainability.

Sources include peer-reviewed journals, institutional reports (e.g., BlackRock, JPMorgan), and academic studies in behavioral finance and machine learning. The findings are organized into a strengths and challenges matrix to facilitate side-by-side comparison. Moreover, the implications of AI in investment decision making at theoretical and practical level are presented as well.

3. COMPARATIVE ANALYSIS

There are several aspects through which the main characteristics of the human-led and AI-driven investment decision can be compared. Based on the reviewed literature eight aspects were identified: decision-making, data usage, speed and scalability, transparency, bias and emotion, portfolio optimization, flexibility to market change and human oversight.

The main findings of this comparative analysis are collected and presented in Table 1 and are described as follows.

Regarding the *decision-making* aspect it can be said that Traditional investing is driven by human expertise, relying on economic theories, behavioral intuition, and market experience. This subjective approach can excel in situations requiring qualitative judgment but is prone to inconsistency and individual bias. AI-driven investing, on the other hand, utilizes machine learning and statistical models to identify patterns across vast datasets, often outperforming human intuition in data-rich contexts (Heaton et al. (2017); Gu et al.; Bussmann et al., 2021).

Data usage in the case of traditional methods typically focus on structured financial data (e.g. balance sheets, economic indicators), while AI systems are capable of analyzing high-volume, high-frequency, and unstructured data such as social media, news articles, and satellite imagery. This broader scope allows AI to detect signals missed by conventional analysis. (Gu et al.,2020; Deng et al., 2020; Bussmann et al., 2021)

If we take into account the *speed and scalability* aspect, human-led investing is limited by analytical speed and cognitive load. In contrast, AI technologies can process and act upon information in real time, scaling their analysis to thousands of assets simultaneously, which is an essential feature for institutional-level strategies or high-frequency trading. (Kolanovic and Krishnamachari, 2017; Bussmann et al., 2021)

The *transparency, also known as explainability* criterion is strong in the case of human-led investment decisions as they are typically transparent and explainable, rooted in recognizable theories and historical precedent. AI models, especially those based on deep learning often lack interpretability, making it difficult to understand. (Heaton et al.,2017; Deng et al., 2020).

Bias and emotion are by default human characteristics, it is therefore no wonder that on the one hand human-led investment decisions are susceptible to cognitive biases such as overconfidence and loss aversion. On the other hand AI removes emotional bias, it is still vulnerable to other forms of bias stemming from flawed training data or algorithm design. (Bartram et al.,2020; Gu et al.,2020).

Regarding the *portfolio optimization aspect*, traditional portfolio construction models like Markowitz's Modern Portfolio Theory or CAPM assume rational investors and normally distributed returns. AI enables more dynamic, non-linear, and adaptive optimization strategies, often using reinforcement learning to continually adjust to new data. (Gu et al.,2020; Kolanovic and Krishnamachari, 2017; Deng et al.,2020)

Table 1: Comparative analysis of human-led and AI-driven investment decisions

Aspect	Traditional (human-led) investing	AI- driven investing
Decision-making	Human judgment, economic theories, experience, and behavioural intuition	Machine learning models, statistical patterns, alternative and big data
Data usage	Limited datasets, mostly financial statements and economic indicators	Large-scale, high-frequency, unstructured data (news, social media, satellite images, etc.)
Speed and scalability	Slower analysis and decision-making	Real-time analysis, scalable across thousands of assets
Transparency (Explainability)	Generally high —investment rationale is interpretable	Often low due to “black-box” models (deep learning)
Bias and emotion	Susceptible to behavioural biases (e.g. overconfidence or loss aversion)	Less emotional bias, but model biases and data selection risks persist
Portfolio optimization	Traditional models like Markowitz or CAPM	Dynamic optimization using reinforcement learning and non-linear algorithms
Flexibility to market change	Adaptability depends on analyst's speed to update models	AI can adjust quickly to new data patterns if trained accordingly
Human oversight	Fully reliant on human decision-makers	Often hybrid (AI supports, human oversees), or autonomous in algorithmic trading

Source: Authors’ own edition based on Bartam et al (2020); Bussmann et al (2021); Deng et al (2020); Heaton et. al (2017); Gu et al (2020); Kolanovic and Krishnamachari (2017)

The seventh aspect as shown in Table 1 includes *flexibility to market change*. This aspect represents one of the core strengths of AI investing as human adaptability depends on the analyst's ability and speed to interpret new data or shift models, while AI systems can react more quickly to changing data

patterns and volatility, if they are trained properly. However AI systems may struggle in unprecedented market conditions (Heaton et al., 2017; Bussmann et al., 2021; Deng et al., 2020). The last aspect, the *human oversight* is important regarding the hybrid solutions: traditional investments are entirely human-led, whereas AI-driven systems range from hybrid approaches to fully automated execution. Most institutional investors currently favor a blended model where AI augments human judgment, balancing efficiency with oversight (Kolanovic and Krishnamachari, 2017; Bussmann et al,2021.; Bartram et al.,2020).

4. STRENGTHS AND CHALLENGES OF HUMAN-LED AND AI DRIVEN INVESTMENT DECISION-MAKING

Based on the literature cited in previous chapter, Table 2 and 3 contain the Strengths and challenges of human-led and AI driven investment decision-making.

Table 2: Strengths and challenges of human-led investing

<i>Strengths</i>	<i>Challenges</i>
Deep contextual understanding	Cognitive limitations
Long-term experience and capability to long term decision making	Slower processing
Qualitative assessment and strategic thinking	Subjective decisions

Source: Authors' own edition based on Bartam et al (2020); Bussmann et al (2021); Heaton et. al (2017); Gu et al (2020); Kolanovic and Krishnamachari (2017)

A human investor possesses the ability to integrate complex, ambiguous, and qualitative information (such as geopolitical developments, regulatory changes, or company-specific news) into their decision-making processes. This contextual insight often goes beyond the capability of current AI systems, especially when data is sparse or unstructured (Heaton et al., 2017; Bartram et al., 2020). What is more, traditional investing leverages the human capacity for intuition, strategic thinking, and long-term perspective.

Regarding the long term decision making, according to Benjamin Graham "The intelligent investor is one who realizes that success in investing is not about predicting short-term movements but about positioning oneself for the long haul" (2006). Human investors can draw upon **decades of accumulated knowledge**, including memory of rare events (e.g. financial crises over the time), and understand the broader historical and psychological patterns of markets. In contrast, many AI systems are **trained on limited historical windows** and can underperform when facing unfamiliar regimes (Gu et al., 2020).

In traditional investment decisions humans can evaluate **non-numerical factors**, such as management credibility, company culture, competitive positioning, or ESG criteria, that are difficult to quantify accurately. This strength is particularly important in **venture capital, private equity, and emerging markets**, where reliable data is scarce or inconsistent. (Heaton et al., 2017). This aspect is closely related to strategic thinking which is another advantage of human-led decision making as humans are capable of **formulating, adapting, and executing strategic visions** that incorporate uncertainty, market psychology, and long-term macro trends. They can plan beyond the framework of optimization models, using reasoning and foresight (Bartram et al.,2020; Kolanovic and Krishnamachari, 2017).

Beside its' strong points, traditional investment decision-making has several challenges as well. One of them are the cognitive limitations, wchich means that human investors can only process a limited number of variables at once and often rely on heuristics, which can lead to systematic errors. In complex environments with high-dimensional data (like modern financial markets), this limitation

reduces analytical depth and accuracy (Bartam et al, 2020). These constraints also make it difficult for humans to consistently outperform in fast-moving or information-dense markets.

Another challenge is slower processing, which means that humans take significantly more time to **gather, analyze, interpret, and act** on information as compared to AI systems. In volatile markets, such delays can translate to **missed opportunities or suboptimal trades**, especially when timing is critical (Kolanovic and Krishnamachari, 2017).

Subjective decisions are considered to be another significant challenge in human-led investing because subjective decision-making may lead to **inconsistency**, as outcomes vary across individuals and circumstances (Bussmann et al., 2021). What is more, human decisions are prone to emotional and cognitive biases such as overconfidence or loss aversion (Heaton et al., 2017). Human factors like loss aversion, overconfidence, confirmation bias lead to irrational decisions (e.g. holding losing assets for too long; buying into bubbles) (Kahneman, Tversky, 1979). Emotional influence driven by fear or greed lead to subjective decisions, especially if the market is volatile. This can lead to panic selling during downturns or overbuying during bull runs (Lo, 2005).

Summarizing the above mentioned ideas we can say that while human-led investing offers strengths in **strategic vision, qualitative evaluation, and long-term orientation**, it also faces **significant limitations**. Cognitive constraints, slower data processing, and psychological biases can impair decision quality, particularly in **data-intensive or high-frequency environments**. These weaknesses emphasize the need for **decision support tools**, including AI, to enhance objectivity and execution efficiency.

Table 3: Strengths and challenges of AI investing

<i>Strengths</i>	<i>Challenges</i>
Speed and efficiency	Lack of explainability
Pattern recognition	Overfitting
Handling complexity	Regulatory and ethical concerns

Source: Authors' own edition based on Bartam et al (2020); Bussmann et al (2021); Deng et al (2020); Heaton et. al (2017); Gu et al (2020); Kolanovic and Krishnamachari (2017)

The strengths of AI in investment decision-making is unquestionable. Two of the aspects that almost anyone, even a layperson, can think about is the speed and the efficiency of the AI system in investing. AI systems excel in **processing and reacting to market data in real time**, allowing for near-instantaneous decision-making. Algorithmic trading platforms can execute thousands of trades in milliseconds, far surpassing human capabilities (Bussmann et al, 2021; Kolanovic and Krishnamachari, 2017). Regarding the efficiency, AI increases operational efficiency by automating repetitive tasks (e.g., screening stocks, monitoring news, rebalancing portfolios). It can **analyze massive datasets** simultaneously with minimal marginal cost. (Gu et al., 2020).

Pattern recognition means that AI can identify subtle and **non-linear patterns** in financial and alternative data sources that humans may not detect. This includes sentiment trends in social media, supply chain signals from satellite data, and predictive patterns in price movements (Deng et al., 2020).

The complexity handling attribute means the ability of AI systems—especially machine learning and deep learning models—to analyze and make sense of very large, messy, and nonlinear datasets that are difficult or impossible for humans to interpret effectively. The processed data can be unstructured, high-dimensional, with non-linear relationship among them. (Gu et al, 2020; Kumar et al, 2024).

Similar to human-led investment decision-making, in the case of AI driven investing there are not only strengths but also challenges. One of the most mentioned challenges is the so-called “black box” effect, which refers to the lack of explainability. In the case of AI-driven investing the **opacity of complex models** is a real issue, particularly in deep learning systems. (Heaton et al., 2017).

Overfitting happens when an AI model learns the training data too well, including its random noise or anomalies, instead of just learning the underlying patterns that would generalize to new, unseen

data. In finance, this means: the model may perform very well on past data (historical prices, returns) but poorly in the real world, because it has essentially memorized irrelevant fluctuations rather than learned useful patterns (Ahmed, 2023).

AI deployment in investment management raises **regulatory and ethical challenges**, including: **accountability** in algorithmic decisions, **data privacy** (e.g., use of social media or biometric data), **fairness** and bias in training data, **market manipulation** concerns in high-frequency strategies (Bussmann et al, 2021). Ethically, the use of alternative data (e.g., geolocation, satellite images) invites questions about **consent** and **data ownership** (Bartam et al., 2020).

5. IMPLICATIONS OF AI IN INVESTMENT THEORIES AND PRACTICES

5.1 Implications in investment theories

The implication of AI in investment decision making is not only transforming financial practice but also raising profound questions for foundational financial theories. Specifically, AI challenges the assumptions underlying the Efficient Market Hypothesis (EMH), prompts a re-evaluation of asset pricing models, and invites a reconceptualization of investor rationality.

The Efficient Market Hypothesis, particularly in its strong and semi-strong forms, posits that financial markets fully and instantly incorporate all available information into asset prices, leaving no room for consistent outperformance through information-based strategies. However, empirical evidence increasingly suggests that **AI models can detect patterns, signals, and anomalies in data that EMH assumes are either non-existent or already arbitrated away.**

Machine learning techniques have demonstrated the ability to extract predictive signals from **alternative and high-frequency data sources**, including news sentiment, satellite imagery, and social media. These signals often represent **non-linear and previously unexploited relationships**, contradicting the notion that all relevant information is already reflected in asset prices (Gu et al., 2020). This capability implies that markets may be **less efficient than traditionally thought**, or at the very least, that **efficiency is conditional on the analytical capacity of market participants**, which is now evolving rapidly with AI.

Another implication in theory is the new approach to asset pricing model. Traditional asset pricing frameworks, such as the Capital Asset Pricing Model (CAPM) and the Fama-French multifactor models, are grounded in **linear, parametric assumptions** about risk and return. These models rely on a limited set of macroeconomic and firm-specific variables and often assume normally distributed returns and rational investor behavior (Heaton et al., 2017).

Redefinition of rationality is another theoretical implication, which means that the cognitive biases that are characteristic for behavioural finance are missing in the case of AI's emotion free logic, this brings a new rationality in decision making (Heaton et al., 2017).

5.2 Implications in investment practices

This subchapter briefly presents three of the real-world applications of artificial intelligence in investment decision-making.

5.2.1 BlackRock's Aladdin Platform: AI in Institutional Asset Management

One of the leading practical applications of artificial intelligence in investment decision-making is BlackRock's Aladdin (Asset, Liability, Debt, and Derivative Investment Network) platform. Aladdin is a comprehensive, AI-enhanced ecosystem that combines risk analytics, portfolio management, and investment operations, and is regarded as a standard for technology-driven asset management systems. Aladdin is utilized by *more than 200 institutions* worldwide, such as insurance firms, pension funds, asset managers, and sovereign wealth funds. It functions as a centralized platform that allows clients to assess risk exposure, track real-time market changes, and make informed investment choices based on data. Its broad adoption highlights the increasing dependence of institutions on AI-

driven systems for managing extensive and intricate investment portfolios. Aladdin demonstrates how AI systems can enhance human expertise rather than replace it. Portfolio managers continue to formulate investment strategies and interpret insights, while the AI tools integrated into Aladdin offer an analytical advantage that enhances the quality, speed, and scope of their decision-making. Theoretically, platforms like Aladdin challenge conventional notions of market efficiency and investor rationality. By identifying subtle and often nonlinear patterns within market data, these AI platforms can exploit inefficiencies that might be overlooked by human analysts, thus contributing to a new understanding of market dynamics in practice. In conclusion, BlackRock's Aladdin represents more than just a technological solution; it signifies a paradigm shift in asset management architecture. It highlights the real-world integration of AI capabilities, institutional confidence, and theoretical advancements, marking a crucial milestone in the evolution of financial decision-making (Blackrock, 2025).

5.2.2 JPMorgan Chase's LOXM Algorithm: AI in Trade Execution

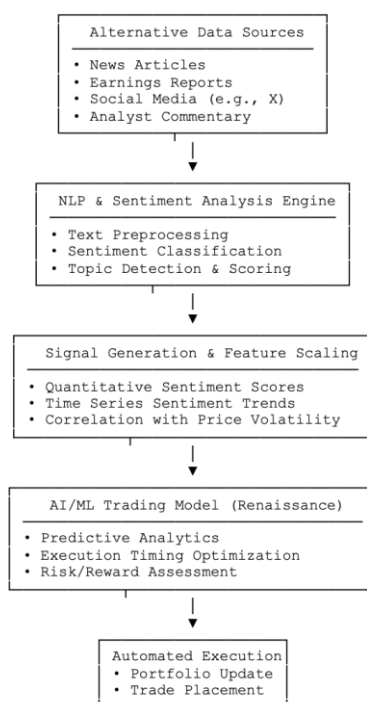
JPMorgan Chase has made notable progress in artificial intelligence within capital markets with the creation of LOXM, an AI-powered trade execution algorithm initially developed for European equity markets. According to Kolanovic and Krishnamachari (2017), LOXM utilizes both historical trading data and real-time learning to identify the most efficient strategies for executing large and complex orders, especially in fragmented and volatile market conditions. Unlike traditional trading algorithms that rely on static rules or pre-defined conditions, LOXM incorporates **reinforcement learning techniques** and advanced data analytics to dynamically adapt to changing market microstructures. It continuously evaluates market depth, liquidity, and price trajectories, optimizing trade execution to minimize **market impact and transaction costs** (Digitaldefynd, 2025).

From a strategic perspective, LOXM demonstrates how **AI systems can augment or even surpass human expertise** in high-frequency, high-volume financial environments where milliseconds matter. It also provides empirical evidence that **AI can contribute to increased market efficiency** by improving liquidity and lowering trading friction. However, the use of such advanced execution algorithms also raises **regulatory and ethical considerations**. The ability of AI to operate autonomously in fragmented markets requires robust oversight mechanisms to ensure compliance, prevent systemic risks, and guard against unintended market manipulation. As with BlackRock's Aladdin platform, LOXM exemplifies the broader shift in financial services toward **automated, data-driven decision-making**. It represents a crucial step forward in the application of AI not only as an analytical tool, but as an active participant in market operations (Kolanovic and Krishnamachari, 2017).

5.2.3 Sentiment Analysis in Hedge Funds: The Case of Renaissance Technologies

Among the most advanced applications of artificial intelligence in asset management is the use of **sentiment analysis** to derive actionable insights from unstructured data. **Renaissance Technologies**, a hedge fund renowned for its quantitative trading strategies, is widely believed to employ sophisticated sentiment analysis tools to enhance market predictions and optimize trading decisions (Bartram et al., 2020).

Figure 1: Alternative Data Sources Workflow



Source: Authors' own edition based on Bartram et al. (2020)

Figure 1 illustrates the alternative data source workflow of sentiment analysis applied by **Renaissance Technologies**. This process involves several technical steps such as **text mining** of relevant sources, **contextual sentiment scoring**, which differentiates between positive, negative, and neutral language, **temporal analysis**, where sentiment trends are tracked over time to anticipate reversals or momentum shifts. The resulting sentiment metrics are incorporated into trading models, either as standalone signals or in combination with traditional financial indicators. In practice, these systems can: **identify early signals of market inflection points**, such as political risk, corporate scandals, or unexpected macroeconomic developments, **improve the timing of entries and exits**, particularly in fast-moving or sentiment-sensitive markets like technology or crypto-assets, **enhance diversification**, by integrating alternative data sources that may capture risks not evident in price-based models. The use of sentiment analysis by hedge funds such as Renaissance Technologies reflects a broader trend in the industry toward **exploiting alternative, non-financial data** for alpha generation. It also illustrates how **qualitative data can be systematically quantified** and embedded in algorithmic trading strategies, reinforcing the blurring lines between traditional fundamental analysis and quantitative investing. (Bartram et al, 2020)

Moreover, the success of these approaches further challenges the **Efficient Market Hypothesis**, suggesting that **publicly available yet unstructured information** may still contain **underexploited signals**—provided one has the technological tools to extract them. So, this raises the question: Is it still possible to beat the market? - question to which the answer was clearly no based on the traditional human-led investment decision-making.

6. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

AI offers transformative potential for the financial sector. Its strengths in pattern recognition and data processing position it as a powerful tool in investment management. However, explainability, ethical use, and overfitting remain critical challenges. Rather than viewing AI as a replacement for human investors, this paper advocates for hybrid approaches that merge machine precision with human judgment. As markets evolve, so too must the tools and theories used to understand them. Future

research should aim to deepen our understanding of how AI can be integrated responsibly and effectively into investment decision-making.

There are numerous interesting research ideas regarding the topic discussed in present article, such as: analysis of behavioural and cognitive aspects - focus on the psychology behind investment decisions. Humans often make emotional or biased choices (e.g., overconfidence, loss aversion). AI doesn't have emotions, but can inherit biases from data. Investors could be asked via surveys how often they recognize bias in human or AI decisions. Another research proposal is a comparative performance analysis - investment results should be tracked over time: Is AI consistently outperforming or underperforming humans? It could be also attention-grabbing to examine market demographics and behaviour with a focus on who prefers AI vs humans and why, what are the preferences by age, income, education, etc. These ideas raise further questions on the subject: Does AI outperform human managers during high-volatility periods? Do human-led portfolios have better Sharpe ratios in emerging markets? How does AI handle market crashes compared to human decision-makers?

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AUTHORS' ADDRESS

Bíborka-Eszter BÍRÓ, PhD, Univeristy lecturer

SAPIENTIA HUNGARIAN UNIVERSITY OF TRANSYLVANIA, Faculty of Economics, Socio-Human Sciences and Engineering
Department of Business Sciences
Miercurea Ciuc, Romania
E-mail: birobiborka@uni.sapientia.ro

Boróka-Júlia BÍRÓ, PhD, Univeristy lecturer

SAPIENTIA HUNGARIAN UNIVERSITY OF TRANSYLVANIA, Faculty of Life Sciences and Sports
Department of Life Sciences
Sfantu Gheorghe, Romania
E-mail: biroboroka@uni.sapientia.ro

THE ROLE OF TRADITIONAL AND CASH-FLOW BASED PROFITABILITY INDICATORS IN DIVIDEND POLICY: AN EMPIRICAL STUDY OF US AND GERMAN LISTED COMPANIES (2019-2022)

HAMAD MIRJAM¹

¹*Department of Accounting, Institute of Accounting and Finance, University of Debrecen, Debrecen, Hungary*

Abstract

This research examined the dividend payments of two groups of companies (Dow Jones Industrial Average and DAX index) and the impact of profitability indicators on them between 2019 and 2022. The aim of the research was to investigate which profitability indicators influence the dividend to equity (DIV/EQUITY) ratio of companies in these two groups and the extent of this influence. The research employed a multivariate regression model, incorporating control variables (year, index, size), and one-way and multi-way analysis of variance (ANOVA) to assess how the examined financial indicators (traditional and cash-flow based profitability indicators) influence the ratio of dividends paid to equity. The model's goodness-of-fit indicators suggest moderate explanatory power, with an R^2 value of 0.283, showing that the variance in the independent variables can explain approximately 28.3% of the variance in the dependent variable. Based on the ANOVA test, it can be established that cash flow return on equity (CFROE, $p = 0.006$) and cash flow return on sales (CFROS, $p < 0.001$) indicators have a significant impact on the DIV/Equity ratio, suggesting that companies with higher operating cash flow have a higher dividend payout ratio relative to equity. However, other financial indicators, such as cash flow return on assets (CFROA), the ratio of free cash flow to total assets (FCF/Assets), and traditional profitability indicators (ROE, ROA, and ROS), do not show a statistically significant impact. The regression coefficients confirm the finding that CFROE ($\beta = 0.0572$, $p = 0.006$) and CFROS ($\beta = 0.0690$, $p < 0.001$) indicators have a positive impact on the DIV/Equity ratio. In contrast, company size (divided into quartiles based on asset value), the company group (Dow Jones Industrial Average or DAX index), and time effects (annual comparison) do not show a significant impact. Based on the results, it can be concluded that companies with higher cash flow return on equity and cash flow return on sales have a higher dividend payment to equity ratio, while traditional profitability indicators (ROE, ROA, and ROS) have less influence on dividend payments. Dividend payments are also less influenced by company size or the economic environment in which it operates.

Keywords:

Dividend policy, Profitability indicators, Cash-flow based profitability

1. Introduction

Dividend policy plays a key role in companies' financial strategies. There is a relation between dividend policy and companies' performance, financial indicators, which is supported by numerous studies. One of the financial indicators that plays a significant role in dividend payouts is profitability. Traditional profitability indicators such as ROE (Return on Equity), ROA (Return on Assets), and ROS (Return on Sales) measure a company's earnings to its equity, assets, and revenues. However, traditional profitability indicators focus on the accounting profit, which does not reflect the liquidity and the ability to pay dividends. On the other hand, the cash-flow based profitability indicators, such as CFROE (Cash-flow Return on Equity), CFROA (Cash-flow Return on Assets), and CFROS (Cash-flow Return on Sales) are measuring profitability based on actual cash generated, offering a more reliable view of a company's liquidity and its ability to pay dividends. Numerous studies have shown a significant relation between dividend payout and profitability indicators, both traditional and cash-flow based. For instance, (Lee et al., 2022) found that profitability has a positive and significant impact on the dividend payout ratio of listed companies in the Vietnamese Stock Exchange. Other

studies also confirm the significant relationship between traditional profitability indicators and the dividend payout ratio (Gill et al., 2010, Lohonauman and Budiarmo, 2021, Nikhil and Marisetty, 2023). Other studies focus on and examine the relationship between cash-flow based profitability and dividend payout ratios (Amidu and Abor, 2006, Anil and Kapoor, 2008, Ben Naceur et al., 2006, Nizar Al-Malkawi, 2007).

Based on the above-mentioned findings, I decided to examine the relationship between different types of profitability indicators (traditional and cash-flow based) and the dividend-to-equity (DIV/EQUITY) ratio of companies included in the Dow Jones Industrial Average (DJIA) and Deutscher Aktien Index (DAX). These two groups of companies reflect a selection of the largest and most influential publicly traded companies in the United States (represented by components of the Dow Jones Industrial Average) and Germany (represented by components of the DAX index). The main research question was which profitability indicators significantly influence the dividend-to-equity (DIV/EQUITY) ratio of companies listed on the Dow Jones Industrial Average and DAX indices during the 2019-2022 period. Based on that, the following sub-research questions were determined:

RQ1: Is there a significant impact of traditional profitability indicators (specifically ROE, ROA, and ROS) on the dividend-to-equity (DIV/EQUITY) ratio for companies included in the Dow Jones Industrial Average and DAX indices between 2019 and 2022?

RQ2: Is there a significant impact of cash-flow based profitability indicators (specifically CFROE, CFROA, CFROS, and FCF/Assets) on the dividend-to-equity (DIV/EQUITY) ratio for companies included in the Dow Jones Industrial Average and DAX indices between 2019 and 2022?

RQ3: Is there a statistically significant difference in the dividend to equity (DIV/EQUITY) ratios between companies listed on the Dow Jones Industrial Average and companies listed on the DAX index during the 2019-2022 period?

2. Materials and Methods

2.1. Materials

The research database contained publicly available financial data from companies listed on two stock market indices, the Dow Jones Industrial Average (DJIA) and the DAX index, covering the period from 2019 to 2022. The sample from the DAX index initially consisted of 40 German companies (two companies were excluded), while the sample from the Dow Jones Industrial Average (DJIA) initially included 30 U.S. companies (one company was excluded).

2.2. Methods

The variables used in this research are defined as follows:

The dependent variable is the dividend-to-equity ratio (DIV/EQUITY), which measures the proportion of dividends paid out relative to the company's total equity.

For the independent variables, I divided the variables into two main categories of profitability:

- Traditional profitability indicators, which included Return on Equity (ROE), Return on Assets (ROA), and Return on Sales (ROS).
- Cash-flow-based profitability indicators, such as Cash Flow Return on Equity (CFROE), Cash Flow Return on Assets (CFROA), Cash Flow Return on Sales (CFROS), and Free Cash Flow to Total Assets (FCF/Assets), were included.

To take other factors that might influence the dividend payout ratio into account, the following control variables were included:

- Company size, which was measured by categorizing companies into quartiles based on their total assets.
- Year
- Group where the two index group companies were distinguished (DJIA and DAX)

The data were analyzed using multiple linear regression to investigate the impact of profitability indicators on the dividend-to-equity ratio. Analysis of Variance (ANOVA) was also used to assess the overall significance of the regression models and the individual impact of the dependent variables on the dividend-to-equity ratio.

3. Results and Discussion

Before analyzing the data with multiple linear regression, I performed descriptive statistics to summarize the characteristics of the variables included in the research. Table 1 shows the descriptive statistics by the company's group.

Table 1: Descriptive statistics by company group (aggregated across years 2019-2022)

Variable	Group	Mean	Standard Deviation	IQR	Minimum	Maximum
DIV/Equity	DAX	2.60	10.3	0.0504	0.00	60.8
	DJIA	0.0431	0.562	0.120	-4.12	1.96
ROE	DAX	0.0806	0.170	0.0841	-1.21	0.440
	DJIA	0.124	1.25	0.268	-9.69	3.90
ROA	DAX	0.0285	0.0521	0.0462	-0.258	0.131
	DJIA	0.0852	0.0668	0.0929	-0.0785	0.283
ROS	DAX	0.0626	0.131	0.0624	-0.569	0.804
	DJIA	0.161	0.122	0.154	-0.205	0.507
CFROE	DAX	27.1	100	0.258	-467	510
	DJIA	8.08	84.8	0.280	-9.77	917
CFROA	DAX	10.7	37.4	0.0783	-134	202
	DJIA	3.49	36.4	0.0800	-0.121	394
CFROS	DAX	13.5	64.7	0.170	-289	334
	DJIA	1.62	14.8	0.195	-0.839	160
FCF/Assets	DAX	4.07	27.9	0.0550	-160	98.5
	DJIA	3.04	31.9	0.0773	-0.130	345

Source: Own calculation using Jamovi

As seen in Table 1, DAX companies show a higher mean in terms of the DIV/Equity ratio. The DJIA group displays a much lower average DIV/Equity and considerably less dispersion, though it includes instances of negative ratios. The very small IQR for DAX, despite its high mean and standard deviation, indicates that most DAX companies have DIV/Equity ratios in a tight cluster, with a few extreme positive values distorting the mean. Regarding Return on Equity (ROE), DJIA companies exhibited a higher mean of 0.124 compared to 0.0806 for DAX companies. However, this higher average for DJIA companies was accompanied by substantially greater variability, as evidenced by a standard deviation of 1.25 (versus 0.170 for DAX) and a considerably wider range, including more extreme negative minimum values (-9.69 for DJIA compared to -1.21 for DAX). This suggests that while DJIA companies, on average, reported higher ROE, they also faced a greater dispersion of outcomes, including more significant losses relative to equity for some companies. Turning to Return

on Assets (ROA), DJIA companies again had a greater performance on average, with a mean ROA of 0.0852, significantly higher than the 0.0285 recorded for DAX companies. The interquartile range for ROA was also wider for DJIA firms (0.0929) compared to DAX firms (0.0462), indicating a broader spread in asset profitability among the middle 50% of DJIA companies. Overall, these figures point to more effective average asset utilization in generating profits for the DJIA group. The Return on Sales (ROS) also indicated greater profitability for DJIA companies, which reported a mean ROS of 0.161, exceeding the mean of 0.0626 for DAX companies. While the standard deviations were comparable (0.122 for DJIA and 0.131 for DAX), the interquartile range for DJIA companies (0.154) was more than double that of DAX companies (0.0624), suggesting that DJIA firms not only achieved higher average profit margins from sales but also showed a wider spread in these margins among the central cohort of companies. Collectively, these traditional profitability metrics suggest that, on average, DJIA-listed companies were more profitable than their DAX-listed counterparts during the period under review, though often with greater associated variability, particularly in ROE.

In terms of cash-flow-based profitability ratios, the DAX group reported a mean of 27.1 in the case of CFROE, accompanied by an exceptionally large standard deviation. In stark contrast, its IQR was only 0.258, highlighting that the mean is heavily distorted by extreme values. Similarly, the DJIA group showed a mean CFROE of 8.08 with a large standard deviation of 84.8, a wide range from -9.77 to 917, and an IQR of 0.280, also indicating a highly skewed distribution. A similar pattern of skewness and high dispersion is observed for CFROA. Regarding CFROS, the DAX group's mean was 13.5, with a very large standard deviation of 64.7 and an IQR of 0.170, within a range of -289 to 334, indicating significant positive skewness. The DJIA group showed a lower mean CFROS of 1.62, a considerably smaller standard deviation of 14.8, and an IQR of 0.195, with a less extreme range from -0.839 to 160. This suggests that CFROS for DAX companies is more susceptible to extreme values and exhibits greater overall dispersion than for DJIA companies. In the case of FCF/Assets, we can also witness a high variability for both groups. In summary, all examined cash-flow-based indicators (CFROE, CFROA, CFROS, FCF/Assets) are characterized by substantial positive skewness and high volatility for both DAX and DJIA groups.

After the descriptive statistics, I analyzed the data by using multiple linear regression to investigate the impact of profitability indicators on the dividend-to-equity ratio. The independent variables and control variables were as I demonstrated in the Materials and Methods chapter. In Table 2, we can see the summary of the overall model fit for the multiple linear regression analysis.

Table 2: Model fit measures for multiple linear regression

Statistic	Value
R	0.532
R-squared (R^2)	0.283
Adjusted R^2	0.242
F-statistic	6.88
Degrees of freedom 1 (df1)	14
Degrees of freedom 2 (df2)	244
p-value (F)	<.001

Source: Own calculation using Jamovi

Based on Table 2 the model demonstrates a statistically significant ability to explain variation in the dividend-to-equity ratio ($F(14, 244) = 6.88, p < .001$). The R-squared value is 0.283, indicating that approximately 28.3% of the variance in the DIV/EQUITY ratio is accounted for by the independent

and control variables included in the model. The adjusted R-squared, which accounts for the number of predictors, is 0.242.

Following the overall model fit, an omnibus Analysis of Variance (ANOVA) was conducted to assess the individual significance of each independent and control variable in explaining the variation in the dividend-to-equity (DIV/Equity) ratio. The results of the ANOVA are presented in Table 3.

Table 3: Omnibus ANOVA test results

Source of Variation	Sum of Squares	df	Mean Square	F-statistic	p-value
CFROE	369.39	1	369.39	7.755**	0.006
CFROA	74.34	1	74.34	1.561	0.213
CFROS	1188.98	1	1188.98	24.961***	<.001
ROE	1.79	1	1.79	0.038	0.847
ROA	23.44	1	23.44	0.492	0.484
ROS	12.56	1	12.56	0.264	0.608
FCF/Assets	115.02	1	115.02	2.415	0.122
Index Group (DAX vs DJIA)	13.67	1	13.67	0.287	0.593
Year	42.14	3	14.05	0.295	0.829
Size (Total Assets Quartiles)	231.87	3	77.29	1.623	0.185
Residuals	11622.69	244	47.63		

Source: Own calculation using Jamovi

Note: Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

As can be seen in Table 3, CFROE was found to have a statistically significant effect on the DIV/Equity ratio, with an F-statistic of 7.755 and a p-value of 0.006. An even stronger significant impact was observed for CFROS, which yielded an F-statistic of 24.961 and a p-value of <.001. These findings indicate that CFROE and CFROS are significant factors associated with the DIV/Equity ratio of the examined companies. While other cash-flow-based ratios did not show a statistically significant overall effect on the DIV/Equity ratio. Furthermore, the traditional profitability ratios included in the analysis did not demonstrate a significant relationship with the DIV/Equity ratio. Similarly, the control variables did not exhibit a significant overall impact on the DIV/Equity ratio in the ANOVA test. This means that factors such as company size, year, and the group (DAX vs DJIA) were not found to individually explain a statistically significant portion of the variance in the DIV/Equity ratio. To understand and examine the direction of the relationships, a multiple linear regression analysis was performed. The results can be seen in Table 4.

The results indicate that specific cash-flow-based profitability measures are significant predictors of the divided-to-equity ratio. CFROE shows a statistically significant positive relationship with the divided-to-equity ratio (Estimate = 0.0572, SE = 0.0206, $p = 0.006$). This suggests that, holding other factors constant, a one-unit increase in CFROE is associated with an approximate 0.0572 unit increase in the divided-to-equity ratio. Similarly, CFROS has a highly significant positive impact on the divided-to-equity ratio (Estimate = 0.0690, SE = 0.0138, $p < .001$). A one-unit increase in CFROS is associated with an approximate 0.0690 unit increase in the divided-to-equity ratio, ceteris paribus. These findings imply that companies with higher cash flow generation relative to their equity or sales

tend to distribute a larger portion of their equity as dividends. Regarding the traditional profitability indicators, none of them showed a statistically significant relationship with the dividend-to-equity ratio after controlling for other variables in the model.

Table 4: Multiple linear regression results

	Estimate	Std. Error	t-statistic	p-value
Intercept ^a	3.8162	1.3038	2.927	0.004
CFROE	0.0572	0.0206	2.785	0.006
CFROA	-0.0837	0.0670	-1.249	0.213
CFROS	0.0690	0.0138	4.996	<.001
FCF/Assets	-0.0747	0.0481	-1.554	0.122
ROE	0.3366	1.7374	0.194	0.847
ROA	-9.3087	13.2708	-0.701	0.484
ROS	-2.4734	4.8176	-0.513	0.608

Source: Own calculation using Jamovi

4. Conclusion

The study found that specific cash-flow-based profitability indicators play a significant role in shaping dividend policy. Notably, the CFROE and the CFROS found that it has a positive and statistically significant influence on the dividend-to-equity ratio within the examined companies during the examined period (2019-2022). Based on this finding, the greater the operating cash flow-to-equity and to-revenues, the higher the dividend payouts relative to equity will be.

In contrast to other researchers' findings, the traditional profitability ratios, CFROA and FCF-to-total assets, have no statistically significant impact on the dividend payouts.

Furthermore, the control variables included in the analysis – company size (categorized by total asset quartiles), company group (distinguishing between Dow Jones and DAX-listed companies), and year effects – did not exert a statistically significant impact on the dividend-to-equity ratio during the studied period.

Moreover, DJIA companies generally reported higher average values for Return on Assets (ROA) and Return on Sales (ROS) compared to DAX companies. While the mean Return on Equity (ROE) was also higher for the DJIA group, this was accompanied by substantially greater variability and more extreme negative values, suggesting a wider range of performance outcomes within this group for ROE. A key observation across all cash-flow-based indicators (CFROE, CFROA, CFROS, FCF/Assets) for both index groups, and for the DIV/Equity ratio, particularly within the DAX group, was the evidence of significant positive skewness and high volatility.

Based on these findings, managers aiming to enhance or sustain dividend payouts relative to equity should prioritize strategies that improve these specific cash-flow-based profitability metrics. For potential investors, advice could be to focus and place greater emphasis on the CFROE and CFROS ratios

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TACKLING CHALLENGES IN INTERNATIONAL TAXATION AND ACCOUNTING

HUMAN RESOURCE CONTROLLING BASED ON THE EXAMPLE OF A PUBLIC HEALTHCARE INSTITUTION

RITA KOROSZCZŃ PAVLIN

ABSTRACT

Nowadays, human resource controlling operates effectively in the private sector however, within public institutions, we cannot yet speak of efficient HR controlling. In this study, based on data from a Hungarian hospital, I examine whether the activities performed by physicians (focusing exclusively on inpatient care) are in alignment with the compensation provided under the central pay scale. During the course of this examination, I concluded that there are significant differences in physician workload depending on the medical specialty in which they are employed. The pay scale does not differentiate between specialties, therefore it can be stated that it is incapable of addressing the varying workload intensities associated with different fields. By analyzing the activity of physicians within a particular hospital department, I found that among the surgical procedures performed in inpatient care, those requiring lower levels of financing and shorter hospital stays have become dominant. These modern technological procedures are predominantly utilized by younger physicians. However, according to the pay scale, salaries only increase with years of service, which led me to conclude that the pay structure does not reflect physicians' revenue-generating capacity nor their workload. The future task of human resource controlling should be to develop a performance evaluation system that, within an appropriate financial framework, allows for differentiated income supplements in order to make the wage structure more effective.

KEY WORDS

HR controlling, controlling in public institutions, healthcare remuneration structure

1. INTRODUCTION

1.1 The Role of Human Resource Controlling in Organizational Operation

The foundation of economic success in organizations lies in the efficient and effective use of available or acquirable resources. Cost accounting and financial reporting related to human resources began to develop in the 1960s, although it received relatively little attention. In recent decades, however, the value of human resources has significantly increased, which has consequently generated demand for the application of controlling.

As the importance of human resource management has grown, human resource controlling has come to play an increasingly prominent role within the broader controlling system. The responsibilities of HR controlling are diverse, as they are connected to the organization's most vital resource. Human labor, as a production factor, possesses individual will and therefore can influence its own performance. As a result, this performance may vary over time and be affected by external circumstances.

Human resources share several similarities with other resources in that they possess defined capacities and performance potential and are acquired under market conditions. However, they also differ in several respects. Human labor does not depreciate through use. It remains present over the long term,

and with proper development programs and interventions, its performance potential can be enhanced. It cannot be stored. Capacity that is not used at a given time is lost, as unused labor cannot be reserved for future use. Thus, ensuring efficiency requires planned, continuous, and balanced utilization. It is inherently innovative. It is the only resource capable of renewing itself, transforming in quality, and generating new solutions. Depending on its level of motivation and attitude, it can bring about entirely new levels of organizational performance. It does not constitute part of the organization's owned assets. Although it is not part of the organization's equity, its capacity and performance potential contribute to the organization's value over a long period. It acts independently in decision-making. Unlike all other resources, it alone determines how long it remains with a given organization (Maczók-Horváth, 2001).

In service-oriented organizations, personnel costs represent one of the largest expenditures. Management can only be effective if it accounts for the unique characteristics of human resources. Therefore, the traditional tools and perspectives of controlling must be extended to include elements that are not only suitable for evaluating performance outcomes but also for managing behavioral and other qualitative attributes, which are often not quantifiable (Hazafi, 2017).

One of the essential functions of HR controlling is planning. It is responsible for workforce planning, remuneration, incentive structures, and forecasting of labor costs. Furthermore, based on plan-versus-actual comparisons, it provides information regarding performance developments and the alignment between available workforce and required staffing levels in both quantity and structure (Szűcs, 2017). HR controlling takes on special functions in the public sector. In this context, opportunities for motivating and compensating labor are limited. In civil service, salaries are generally centrally regulated (e.g., pay scales, salary bases). Institutions may not, or only under strict conditions and with prior approval, deviate from these regulations. This severely complicates the implementation of performance-based pay or adjustment to labor market conditions. Often, public institutions are not allowed to make autonomous decisions about reducing or increasing staff numbers, as staffing levels are centrally defined (Barna, 2022).

Public sector institutions operate within annual budget frameworks, typically defined by the funding authority (state or local government), which imposes numerous constraints on HR controlling. It may occur that a hiring freeze is in effect for a given year, meaning that the institution cannot hire new employees even when there is a demand for them. In such cases, HR controlling cannot offer an effective response to employee turnover or increasing workload. Wage costs are confined within a predetermined framework, which makes it difficult or impossible to pay overtime, bonuses, or performance premiums. This can have a demotivating effect and, as a result, may negatively impact performance. The creation of new positions or the approval of new job roles can often take several months due to bureaucratic processes, which can diminish organizational responsiveness and competitiveness.

Given these factors, HR controlling is unable to contribute proactively to strategic workforce planning, operates with limited tools for optimization (such as flexible wage structures), and is often reduced to a monitoring and reporting role without the capacity to intervene.

1.2 Budgetary Constraints in Healthcare HR Controlling

Human resource controlling in public service represents a specialized domain that monitors, evaluates, and optimizes human resource management in public institutions through data-driven decision-making. While the private sector focuses on profit maximization, the public sector is guided by the effectiveness and transparency of public services and the responsible management of public funds (Boros et al., 2021). Controlling in the public sector faces several challenges. Data extraction

is often difficult because institutions typically operate with non-integrated HR systems and outdated IT infrastructures (Demmke, 2017). For the purposes of this study, particular attention is given to the limited flexibility in salary and staffing management that characterizes the public sector.

Due to centrally regulated salary structures, there is no flexibility to adapt to market conditions. In Hungary, healthcare professionals such as doctors and nurses are remunerated based on a nationwide pay scale, typically in accordance with the provisions of the "healthcare service employment relationship." This means that a hospital HR controller cannot offer salaries that are competitive with the private sector or with foreign job offers, nor can they implement a flexible performance-based bonus system, as such measures are only allowed under strict legal regulations. As a result, HR controlling cannot intervene even when it becomes evident that attrition rates are increasing (Cogin et al., 2016).

Another recurring problem is the existence of hiring freezes or staffing limits. In some cases, it is not possible to expand the number of employees even when there is an operational need for additional staff. For example, in a county hospital, the HR controller may clearly demonstrate that the nurse-to-patient ratio in a particular department is critically high, but the creation of new positions can only occur with ministerial approval. Consequently, the institution is unable to react swiftly, and the HR controller can only report on the overburdening of the staff without the ability to initiate concrete solutions (Homauni, 2023).

Hungarian public sector controlling must overcome numerous challenges, particularly the need to implement the principles of efficiency, effectiveness, and cost-efficiency. These principles must align strategic public goals with the entirety of the public administration toolset, as interpreted within the controlling system (Novosz  th, 2019).

2. MATERIAL AND METHODS

This study examines personnel controlling for physicians working in the public sector. In the case of doctors, personnel controlling involves the application of performance indicators and analyses that allow management to monitor their contributions. Optimal workforce planning and job organization are of crucial importance for hospitals, as they must continuously ensure the provision of care under a 24/7 schedule. Physician emigration has posed a longstanding challenge, which is not only driven by the lure of higher foreign salaries but also by the demotivating domestic pay scales.

The analysis is based on the case of a Hungarian hospital, focusing on the differences between departments in terms of average DRG weight and German points per patient, which serve as proxies for revenue-generating capacity. These indicators allow for an assessment of the degree of workload required in each department for physicians to generate institutional revenue.

Within the analysis of activities in a selected hospital department, changes in the average length of hospital stay over the past years are also reviewed. Since the hospital's DRG-based revenue depends directly on this variable, its impact on funding is substantial. The focus of this study lies in the observation that the majority of revenue-generating activities are performed by physicians under the age of 50, even though significantly higher wages are only available after 20 years of service. This discrepancy leads to a demotivation of younger physicians, prompting emigration to foreign or private-sector positions, and ultimately resulting in an aging medical workforce and a potential decline in the professional quality of public healthcare in the future.

The analysis evaluates DRG weight data across departments for a specific year. For performance evaluation, a single department was selected, and within this department, average length of stay, DRG weights per physician, and German points were examined. Because the underlying data did not follow a normal distribution, the natural logarithm of the values was used for the analysis. Regression analysis and data visualization were carried out using Microsoft Excel and the STATA statistical software.

3. RESULTS AND DISCUSSION

One of the main sources of revenue for healthcare institutions is budgetary financing determined based on diagnosis-related groups (DRG). Consequently, one of the key indicators of physician performance measurement can be considered their revenue-generating capacity. Within the framework of controlling activities, it is relatively straightforward to determine the amount of DRG weight produced by individual departments over a given period, thereby making the revenue-generating capacity of different hospital units comparable. The following figure presents the average value of DRG weight per case for various departments within the examined hospital.

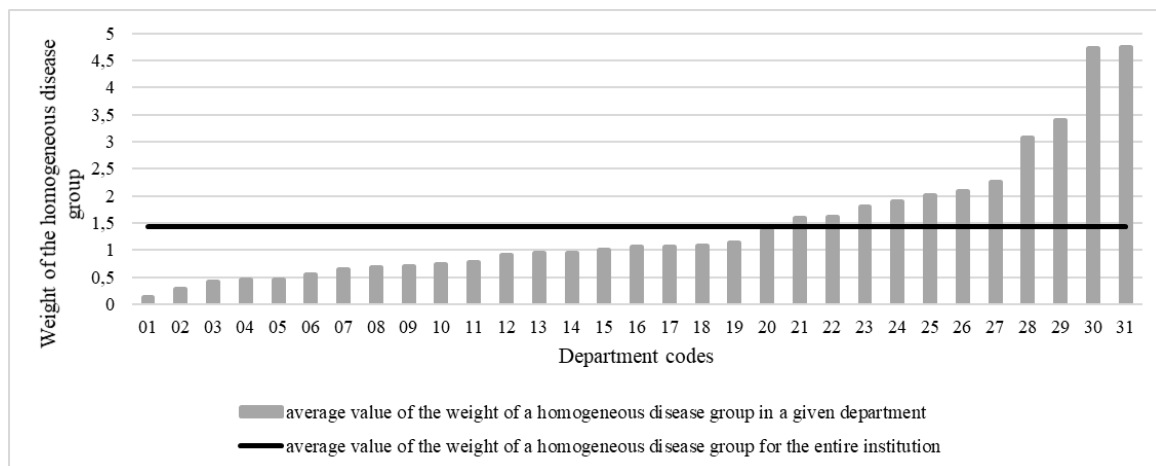


Figure 1: The average value of DRG weight per case for various departments

Source: own editing based on the examined hospital data

The horizontal axis of the chart shows the anonymized codes of hospital departments, while the vertical axis displays the average annual DRG weight per capita for each department. A grey line indicates the average DRG weight per case for the entire institution, which is 1.4381. Upon analyzing the data, it becomes evident that there are significant differences in the DRG weight production across hospital departments. This observation suggests that the workload required to generate revenue differs between units. Since physician salaries are not differentiated by specialty, it follows that there is a mismatch between the revenue-generating capacity of individual hospital departments, as reflected by their average DRG weight per case, and their personnel expenditures. This imbalance results in a situation where departments with lower average DRG weights must handle a higher number of cases to keep their budgets balanced. An increase in the number of cases leads to a greater workload, as certain tasks (such as patient admission administration) require additional time. Consequently, physicians in departments with lower DRG weights face increased burden, which in turn contributes to higher turnover rates in these specialties.

In the next part of the study, the medical performance of a specific department within the examined hospital is evaluated, enabling a more homogeneous comparison of physician performance. One of the fundamental aspects of DRG weight analysis is the number of hospitalization days, as longer hospital stays for a given diagnosis result in higher reimbursement. The following figure illustrates the significantly decreased trend in the average number of hospitalization days between 2005 and 2024.

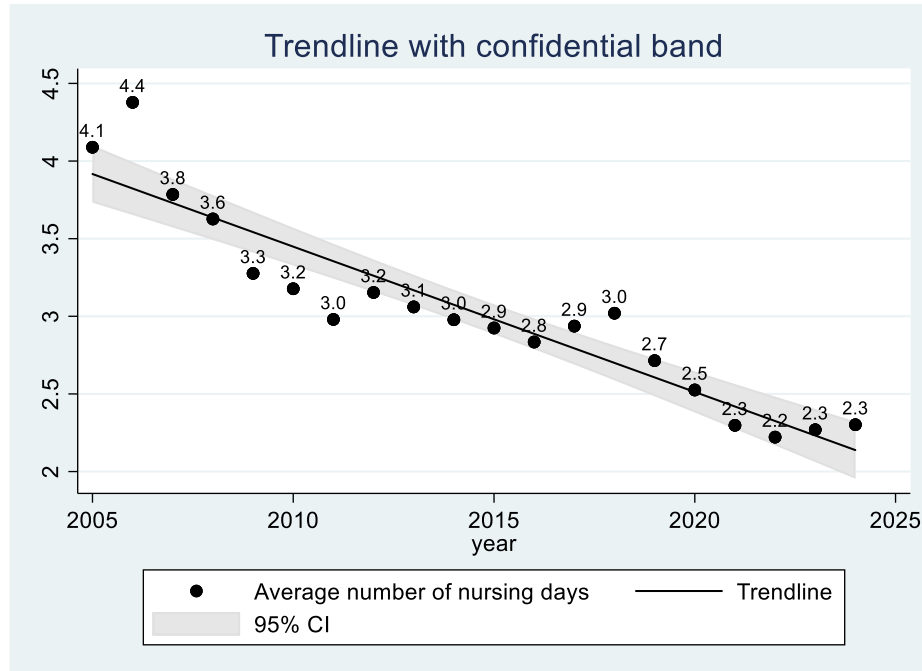


Figure 2: The average number of hospitalization days between 2005 and 2024

Source: own editing based on the examined hospital data

The data indicate that the average length of stay has been halved. This naturally leads to a decrease in DRG weights; however, it also reflects a gain in efficiency, since patients recover in a shorter period of time. Based on these results, it can be concluded that inpatient care is characterized by increased efficiency in service delivery, although it simultaneously demonstrates a reduced revenue-generating capacity. Following this, the proportion of major abdominal surgeries performed in the department between 2019 and 2024 was examined.

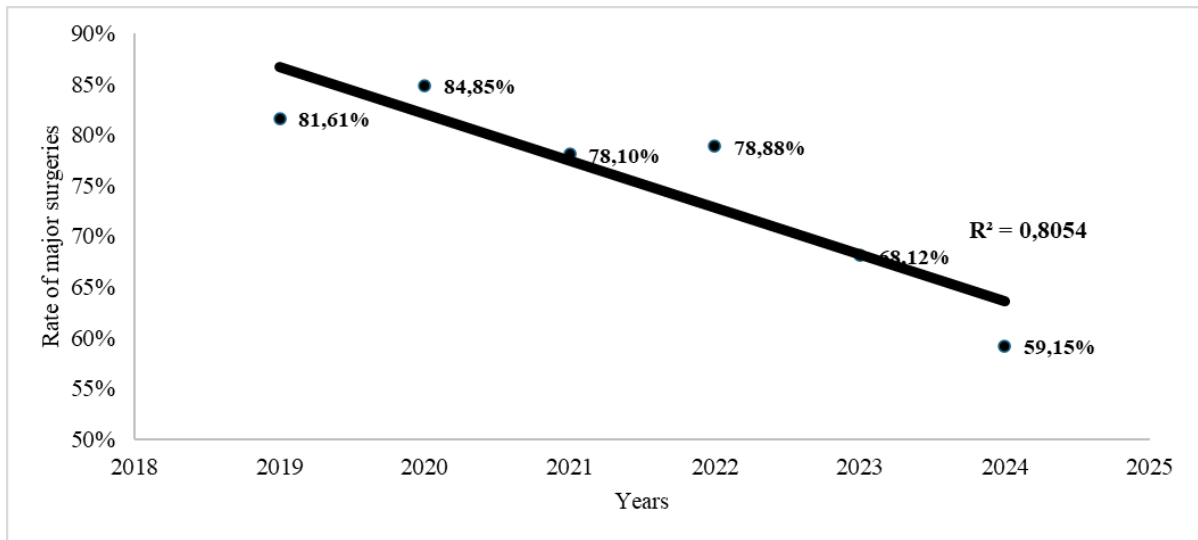


Figure 3: The rate of major surgeries between 2019 and 2024

Source: own editing based on the examined hospital data

Since 2019, the department in question has been performing laparoscopic surgeries. The data clearly show a significant decline in the proportion of major abdominal surgeries, which aligns with the reduction in the average length of hospital stay. The decrease in these surgeries unequivocally reflects more efficient patient care, as patients tend to recover more quickly and are able to return to work sooner. However, due to the reduction in hospital days, a higher number of surgeries must be performed each year to cover the increasing wage costs of physicians, which imposes an additional workload.

The subsequent part of the study examines which age groups of physicians perform the majority of surgeries. This analysis is necessary because physician salaries are determined by a seniority-based pay scale, which means that the older a physician is, the higher their wage. Based on efficient personnel controlling, it could be assumed that older physicians would perform more surgeries, as the DRG weights generated by surgeries provide coverage for the higher wages. Upon reviewing the data, I concluded that 76 percent of the surgeries are performed by physicians under the age of 50, which clearly indicates that the younger cohort is responsible for the majority of DRG-generating activities. The following chart displays the ages of physicians in the department along with the base-10 logarithm of the number of surgeries performed per year.

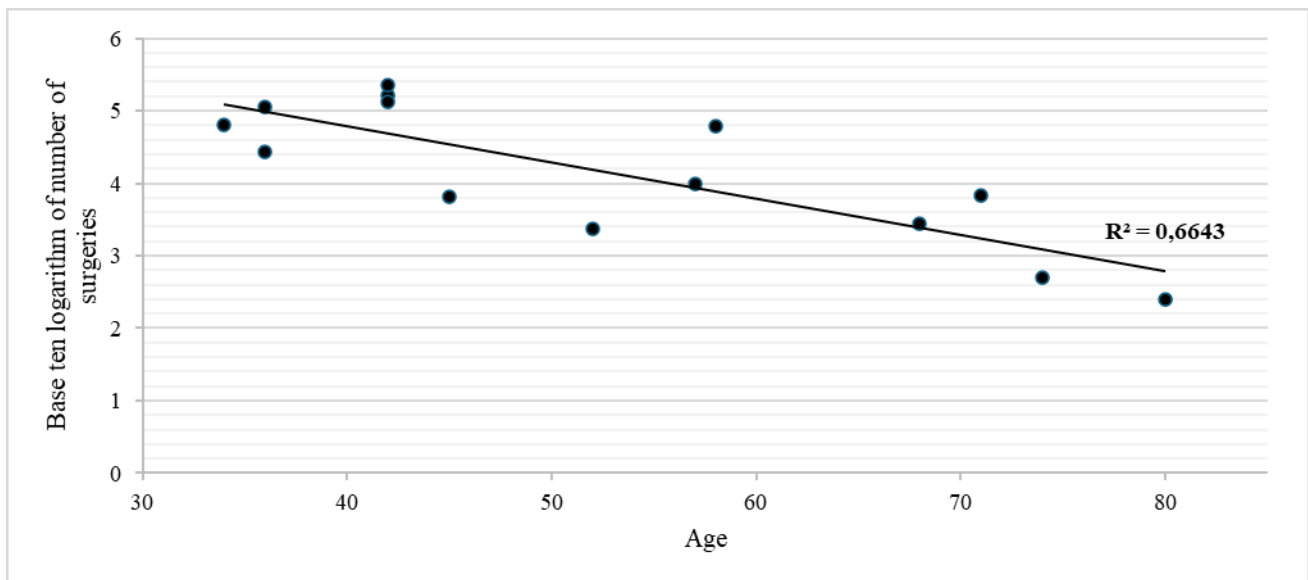


Figure 4: the relationship between the ages of physicians and base-10 logarithm of the number of surgeries performed per year

Source: own editing based on the examined hospital data

I calculated the base-10 logarithm of the number of surgeries performed in order to mitigate the effect of outliers and reduce the data's range. The chart indicates that as the age of the physician performing the surgery increases, there is a slight decline in the number of surgeries performed. Although linear regression does not suggest a strong statistical relationship, it is observable that there is a downward trend in surgical activity after the age of 45.

4. CONCLUSION

Human resource management holds exceptional significance in service-oriented activities. However, in the case of public institutions, personnel management is often subject to rigid constraints imposed by centrally regulated pay scales and staffing freezes. This study examined human resource management in Hungarian public healthcare institutions. The analysis sought to determine whether the standard pay scale applicable to physicians corresponds with the nature and intensity of their professional activity. Specifically, the study focused on revenue-generating performance as measured by DRG weights, both at the departmental level and within specific physician age cohorts.

The investigation revealed that there are considerable disparities between hospital departments in terms of average DRG weight per case. From this, it can be inferred that physicians working in different departments face unequal workloads in generating the same total wage bill through DRG-based revenue. To ensure homogeneity in analysis, one department was selected for further examination, and age-specific subgroup analysis was conducted exclusively for that unit. It was established that over the past decade and a half, the average length of hospitalization has significantly declined (2010–2025). Lower hospitalization times are associated with lower DRG weights, which in turn generate less direct funding to cover related costs. At the same time, the underlying cause of this decline lies in more effective treatments and procedures that lead to better quality of life for patients. These modern interventions are predominantly performed by physicians who fall into the younger age brackets and are positioned in the lower tiers of the pay scale.

The findings clearly indicate that the current financing system inadvertently incentivizes outdated procedures, as modern techniques tend to result in shorter recovery periods and consequently lower DRG weights. Because of this, a higher number of lower-weight procedures must be performed in order to cover the personnel costs defined by the standard wage scale. Most of these procedures are performed by younger physicians, which creates a motivational imbalance, as their salaries remain relatively low under the existing structure. This situation generates internal tension within institutions, which should ideally be addressed through effective HR controlling. However, the leadership of public institutions has very limited room to maneuver in this respect.

Currently, controlling units within public institutions invest considerable effort into developing performance evaluation systems that could objectively measure individual employee output. Nevertheless, in many cases, these evaluations are not linked to any kind of financial compensation due to the constraints of the central budgetary framework. To resolve the issues identified in this study, the first step should involve updating the central financing mechanism for services performed by physicians—in this case, surgical procedures—as the current system fails to incentivize modern techniques that enable shorter recovery times. While the use of a national pay scale is an inherent feature of public sector employment, it would be beneficial to introduce an institutional budget pool that managers could allocate annually based on performance evaluations. Such a reform would significantly support the expansion and effectiveness of human resource controlling within public healthcare institutions.

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AUTHOR ADDRESS:

Rita Koroseczné Pavlin: Hungarian University of Agriculture and Life Sciences, Institute of Rural Development and Sustainable Economy; Kaposvár, Hungary, koroseczne.pavlin.rita@uni-mate.hu

THE IMPACT OF INDUSTRY 4.0 ON THE MANAGEMENT ACCOUNTING IN CASE OF CROPS

RITA KOROSZCZYNÉ PAVLIN - VERONIKA GÁL – IRÉN WICKERT

ABSTRACT

In recent years, arable crop production has undergone significant technological transformation. The advancement of technology has enabled the collection of vast datasets, the analysis of which allows management accounting to provide valuable insights into the profitability of specific agricultural plots. This study explores how these data sets can be utilized in both managerial and financial accounting. Using data from a Hungarian small enterprise, we demonstrate which cost elements can be more precisely attributed to specific parcels. Our findings suggest that in financial accounting, the valuation of work-in-progress inventories becomes more accurate through the use of data generated by precision agriculture tools. Additionally, in management accounting, cost allocation becomes more refined during cost calculation, allowing for parcel-level profitability assessments that support decision-making. Moreover, the data derived from Agriculture 4.0 are not only beneficial at the micro-level but may also inform macro-level policy, such as replacing the controversial "golden crown" land valuation metric with a parcel-based profitability evaluation model. Our study was funded by the European Commission through the Horizon Europe programme (Project Number: 101071317) under the Cooperating for excellence and impact in research and innovation EUDRES Entrenovators project.

KEY WORDS

management accounting, cost of crops, profitability of the land

1. INTRODUCTION

Digitalization has become pervasive in all aspects of life, significantly impacting administrative processes as well. The latest developments in digitalization and the use of artificial intelligence have now extended to accounting processes, including controlling and even auditing activities (Hoschek & Szóka, 2024). Industry 4.0 primarily affects the production sector, and thus plays a major role in agriculture, resulting in changes in production processes.

When analyzing risks in agriculture, exposure to weather and global warming typically come to mind first. However, from an economic standpoint, a more significant factor today is the changing structure of the labor market. Previously, agricultural labor was predominantly supplied by rural residents, often in regions characterized by lower levels of education. Today, the agricultural sector increasingly demands skilled labor capable of keeping up with technological changes. Modern agricultural machinery is equipped with advanced, computer-controlled technology, requiring operators with at least basic digital literacy.

As a result, crop production today is characterized by a smaller but more skilled and better-paid workforce than two decades ago. This shift is largely due to technological advancements, as modern machines can process far more land per unit of time than in the past (Nagy, 2022). Consequently, the

capital-to-labor ratio has tilted in favor of capital, increasing the significance of fixed costs in accounting records.

Modern, results-oriented farming necessitates continuous monitoring of operational efficiency. One of the most important areas of management accounting is cost calculation. Analyzing costs is indispensable for strategic planning, business decision-making, and effective management. This analysis relies on cost tracking and cost calculation (Ferke, 2011).

There is no direct statutory regulation governing cost calculation as a method. Hungarian accounting law does not mandate cost calculation, but it requires that self-manufactured assets (including inventories) be recorded at direct production cost. Determining this direct cost essentially constitutes cost calculation. According to §51 of Act C of 2000 on Accounting, the cost of production includes expenses that:

- arise directly during production, installation, expansion, transformation, or restoration of an asset (product),
- are demonstrably closely related to production, and
- can be allocated to the asset (product) using appropriate indicators or characteristics.

Cost calculation thus refers to determining the planned or actual direct, technological, limited, or full cost of a product or activity (service). Enterprises must decide (and specify in their accounting policy) how and when to determine the cost of self-manufactured assets. For larger companies, this is strongly influenced by §14(7) of the Accounting Act. It mandates that the direct cost of self-manufactured products and provided services must be determined using a retrospective calculation method defined in an internal regulation on cost calculation if the net sales revenue, after deducting the cost of goods sold and mediated services, exceeds HUF 4 billion or total costs exceed HUF 2 billion in any fiscal year. Once this threshold is met, the obligation continues regardless of future values.

Cost determination under §51 of the Hungarian Accounting Act may be based on production cost, average (weighted) direct cost, or FIFO (first-in-first-out). Direct cost may be determined retrospectively or using standard costing. For work-in-progress, the standard direct cost can be estimated proportionally from the cost of the finished product, based on the stage of completion. When preparing simplified financial statements, inventories may be valued at their estimated selling price minus foreseeable additional costs and calculated profit; these additional costs can also be proportionally estimated based on completion rates (Bosnyák et al., 2010).

1.1 The Specialities of Cost in Agriculture

Due to the specific characteristics of agricultural activities, cost cannot be calculated using normative costing methods. Therefore, in the case of agricultural crops, products, and animal products, cost determination can only be performed through retrospective (post-calculation) methods. There is no legally mandated costing scheme—only recommended approaches exist.

In agriculture, valuation based on direct cost is predominant, as the products are primarily biological in origin (i.e., living), which limits the range of applicable cost calculation methods. For example, in the case of work-in-progress, it is permitted to determine the direct cost based on standard costing, proportionally calculated from the finished product's standard direct cost and adjusted for the level of completion. However, such methods are not applicable in the case of a field inventory. While the stage of completion can be precisely determined for an automated industrial product, in the case of a wheat crop on December 31, for instance, such determination can only be speculative. At that point in time, it is impossible to know exactly which operations will be required until harvest (e.g., weeding, protection against plant diseases or pests, etc.).

As such, the method of cost determination must rely on post-calculation. This method is particularly suitable for determining the cost of self-manufactured inventories, especially work-in-progress. The accounting policy must specify under which circumstances and to what extent post-calculation will be applied for determining cost (Sabján & Sutus, 2003).

When designing a product costing scheme, it is advisable to separate cost types. With the widespread use of total-cost-based income statements, classical analytical records have been phased out—even though they are fundamental for performing post-calculation. The cornerstone of accurate post-calculation is precise cost allocation. The primacy of direct costs determines the effectiveness of post-calculation. A recurring challenge is the allocation of maintenance and auxiliary operational costs. These must first be collected and then allocated to the respective product based on actual usage.

Companies require detailed analytics to support cost allocation. This requires that the performance of maintenance and auxiliary operations be continuously recorded according to usage. The allocation of auxiliary operational costs in agriculture is particularly complex, especially in crop production, where certain assumptions may lead to inaccurate results. A method published by the Ministry of Agriculture and Food in 1982 proposed using the concept of a “standard hectare” as the basis of cost allocation. A standard hectare is equivalent to one hectare of flat, medium-textured soil ploughed to a medium depth. This standard value is then corrected based on the actual characteristics of the land in question (MÉM, 1982).

Today, however, agricultural machinery equipped with digital technology is capable of recording data per plot (parcel), such as the number of machine hours used and the quantity of input materials applied. Our study investigates how this digital revolution is changing cost accounting in the context of arable crop production.

2. MATERIAL AND METHODS

In our study, we examine the scope of data available for accounting systems through the case of a small enterprise. This agricultural business is engaged in arable crop production and has recently upgraded its machinery with the help of support programs aimed at fostering digital transition in agriculture. The company cultivates approximately 2,000 hectares of land in Somogy County, Hungary.

Currently, it collects and analyzes production-related data from 199 individual plots. Data processing is carried out using the PGR system implemented by the enterprise. Accordingly, the visual outputs and figures presented in this study are generated by this system.

3. RESULTS AND DISCUSSION

With the advent of digital technology, modern agricultural machinery has become capable of storing data with GPS-level accuracy. This development enables more precise cost calculation for agricultural work-in-progress. The potential of big data makes it feasible to allocate costs at the parcel level. But why is this important for management accounting and decision-making?

Agricultural enterprises typically operate on geographically dispersed plots with varying topographical features. Because of these differences, it is evident that the cost per hectare will also vary across fields. Without digital technology, these cost differences could not be accurately tracked. Even today, we cannot claim to have all the necessary data, as many enterprises have not yet fully

replaced their machinery. If any operational phase lacks digital data capture, estimated values must be inserted, compromising the precision of the calculation.

To perform parcel-level cost accounting, each field operation must be executed using equipment capable of digital data collection. Thanks to EU agricultural infrastructure support, many small enterprises in Hungary and Romania have partially modernized their machinery for precision farming, facilitating a digital transformation in recent years.

Our study presents the example of an agricultural enterprise in Somogy County, Hungary, to demonstrate how data is collected through advanced technology obtained via such funding.

Agricultural drones can generate topographical maps for each parcel, thereby visualizing terrain variations, as shown in **Figure 1**. While the printed version of the map uses grayscale for formatting purposes, in reality, these maps are color-coded from red to green, offering a more vivid and informative display. Since our analysis does not require exact GPS coordinates, grayscale is sufficient for illustrating differences.

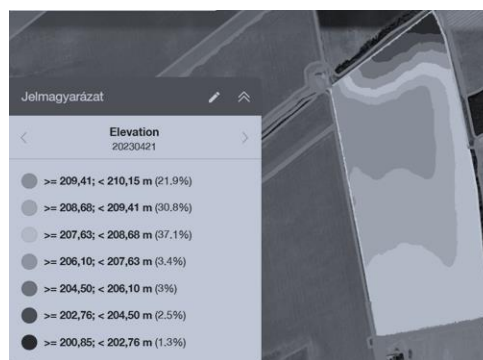


Figure 1: Elevation Map of a Parcel (Above Sea Level)

Source: Output generated based on the company's data

Using the precision farming system, the agronomist designs the seeding plan according to the topographical characteristics shown in Figure 1. In addition to elevation, the layout must also consider field roads and forest strips adjacent to the parcel. The resulting seeding plan is shown in the next figure.



Figure 2: GPS-based Seeding Map of a Parcel

Source: Output generated based on the company's data

As illustrated in **Figure 2**, lower seeding density (lighter shades) is used along the parcel's edges, while the denser seeding (darker shades) appears in the lower central section. This area lies at a lower

elevation, and therefore rainfall and leaching fertilizers or pesticides tend to accumulate here. As a result, higher seeding density is more likely to be productive in this section.

Fertilizer application is also planned using a similar approach. During plant protection operations, agricultural drones first assess the plant condition. Based on the analysis, pesticides are applied in varying doses per GPS coordinate. This targeted application lies at the heart of precision agriculture, which significantly reduces unnecessary pesticide and fertilizer use. This has considerable environmental implications from both societal and sustainability perspectives. At the enterprise level, it also translates to a substantial reduction in raw material costs.

It's worth emphasizing that enterprises in arable farming typically engage in forward contracts for grain sales. Thus, selling prices are often fixed in advance. To realize profit, companies must therefore focus on maximizing yield while reducing costs. As discussed, increased yield can be achieved through well-designed seeding plans and targeted crop protection.

Naturally, environmental impacts cannot be eliminated in arable crop production. However, for the purposes of this study, we assume that the field in question is not affected by drought, which has been common in recent years. While the selling price cannot be influenced, yield (i.e., quantity) can be optimized through targeted application. Similarly, cost reduction depends on avoiding purchases and applications of fertilizer or pesticide that do not contribute to production. This in turn lowers raw material costs.

Therefore, precision agriculture clearly contributes to cost reduction, which becomes evident in financial accounting through the income statement. In financial accounting, year-end inventory valuation is especially critical, particularly the valuation of self-produced inventories. One of the most complex tasks for agricultural businesses is determining the value of work-in-progress. The next section explores its significance in greater depth.

3.1 WORK-IN-PROGRESS IN AGRICULTURE

Work-in-progress refers to products that have already undergone at least one substantial production operation but have not yet completed the full production process and therefore cannot be recognized as finished self-produced inventories.

In agriculture, typical forms of work-in-progress include (Adorján et al., 2017):

- **Crop production work-in-progress:** autumn sowing, soil preparation for spring sowing, planting of perennial crops, organic fertilization, establishment of meadows and pastures, etc.
- **Livestock work-in-progress:** eggs in incubation
- **Other agricultural work-in-progress:** seeds undergoing processing in seed plants, based on the level of completion

The most common form of agricultural work-in-progress is **field inventory**. This category includes expenses incurred in the current year in preparation for crop production in the following year(s) (Musinszki, 2012).

According to §51 of the Accounting Act, the acquisition cost of self-produced inventories includes all production costs incurred from the start to the end of the production process. A particular feature of agriculture is that the production cycle for some crops spans more than one year, requiring inter-period cost allocation. The production cost of work-in-progress reflects the value included in inventory.

This raises the question: **What is the value of work-in-progress?** With accurate cost tracking (analytics), direct costs can be precisely identified. Maintenance and auxiliary operational costs can

be allocated using appropriate indicators, enabling accounting to produce a correct financial outcome. However, the actual value and eventual recovery of the field inventory will only be confirmed at harvest.

Several **risk factors** may affect the market value of the calculated acquisition cost (AKI, 2009), such as:

- topographical conditions and soil characteristics of the location
- sustainability of the applied production technology (e.g., nutrient supply)
- climate conditions (e.g., temperature, precipitation)
- animal pests
- plant diseases

Considering these environmental risks, it may be necessary to reconsider the applied valuation method. According to the **principle of prudence**, assets must not be overvalued, as this could result in the recognition of unrealized profits (Ormos, 2018). The value of self-produced inventories (including field inventories) is a factor that directly influences profit. While these inventories cannot be written up, a **write-down** may be justified in light of the mentioned risk factors.

An important accounting question is whether damage caused by these risks qualifies as a **casualty loss** or rather a **loss of value**. If it qualifies as a typical agricultural casualty loss, its usual amount is recorded under other operating expenses. According to §56(2) of the Accounting Act, the acquisition cost of self-produced inventories must be reduced in the balance sheet if:

- the inventory does not comply with applicable regulations or its intended use,
- it is damaged,
- its utilization or sale is doubtful, or
- it has become redundant.

The inventory's value must be written down to reflect its **usable value** at the time of balance sheet preparation.

3.2 PARCEL-LEVEL DATA AND MANAGERIAL DECISION SUPPORT

Beyond financial accounting, parcel-level information derived from precision farming is highly valuable for **management accounting** and for informing **managerial decisions**. With the data provided by precision agriculture technologies, we can determine the following for each parcel:

- **Exact material usage** (seeds, fertilizers, pesticides)
- **Time spent working the land**, measured in labor hours
- **Amount of fuel used** during operations, measured in liters
- **Harvested yield**, measured in tons

The last point is crucial because the yields from nearby parcels are often collected together and transported in bulk by trucks, meaning that the recorded quantity at the warehouse reflects an aggregated total from several plots.

Fuel consumption is a particularly significant cost factor in arable farming and therefore deserves detailed analysis. Thanks to digital data, we can now separate fuel usage into two distinct phases:

- **Transport fuel**: from the central site to the field
- **Operational fuel**: consumed during fieldwork

By refining cost and revenue calculations at the **parcel level**, it becomes possible to determine each parcel's **contribution margin**. This data is extremely valuable to management because it supports strategic decisions such as **ranking rented land parcels by profitability**.

Currently, the only official valuation measure for arable land in Hungary is the "**golden crown**" (**aranykorona**) system. This value is often used as the basis for:

- determining **rental prices** for farmland,
- **credit evaluation**, and
- **tax assessments**.

However, research by Szabó et al. (2018) and others confirms only a **weak positive correlation** between the golden crown value and the actual market price of farmland. Farmers and business owners often encounter discrepancies between this indicator and the **real income-generating capacity** or **economic value** of a plot.

Thanks to digital technology, however, a **modern, data-driven valuation model** could now be developed, one that surpasses the outdated golden crown system and reflects **actual profitability** and **economic potential** based on real-time operational data.

4. CONCLUSION

In this study, we examined how Agriculture 4.0 impacts accounting information systems and how these systems have evolved as a result. In the context of financial accounting, inventory valuation is of great importance for production enterprises, particularly for those operating in agriculture.

We found that the availability of big data supports the accurate valuation of work-in-progress inventories—especially **field inventories**—within the domain of financial accounting. At the same time, the **digitalization of machinery** has brought significant advantages for **management accounting** as well. It enables more precise cost calculations and the assessment of **profitability at the parcel level**.

The data generated through precision farming further allows for the development of **comparative analyses** between different parcels in terms of profitability. This opens the door to designing a **new land valuation model** that could serve as a more accurate and economically meaningful alternative to the currently used **golden crown** system.

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AUTHOR'S ADDRESS:

Rita Koroseczné Pavlin: Hungarian University of Agriculture and Life Sciences, Institute of Rural Development and Sustainable Economy; Kaposvár, Hungary, koroseczne.pavlin.rita@uni-mate.hu

Veronika Gál: Hungarian University of Agriculture and Life Sciences, Institute of Rural Development and Sustainable Economy; Kaposvár, Hungary, gal.veronika.alexandra@uni-mate.hu

Irén Wickert: Hungarian University of Agriculture and Life Sciences, Institute of Rural Development and Sustainable Economy; Kaposvár, Hungary, wickert.iren@uni-mate.hu

USAGE OF INTERNATIONAL STANDARDS IN ACCOUNTING AND FINANCIAL AUDIT OF LEASING OPERATIONS

ANTÓNIA ZAKARIÁS - RITA KOROSZCZNE PAVLIN

ABSTRACT

A significant proportion of companies use debt to finance their asset purchases. One form of financing is financial leasing, which is a fairly common source of finance. However, national and international accounting rules do not provide a consistent picture of the methodology for their treatment and recognition of their value. During the audit, auditors check the financial position of companies, their transactions and their leasing operations to ensure that they comply with accounting rules, but from an investor's perspective, the values of leases reported under different standards may have different meanings. In our study, we present an analysis of international accounting standards and their impact based on data from companies in the fast fashion sector, which is a sector with a significant amount of financial leasing, mainly for the rental of commercial premises. The aim of the study is to illustrate the differences between International Financial Reporting Standards (IFRS) and U.S. Generally Accepted Accounting Principles (U.S. GAAP) in the valuation of leased assets, using a European and a U.S. company as case studies. Based on the data, we found that there are significant differences between the two companies' valuations of finance leases in terms of the classification of low-value leased assets, the types of leases recognized on the balance sheet, and the accounting for lease changes.

KEYWORDS

financial leasing in fashion sector, valuation of leased assets

INTRODUCTION

The aim of this study is to analyze the differences between International Financial Reporting Standards (IFRS) and U.S. Generally Accepted Accounting Principles (U.S. GAAP) in the light of leased assets through two companies. IFRS 16 is an international accounting standard, that has brought significant changes to the accounting treatment of leases. It was introduced in 2016 and is mandatory for all companies applying International Financial Reporting Standards from 1st January 2019 (IFRS). Under U.S. GAAP (United States Generally Accepted Accounting Principles), the accounting rules for leasing are set out in ASC 842 (FASB). The effective date of ASC 842 was different for public and private companies. Publicly listed companies were required to transition to the new standard for reporting periods beginning after 15th December 2018. This meant that calendar year-end companies adopted the standard on 1st January 2019. For private companies and not-for-profit entities, the initial effective date was set for reporting periods beginning after 15th December 2019. However, in the summer of 2019, as a result of feedback from public companies regarding the complexity of the implementation, the FASB delayed it to give these entities more time to prepare for the transition. Subsequently, in 2020, the Board delayed the effective date for a second time in response to the impact of pandemic COVID-19. Following these two delays, the effective date for private companies and not-for-profit organizations was set for reporting periods beginning after 15th December 2021, and most private companies and not-for-profit organizations transitioned to ASC 842 for fiscal year 2022 (FinQuery).

MATERIAL AND METHODS

The international standards for the accounting treatment of leases, IFRS 16 and ASC 842, differ in a number of aspects. To illustrate some of the more important differences, we would like to use two companies, Inditex Group and The Gap Inc. Inditex Group is a fast fashion company based in Spain,

that prepares its annual accounts in accordance with International Financial Reporting Standards (IFRS), which include the annual consolidated balance sheet, consolidated statement of comprehensive income and consolidated statement of cash flows (Inditex Group, 2024). The Gap Inc. is a U.S. fast fashion company, prepares its annual financial statements in accordance with U.S. accounting standards, in which they also disclose their annual consolidated balance sheet, consolidated statement of comprehensive income and consolidated statement of cash flows, which are prepared in accordance with U.S. GAAP standards (The Gap Inc., 2024).

RESULTS AND DISCUSSION

Our research is based on a study by KPMG, which summarized in detail some of the major differences between IFRS 16 and ASC 842, which we have illustrated in the first table.

	IFRS 16	ASC 842
1.	☒ property, plant and equipment, other assets ☒ intangible assets, except certain licensing agreements	☒ ☒ property, plant and equipment ☒ inventories, assets under construction, intangible assets
2.	☒ recognition exemption (leases): low-value assets	☒ no exemption for leasing low-value assets
3.	☒ recognition exemption for leases of 12 months or less (lease term) purchase option leases $\neq$ short-term leases	☒ recognition exemption for short-term leases purchase option leases $\approx$ short-term leases (if the lessee is not reasonably certain to exercise the option)
4.	a single balance sheet lease accounting model	there are two types of balance sheet lease accounting: 1. finance leasing 2. operating leasing
5.	remeasurement: required CF change	index/rate change $\neq$ reassessment remeasure: for other reasons, e.g. lease term change
6.	discount rate = rate implicit in the lease/ incremental borrowing rate	discount rate = rate implicit in the lease/ risk-free discount rate
7.	modification $\rightarrow$ scope of the lease $\downarrow$ = profit/loss recognition	☒ profit/loss recognition
8.	option to repurchase the asset: transfer $\neq$ sale	option to repurchase the asset (not real estate) $\approx$ sale (under certain circumstances)
9.	right-of-use asset = previous book value of underlying asset recognition profit/loss on rights transferred to the lessor	right-of-use asset = like any other lease sales - book value = profit/loss

10.	lessor: sublease = finance/operating lease (referring to the right-of-use asset from the main lease)	lessor: sublease → referring to the underlying asset

Table 1: 10 differences between IFRS 16 and ASC 842

source: KPMG, Author's own edition

KPMG has formulated the differences along the following lines: scope, leases recognized on balance sheet, lease classification, remeasurement assessment for leases with variable payments based on an index or rate, discount rate, subleases, lease modifications and sale-leaseback transactions (KPMG). On the topic of purpose, KPMG has highlighted one significant difference, which is:

- IFRS 16 applies to leases of property, plant and equipment and other assets, with limited exceptions, the standard applies to leases of intangible assets, except for rights held under certain licensing agreements (e.g. motion pictures, video recordings, copyrights, etc.);
- in contrast, ASC 842 applies to leases of property, plant and equipment, but its scope exclusions are broader, so that leases of inventories, leases of assets under construction and leases of intangible assets are excluded from the scope of 842 (KPMG).

Therefore, certain arrangements accounted for as leases under IFRS 16 may not be within the scope of ASC 842.

Inditex assesses on the start date of each contract whether the contract is a lease or contains a lease. For such contracts, it recognizes a liability for the present value of the payments to be made during the lease term, known at the inception of the lease, and an asset for the right to use the underlying asset during the lease term. Assets with a right-of-use are carried at cost (which includes initial direct costs incurred, payments made before or at the inception of the lease, less any incentives received), adjusted for accumulated depreciation and impairment losses, and adjusted for any revaluation of lease liabilities. Rights-of-use are amortized linear over the lease term. Inditex actively manages more than 6.000 lease contracts. The recognized leases, in which it acts as lessee, relate mainly to commercial premises. It is also noted, that certain contracts for logistics services are classified as leases under the terms of these contracts, which grant exclusive access to the logistics facilities, where these services are provided (Inditex Group, 2024). These lease contracts are accounted for as intangible assets by the company.

Inditex's inventories include raw materials and consumables, not finished and finished goods, and goods for sale. The company does not have any leased inventory (Inditex, 2024). In 2023, the value of leased assets reported in the balance sheet was 5.097 million EUR (Inditex Group, 2024), representing 15,57% of assets (Figure 1) and 30,49% of non-current assets (Figure 2).

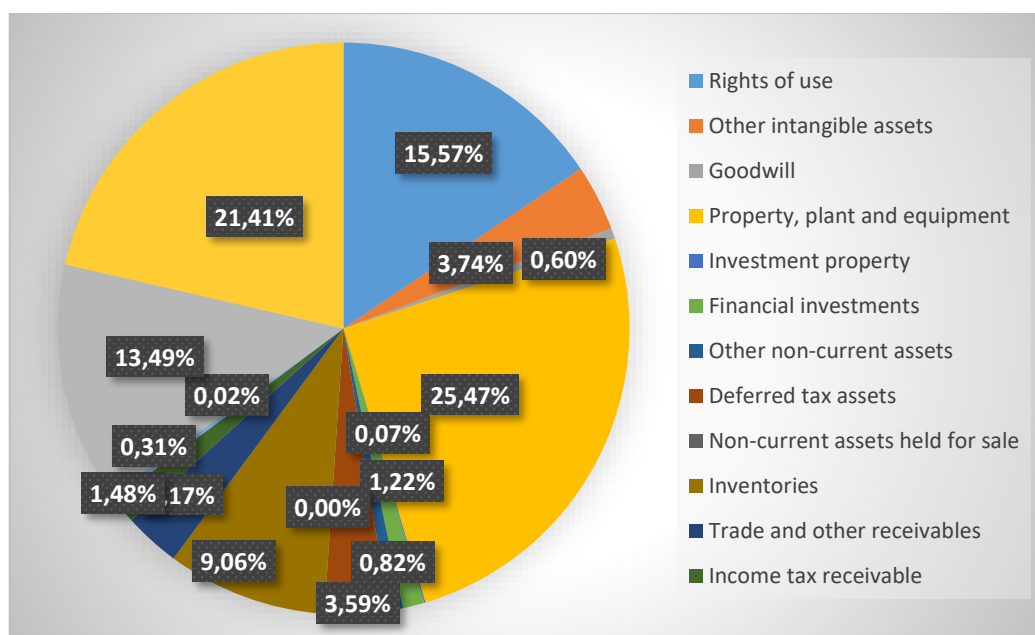


Figure 1: Distribution of Inditex's assets in 2023
source: Author's own edition

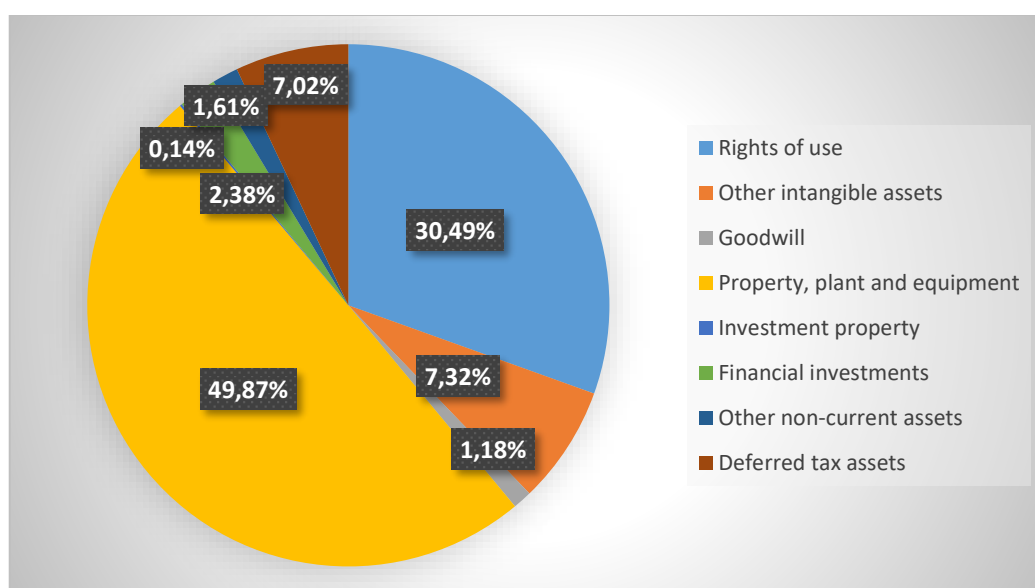


Figure 2: Distribution of Inditex's fixed assets in 2023
source: Author's own edition

Gap also determines at the beginning whether a long-term contractual obligation is a lease. The majority of operating leases relate to the company's commercial premises. These operating leases expire at various dates through fiscal year 2047 (The Gap Inc., 2024). So, in essence, the Gap leases commercial premises, that it reports as operating leases and as fixed assets.

In 2023, the value of operating lease assets was 3.115 million USD (The Gap Inc., 2024), which is 28,21% of total assets (Figure 3), while operating leases accounted for almost half of fixed assets, 46,85% (Figure 4).

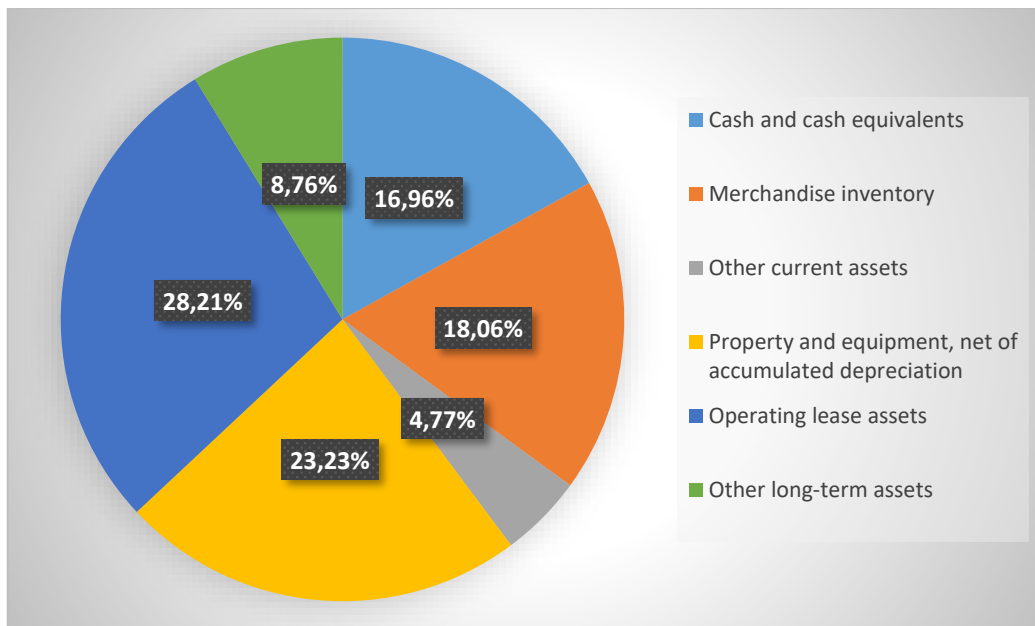


Figure 3: Breakdown of the Gap's assets in 2023
source: Author's own edition

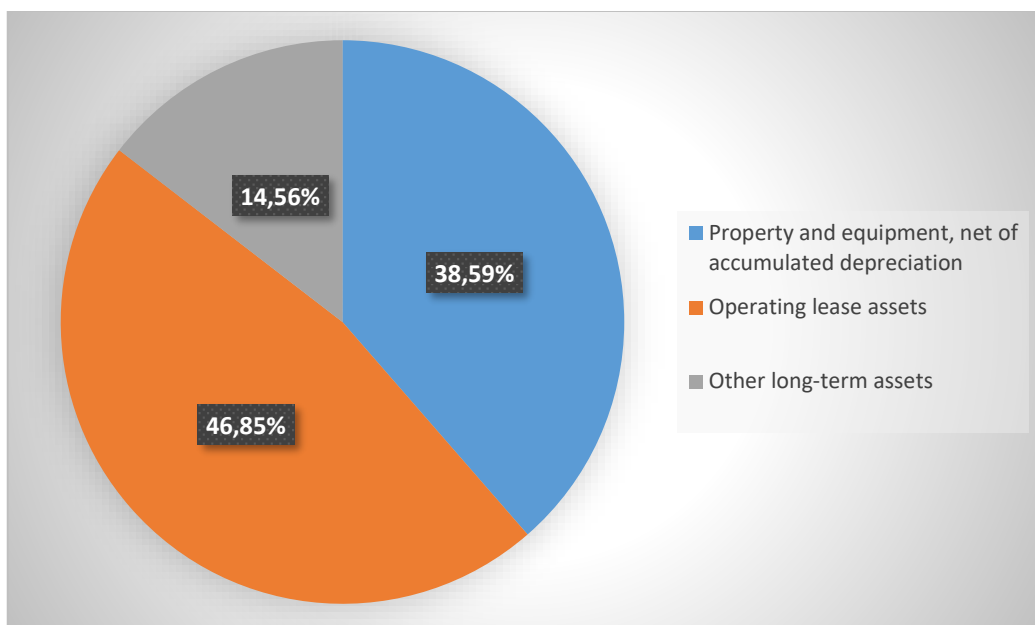


Figure 4: Breakdown of the Gap's fixed assets in 2023
source: Author's own edition

In numerical terms, approximately 0,5 million square meters of corporate office space is leased in San Francisco, California, New York, Albuquerque, New Mexico, Hyderabad and India. Approximately 0,5 million square feet of distribution space is leased in Phoenix, Arizona, Erlanger, Hebron, and Kentucky. Operating lease costs are recognized over the estimated lease term, which includes options to extend the lease term, which are reasonably certain to be exercised, from the time the property is taken possession of by the lessor, which generally includes the construction period prior to the opening of the store. When the fixed rent of a lease is predetermined or covers a fixed asset allocation, the related operating lease expense is recognized on a linear basis over the lease term (The Gap Inc., 2024).

The Gap does not report leases under construction as operating lease assets on the balance sheet, as these assets do not fall under ASC 842, and therefore increase the value of property and equipment (The Gap Inc., 2024).

million USD	2019	2020	2021	2022	2023
Property and equipment, net of accumulated depreciation	3.122	2.841	3.037	2.688	2.566
Property and equipment, at cost	8.961	8.449	8.108	7.525	7.440
Leasehold improvements	2.923	2.627	2.487	2.270	2.197

Table 2: Gap's leased assets under construction 2019-2023

source: Author's own edition

In the second table, we have illustrated the assets under construction that Gap has leased, has not reported as operating lease assets, but also has increased the value of property and equipment on the balance sheet, as assets under construction are not yet within the scope of leases under ASC 842. The value of these assets was 2.923 million USD in 2019 (The Gap Inc., 2020), 2.627 million USD in 2020, 2.487 million USD in 2021 (The Gap Inc., 2022), 2.270 million USD in 2022, and 2.197 million USD in 2023 (The Gap Inc., 2024).

In addition to the above, KPMG cites the following differences in the leases recognized in the balance sheet:

- under IFRS 16, lessees may elect not to recognize leases of low-value assets even if such leases are material in the aggregate,
- in contrast, under U.S. GAAP 842, there is no exemption for leases of small assets (KPMG).

An underlying asset can only be of low-value if:

- the lessee can benefit from the use of the underlying asset, either alone or in combination with other resources readily available to the lessee;
- the underlying asset is not highly dependent on, or substantially related to, other assets (IFRS Foundation, 2024).

A lease of an asset is not a lease of a low-value asset if its nature is such that the asset is not typically of low-value when used as new. For example, a lease of a car is not a lease of a low-value asset, because a new car is not typically of low-value (IFRS Foundation, 2024).

If the lessee subleases an asset or expects to sublease an asset, the head lease is not a lease of a low-value asset. Low-value underlying assets may include, for example, tablets and computers, small office furniture and telephones (IFRS Foundation, 2024).

The general benchmark (not a formal threshold) for low-value is a new asset of around 5.000 USD or less, but asset value measurements should remain consistent across entities of different sizes (IFRS Community, 2025).

Inditex applies an exemption for leases where the asset is considered to be low-value. For these contracts, lease payments are recognized as operating expenses over the term of the contract. It is also important to highlight that the expenses of leases for which the low-value exemption has been applied are not significant (Inditex Group, 2024).

In the fifth figure, we have illustrated the operating expenses of Inditex, its content between 2019 and 2023. The figure also clearly shows, that the leased assets for which the company applies the low-value exemption are very low, as 2-10% of operating expenses were of this type of expense in the 2019-2023 timeframe.

Inditex's expenses on small value leased assets was as follows: 695 million EUR in 2019 (Inditex Group, 2020), 181 million EUR in 2020 (Inditex Group, 2022), 519 million EUR in 2021 (Inditex

Group, 2022), 859 million EUR in 2022 (Inditex Group, 2024) and 989 million EUR in 2023 (Inditex Group, 2024).

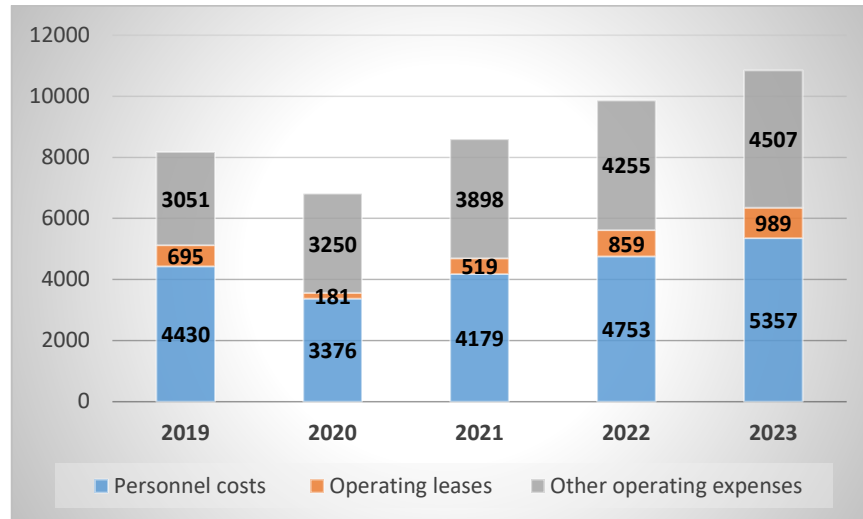


Figure 5: Breakdown of Inditex’s operating expenses in million EUR between 2019-2023 source: Author’s own edition

The Gap does not mention small leased assets at all in its 2023 report, as this is not relevant under Standard 842.

The next difference between the two standards is the classification of leases. Under IFRS, the lessee uses a single balance sheet lease accounting model, whereas under U.S. GAAP there are two balance sheet lease accounting models: finance and operating leases. The classification of the lease affects the subsequent measurement of the right-of-use asset, the lease expense, and the income statement and cash flow statement (KPMG). We have illustrated this in Table 3. Essentially, companies that report under IFRS have one set of accounts for the balance sheet, whereas companies that follow the US standard report finance or operating leases on their balance sheet.

IFRS 16	ASC 842	
balance sheet lease accounting	balance sheet lease accounting	
right-of-use asset	finance lease	operating lease

Table 3: Lease classification
source: KPMG, Author’s own edition

In the Inditex company’s balance sheet, assets subject to leases are reported only under “right-of-use assets” (Inditex Group, 2024). In contrast, the Gap company, following the US leasing standard, reports its assets subject to operating leases under “operating lease assets”, and had no finance leases in 2023 (The Gap Inc., 2024).

IFRS 16 requires the lessee to recognize a right-of-use asset in the balance sheet at the inception of the lease. This right-of-use asset represents the right to use the asset for the duration of the lease. At the same time, it should also recognize a lease liability, that reflects the present value of future lease payments. A right-of-use asset may be an operating lease or a finance lease. The current U.S. GAAP standard (ASC 842) also requires the recognition of leases on the balance sheet. However, U.S. GAAP distinguishes between operating and finance leases and applies different accounting treatment to them. For operating leases, U.S. GAAP uses the designation “operating lease assets” on the balance sheet. There is a difference between accounting for a finance lease and an operating lease. In a finance lease, the lessee charges depreciation expense on the leased asset, whereas in an operating lease, since the asset is not transferred, but only leased, the lessor charges depreciation. So, what is important to

note is that in the case of a finance lease, two costs are recognized in the profit and loss account: the interest cost of the leased asset and the amortization cost of the leased asset, whereas in the case of an operating lease, we are talking only about the lease cost, which is essentially the interest cost of the leased asset.

The next aspect is the qualification of the revaluation of leases with variable payments based on an index or interest rate. IFRS 16 requires a lessee to remeasure a lease liability for changes in variable lease payments based on an index or interest rate when there is a change in the cash flows required by the lease. In contrast, for entities using U.S. GAAP 842, a change in an index or interest rate is not a remeasurement event. The lessee remeasures the variable lease payments against an index or interest rate only if the lease payments need to be remeasured for some other reason (e.g. a change in the lease term) (KPMG).

Inditex will reassess the lease obligation (and make the appropriate adjustment to the right-of-use) in the following cases:

- if there is a significant change in the lease term or circumstances that results in a change in the assessment of the exercise of the renewal option, in which case the lease liability is measured by discounting the revised payments at the revised discount rate,
- if a change in future lease payments results in a change in an indexation guarantee, in which case the lease obligation is measured by discounting the changed payments at the discount rate before the change; or
- if the lease is modified and the modification is not accounted for as a separate lease, in which case the lease liability is remeasured by discounting the modified lease payments at the modified discount rate (Inditex Group, 2024).

The Gap's fiscal year 2023 non-cash operating lease asset activity, net of revaluations and adjustments, was 544 million EUR, which was recorded as other long-term liabilities and includes long-term income tax liabilities, permanent store closures and lease retirements (The Gap Inc, 2024). Thus, the company revalued its operating lease assets when some of the stores that were leased, were closed.

There is also a significant difference between IFRS and U.S. GAAP standards for discount rates. For statements prepared under IFRS, the lessee's discount rate for a lease is the rate implicit in the lease or, if that rate cannot be clearly determined, the lessee's incremental borrowing rate. IFRS do not provide different guidance for private companies, so all lessees should use the discount rate guidance in IFRS 16, whereas U.S. GAAP states that if the rate implicit in the lease is not readily determinable, ASC 842 allows a private corporate lessee to use a risk-free discount rate. Expediency can be selected based on the class of the underlying asset. However, there are some statements prepared under U.S. GAAP standards where the company does not take advantage of the option in ASC 842 (KPMG). Most notably, companies that prepare double-entry financial statements do not take advantage of this option because of the need to ensure greater consistency between U.S. GAAP and IFRS accounting. Inditex will determine the present value of the lease obligation using the rate implicit in the lease, and if this cannot be easily determined, the lessee will use the incremental debt rate. Given the difficulty in determining the implicit interest rate for individual leases, the interest rate calculated by market, maturity and currency based on the type of asset leased is used (Inditex Group, 2024).

Gap determines the estimated fair value of its operating lease assets by comparing discounted contractual rental payments with estimated market rental rates using available valuation techniques. It carries its lease obligations at the present value of the unpaid lease payments discounted at the interest rate that it would have to pay if it had borrowed for a similar term against collateral. Because its lease contracts do not contain an implicit interest rate, it uses an incremental borrowing rate based on information available at the inception date to determine the present value of lease payments (The Gap Inc., 2024). Thus, the Gap does not take advantage of the U.S. GAAP standard's advantages for leases, that if there is no implicit interest rate specified in the contract, it uses a borrowing rate rather than a risk-free rate.

There are also significant differences between the two standards in terms of the modifications to the lease. Under IFRS, when a modification reduces the scope of the lease, a gain or loss is recognized

for the difference between the reduction in the lease liability and the proportionate reduction in the right-of-use asset, whereas under U.S. GAAP, a modification that reduces the lease term is not recognized as a reduction in the scope of the lease, and therefore no gain or loss is recognized (KPMG).

In Inditex's consolidated income statement, financial expenses related to leases are shown separately, which also shows that if there is a change in the lease, the company recognizes a cost or income. In addition, the company's 2023 annual report also shows that the financial result in the consolidated income statement includes exchange gains and/or losses on leasing liabilities. These can be observed in the fourth table.

million EUR	2019	2020	2021	2022	2023
Financial results	-152	-140	-142	-214	-11
Finance income	31	6	4	85	380
Foreign exchange gains	16	36	43	47	17
Lease foreign exchange gains	1	0	1	0	9
Total income	48	42	48	132	406
Finance costs	14	8	21	28	75
Lease finance costs	142	120	92	116	196
Foreign exchange losses	39	43	71	195	142
Lease foreign exchange losses	5	11	6	7	4
Total expenses	200	182	190	346	417

Table 4: Inditex financial results 2019-2023

source: Author's own edition

Based on the above table, Inditex recorded a financial loss in each year between 2019 and 2023, largely due to the increase in lease financing costs and in the foreign exchange losses.

At Gap, if an operating lease asset is impaired, the remaining operating lease asset is amortized on a linear basis over the remaining lease term (The Gap Inc., 2024). As shown in Table five, no gain or loss is recognized, but the monthly amortization is adjusted. In addition to clearly describing that the company changes the value of the lease and its amortization in the event of a lease change, the income statement clearly shows that no gain and/or loss is recognized for lease changes.

million USD	2019	2020	2021	2022	2023
Depreciation and amortization	557	507	504	540	522
Impairment of operating lease assets (correction)	239	391	8	33	4

Table 5: Gap operating lease assets impairment adjustment 2019-2023

source: Author's own edition

The Gap has adjusted the impairment of operating lease assets by 239 million USD in 2019, 391 million USD in 2020, 8 million USD in 2021 (The Gap Inc., 2022), 33 million USD in 2022 and 4 million USD in 2023 (The Gap Inc., 2024).

When sale-leaseback transactions are considered, there is a difference between the two standards, as IFRS states that the seller-lessee measures the right-of-use asset at the portion of the previous carrying amount of the underlying asset that is retained. Only the amount of gain or loss relating to the rights transferred to the buyer-lessor is recognized. The recognized gain or loss is adjusted for conditions outside the market. And under U.S. GAAP, the seller-lessee values the right-of-use asset in the same way as any other right-of-use asset in a lease. A gain or loss is recognized for the difference between the sale proceeds and the carrying amount of the underlying asset (KPMG).

Inditex's policy states that after the commencement date, the lease liability is measured by increasing the carrying amount to reflect the interest on the lease liability and decreasing the carrying amount to reflect the lease payments (Inditex Group, 2024). So, the company does not recognize a gain or loss, but changes the carrying amount.

As of 28th January 2023, the Gap's ABL debt was 350 million USD and was included in long-term debt on the consolidated balance sheet. The ABL credit facility limits, among other things, the company's leaseback transactions, and therefore the company had no such leases (The Gap Inc., 2024).

Traditional business financing, in which lenders primarily value the cash flow of the business, works well for many companies. But while cash flow lending depends on the strength and stability of a company's cash flow, some businesses may be eligible for additional borrowing based on the assets they own. For them, the alternative known as asset-based lending, or ABL, may be preferable. With ABL, a wide range of company assets, from receivables to real estate to brand names and intellectual property, can serve as collateral, freeing up the necessary capital (Bank of America).

The ABL facility contains covenants that limit, in certain circumstances:

- the granting of liens;
- the sale or other disposition of assets;
- entering into leaseback transactions;
- making investments in certain subsidiaries;
- pay dividends, make distributions or repurchase shares; and
- merge with, and merge into, or sell substantially all of their assets to, another entity (The Gap Inc., 2024).

The ABL facility is secured by the assets of the company, including inventories, certain receivables and a first lien on related assets. Since a leaseback is a transaction in which a company sells its assets to a leasing company and then leases them back, and Asset-Based Lending (ABL) is a credit facility in which the amount of the loan depends on the value of the company's assets, this credit facility limits the leaseback transactions.

CONCLUSION

As a result of this study, we can say that there are significant differences between IFRS and U.S. GAAP leasing regulations, which we have illustrated in the following table.

	IFRS 16	ASC 842
1.	property, plant and equipment intangible assets inventories assets under construction	property, plant and equipment - - -

2.	recognition exemption (leases): low-value assets	no exemption for leasing low-value assets
3.	a single balance sheet lease accounting model	there are two types of balance sheet lease accounting: 1. finance leasing 2. operating leasing
4.	remeasurement: required CF change	No reassessment for index/rate changes remeasure: e.g. lease term change
5.	rate implicit in the lease incremental borrowing rate	rate implicit in the lease risk-free discount rate
6.	profit/loss recognition	no gain/loss is recognized
7.	book value recognition profit/loss on rights transferred to the lessor	like any other lease profit/loss = sales - book value

Table 6: Differences between IFRS 16 and ASC 842 based on the study

source: Author's own edition

We were able to illustrate seven of the 10 key differences identified by KPMG using Inditex and Gap as examples. The first difference between the two standards is that IFRS 16 covers many more assets than ASC 842, because IFRS 16 not only allows leases of property, plant and equipment to be recognized in the accounts (as under ASC 842), but also includes leases of intangible assets, inventories and assets under construction.

The second major difference between the two standards is that companies that prepare their accounts in accordance with IFRS can choose not to recognize low-value leased assets as leases on their balance sheet, but entities that consider US standards to be authoritative do not have this option.

The third difference, which is confirmed by the study, is that under IFRS 16, companies do not have to show operating and finance leases separately in the balance sheet, but show them under one item. In contrast, the U.S. GAAP standard for leases states that both types of leases should be separately disclosed on the balance sheet.

There is also a difference between IFRS and U.S. GAAP leasing standards in terms of the classification of leases with variable payments based on an index or interest rate as leases are always revalued under IFRS 16 if there is any change in the required cash flows. In contrast, ASC 842 states that lease payments do not need to be remeasured because of a change in an index or interest rate, but are required to be remeasured when, for example, the term of the lease changes.

The fifth difference relates to the discount rate: under IFRS 16, if the lease agreement does not include an implicit interest rate, the company must use an incremental borrowing rate, whereas under ASC 842 it can choose a risk-free discount rate.

There is a significant difference between the two standards when there is a change in a lease, because in IFRS statements, a gain or loss is recognized for the change, but under U.S. GAAP, no gain or loss is recognized, but instead, for example, the Gap changed its monthly amortization expense.

The last difference in the study relates to leasing back. IFRS 16 states that leaseback transactions should be recognized at carrying amount and that only gains and losses on the transferred rights can be recognized. Under ASC 842, this changes as the measurement are similar to any other lease, but the gain or loss is calculated by these entities by subtracting the carrying amount from the proceeds of the sale.

So, this short study shows how significant differences can appear between two companies that prepare their accounts according to different standards.

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AUTHOR'S ADDRESS:

Antónia Zakariás: Hungarian University of Agriculture and Life Sciences, Doctoral School of Economic and Regional Sciences, e-mail: zakarias.antonio@yahoo.com

Rita Koroseczné Pavlin: Hungarian University of Agriculture and Life Sciences, Institute of Rural Development and Sustainable Economy; Kaposvár, Hungary, koroseczne.pavlin.rita@uni-mate.hu

THE IMPACT OF INDUSTRY 4.0 ON THE MANAGEMENT ACCOUNTING IN CASE OF CROPS

RITA KOROSZCZYNÉ PAVLIN - VERONIKA GÁL – IRÉN WICKERT

ABSTRACT

In recent years, arable crop production has undergone significant technological transformation. The advancement of technology has enabled the collection of vast datasets, the analysis of which allows management accounting to provide valuable insights into the profitability of specific agricultural plots. This study explores how these data sets can be utilized in both managerial and financial accounting. Using data from a Hungarian small enterprise, we demonstrate which cost elements can be more precisely attributed to specific parcels. Our findings suggest that in financial accounting, the valuation of work-in-progress inventories becomes more accurate through the use of data generated by precision agriculture tools. Additionally, in management accounting, cost allocation becomes more refined during cost calculation, allowing for parcel-level profitability assessments that support decision-making. Moreover, the data derived from Agriculture 4.0 are not only beneficial at the micro-level but may also inform macro-level policy, such as replacing the controversial "golden crown" land valuation metric with a parcel-based profitability evaluation model. Our study was funded by the European Commission through the Horizon Europe programme (Project Number: 101071317) under the Cooperating for excellence and impact in research and innovation EUDRES Entrenovators project.

KEY WORDS

management accounting, cost of crops, profitability of the land

1. INTRODUCTION

Digitalization has become pervasive in all aspects of life, significantly impacting administrative processes as well. The latest developments in digitalization and the use of artificial intelligence have now extended to accounting processes, including controlling and even auditing activities (Hoschek & Szóka, 2024). Industry 4.0 primarily affects the production sector, and thus plays a major role in agriculture, resulting in changes in production processes.

When analyzing risks in agriculture, exposure to weather and global warming typically come to mind first. However, from an economic standpoint, a more significant factor today is the changing structure of the labor market. Previously, agricultural labor was predominantly supplied by rural residents, often in regions characterized by lower levels of education. Today, the agricultural sector increasingly demands skilled labor capable of keeping up with technological changes. Modern agricultural machinery is equipped with advanced, computer-controlled technology, requiring operators with at least basic digital literacy.

As a result, crop production today is characterized by a smaller but more skilled and better-paid workforce than two decades ago. This shift is largely due to technological advancements, as modern machines can process far more land per unit of time than in the past (Nagy, 2022). Consequently, the

capital-to-labor ratio has tilted in favor of capital, increasing the significance of fixed costs in accounting records.

Modern, results-oriented farming necessitates continuous monitoring of operational efficiency. One of the most important areas of management accounting is cost calculation. Analyzing costs is indispensable for strategic planning, business decision-making, and effective management. This analysis relies on cost tracking and cost calculation (Ferge, 2011).

There is no direct statutory regulation governing cost calculation as a method. Hungarian accounting law does not mandate cost calculation, but it requires that self-manufactured assets (including inventories) be recorded at direct production cost. Determining this direct cost essentially constitutes cost calculation. According to §51 of Act C of 2000 on Accounting, the cost of production includes expenses that:

- arise directly during production, installation, expansion, transformation, or restoration of an asset (product),
- are demonstrably closely related to production, and
- can be allocated to the asset (product) using appropriate indicators or characteristics.

Cost calculation thus refers to determining the planned or actual direct, technological, limited, or full cost of a product or activity (service). Enterprises must decide (and specify in their accounting policy) how and when to determine the cost of self-manufactured assets. For larger companies, this is strongly influenced by §14(7) of the Accounting Act. It mandates that the direct cost of self-manufactured products and provided services must be determined using a retrospective calculation method defined in an internal regulation on cost calculation if the net sales revenue, after deducting the cost of goods sold and mediated services, exceeds HUF 4 billion or total costs exceed HUF 2 billion in any fiscal year. Once this threshold is met, the obligation continues regardless of future values.

Cost determination under §51 of the Hungarian Accounting Act may be based on production cost, average (weighted) direct cost, or FIFO (first-in-first-out). Direct cost may be determined retrospectively or using standard costing. For work-in-progress, the standard direct cost can be estimated proportionally from the cost of the finished product, based on the stage of completion. When preparing simplified financial statements, inventories may be valued at their estimated selling price minus foreseeable additional costs and calculated profit; these additional costs can also be proportionally estimated based on completion rates (Bosnyák et al., 2010).

1.1 The Specialities of Cost in Agriculture

Due to the specific characteristics of agricultural activities, cost cannot be calculated using normative costing methods. Therefore, in the case of agricultural crops, products, and animal products, cost determination can only be performed through retrospective (post-calculation) methods. There is no legally mandated costing scheme—only recommended approaches exist.

In agriculture, valuation based on direct cost is predominant, as the products are primarily biological in origin (i.e., living), which limits the range of applicable cost calculation methods. For example, in the case of work-in-progress, it is permitted to determine the direct cost based on standard costing, proportionally calculated from the finished product's standard direct cost and adjusted for the level of completion. However, such methods are not applicable in the case of a field inventory. While the stage of completion can be precisely determined for an automated industrial product, in the case of a wheat crop on December 31, for instance, such determination can only be speculative. At that point in time, it is impossible to know exactly which operations will be required until harvest (e.g., weeding, protection against plant diseases or pests, etc.).

As such, the method of cost determination must rely on post-calculation. This method is particularly suitable for determining the cost of self-manufactured inventories, especially work-in-progress. The accounting policy must specify under which circumstances and to what extent post-calculation will be applied for determining cost (Sabján & Sutus, 2003).

When designing a product costing scheme, it is advisable to separate cost types. With the widespread use of total-cost-based income statements, classical analytical records have been phased out—even though they are fundamental for performing post-calculation. The cornerstone of accurate post-calculation is precise cost allocation. The primacy of direct costs determines the effectiveness of post-calculation. A recurring challenge is the allocation of maintenance and auxiliary operational costs. These must first be collected and then allocated to the respective product based on actual usage.

Companies require detailed analytics to support cost allocation. This requires that the performance of maintenance and auxiliary operations be continuously recorded according to usage. The allocation of auxiliary operational costs in agriculture is particularly complex, especially in crop production, where certain assumptions may lead to inaccurate results. A method published by the Ministry of Agriculture and Food in 1982 proposed using the concept of a “standard hectare” as the basis of cost allocation. A standard hectare is equivalent to one hectare of flat, medium-textured soil ploughed to a medium depth. This standard value is then corrected based on the actual characteristics of the land in question (MÉM, 1982).

Today, however, agricultural machinery equipped with digital technology is capable of recording data per plot (parcel), such as the number of machine hours used and the quantity of input materials applied. Our study investigates how this digital revolution is changing cost accounting in the context of arable crop production.

2. MATERIAL AND METHODS

In our study, we examine the scope of data available for accounting systems through the case of a small enterprise. This agricultural business is engaged in arable crop production and has recently upgraded its machinery with the help of support programs aimed at fostering digital transition in agriculture. The company cultivates approximately 2,000 hectares of land in Somogy County, Hungary.

Currently, it collects and analyzes production-related data from 199 individual plots. Data processing is carried out using the PGR system implemented by the enterprise. Accordingly, the visual outputs and figures presented in this study are generated by this system.

3. RESULTS AND DISCUSSION

With the advent of digital technology, modern agricultural machinery has become capable of storing data with GPS-level accuracy. This development enables more precise cost calculation for agricultural work-in-progress. The potential of big data makes it feasible to allocate costs at the parcel level. But why is this important for management accounting and decision-making?

Agricultural enterprises typically operate on geographically dispersed plots with varying topographical features. Because of these differences, it is evident that the cost per hectare will also vary across fields. Without digital technology, these cost differences could not be accurately tracked. Even today, we cannot claim to have all the necessary data, as many enterprises have not yet fully

replaced their machinery. If any operational phase lacks digital data capture, estimated values must be inserted, compromising the precision of the calculation.

To perform parcel-level cost accounting, each field operation must be executed using equipment capable of digital data collection. Thanks to EU agricultural infrastructure support, many small enterprises in Hungary and Romania have partially modernized their machinery for precision farming, facilitating a digital transformation in recent years.

Our study presents the example of an agricultural enterprise in Somogy County, Hungary, to demonstrate how data is collected through advanced technology obtained via such funding.

Agricultural drones can generate topographical maps for each parcel, thereby visualizing terrain variations, as shown in **Figure 1**. While the printed version of the map uses grayscale for formatting purposes, in reality, these maps are color-coded from red to green, offering a more vivid and informative display. Since our analysis does not require exact GPS coordinates, grayscale is sufficient for illustrating differences.

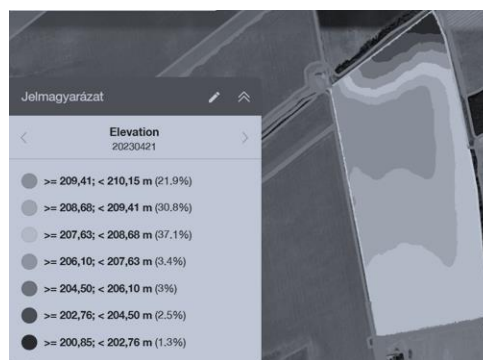


Figure 1: Elevation Map of a Parcel (Above Sea Level)

Source: Output generated based on the company's data

Using the precision farming system, the agronomist designs the seeding plan according to the topographical characteristics shown in Figure 1. In addition to elevation, the layout must also consider field roads and forest strips adjacent to the parcel. The resulting seeding plan is shown in the next figure.



Figure 2: GPS-based Seeding Map of a Parcel

Source: Output generated based on the company's data

As illustrated in **Figure 2**, lower seeding density (lighter shades) is used along the parcel's edges, while the denser seeding (darker shades) appears in the lower central section. This area lies at a lower

elevation, and therefore rainfall and leaching fertilizers or pesticides tend to accumulate here. As a result, higher seeding density is more likely to be productive in this section.

Fertilizer application is also planned using a similar approach. During plant protection operations, agricultural drones first assess the plant condition. Based on the analysis, pesticides are applied in varying doses per GPS coordinate. This targeted application lies at the heart of precision agriculture, which significantly reduces unnecessary pesticide and fertilizer use. This has considerable environmental implications from both societal and sustainability perspectives. At the enterprise level, it also translates to a substantial reduction in raw material costs.

It's worth emphasizing that enterprises in arable farming typically engage in forward contracts for grain sales. Thus, selling prices are often fixed in advance. To realize profit, companies must therefore focus on maximizing yield while reducing costs. As discussed, increased yield can be achieved through well-designed seeding plans and targeted crop protection.

Naturally, environmental impacts cannot be eliminated in arable crop production. However, for the purposes of this study, we assume that the field in question is not affected by drought, which has been common in recent years. While the selling price cannot be influenced, yield (i.e., quantity) can be optimized through targeted application. Similarly, cost reduction depends on avoiding purchases and applications of fertilizer or pesticide that do not contribute to production. This in turn lowers raw material costs.

Therefore, precision agriculture clearly contributes to cost reduction, which becomes evident in financial accounting through the income statement. In financial accounting, year-end inventory valuation is especially critical, particularly the valuation of self-produced inventories. One of the most complex tasks for agricultural businesses is determining the value of work-in-progress. The next section explores its significance in greater depth.

3.1 WORK-IN-PROGRESS IN AGRICULTURE

Work-in-progress refers to products that have already undergone at least one substantial production operation but have not yet completed the full production process and therefore cannot be recognized as finished self-produced inventories.

In agriculture, typical forms of work-in-progress include (Adorján et al., 2017):

- **Crop production work-in-progress:** autumn sowing, soil preparation for spring sowing, planting of perennial crops, organic fertilization, establishment of meadows and pastures, etc.
- **Livestock work-in-progress:** eggs in incubation
- **Other agricultural work-in-progress:** seeds undergoing processing in seed plants, based on the level of completion

The most common form of agricultural work-in-progress is **field inventory**. This category includes expenses incurred in the current year in preparation for crop production in the following year(s) (Musinszki, 2012).

According to §51 of the Accounting Act, the acquisition cost of self-produced inventories includes all production costs incurred from the start to the end of the production process. A particular feature of agriculture is that the production cycle for some crops spans more than one year, requiring inter-period cost allocation. The production cost of work-in-progress reflects the value included in inventory.

This raises the question: **What is the value of work-in-progress?** With accurate cost tracking (analytics), direct costs can be precisely identified. Maintenance and auxiliary operational costs can

be allocated using appropriate indicators, enabling accounting to produce a correct financial outcome. However, the actual value and eventual recovery of the field inventory will only be confirmed at harvest.

Several **risk factors** may affect the market value of the calculated acquisition cost (AKI, 2009), such as:

- topographical conditions and soil characteristics of the location
- sustainability of the applied production technology (e.g., nutrient supply)
- climate conditions (e.g., temperature, precipitation)
- animal pests
- plant diseases

Considering these environmental risks, it may be necessary to reconsider the applied valuation method. According to the **principle of prudence**, assets must not be overvalued, as this could result in the recognition of unrealized profits (Ormos, 2018). The value of self-produced inventories (including field inventories) is a factor that directly influences profit. While these inventories cannot be written up, a **write-down** may be justified in light of the mentioned risk factors.

An important accounting question is whether damage caused by these risks qualifies as a **casualty loss** or rather a **loss of value**. If it qualifies as a typical agricultural casualty loss, its usual amount is recorded under other operating expenses. According to §56(2) of the Accounting Act, the acquisition cost of self-produced inventories must be reduced in the balance sheet if:

- the inventory does not comply with applicable regulations or its intended use,
- it is damaged,
- its utilization or sale is doubtful, or
- it has become redundant.

The inventory's value must be written down to reflect its **usable value** at the time of balance sheet preparation.

3.2 PARCEL-LEVEL DATA AND MANAGERIAL DECISION SUPPORT

Beyond financial accounting, parcel-level information derived from precision farming is highly valuable for **management accounting** and for informing **managerial decisions**. With the data provided by precision agriculture technologies, we can determine the following for each parcel:

- **Exact material usage** (seeds, fertilizers, pesticides)
- **Time spent working the land**, measured in labor hours
- **Amount of fuel used** during operations, measured in liters
- **Harvested yield**, measured in tons

The last point is crucial because the yields from nearby parcels are often collected together and transported in bulk by trucks, meaning that the recorded quantity at the warehouse reflects an aggregated total from several plots.

Fuel consumption is a particularly significant cost factor in arable farming and therefore deserves detailed analysis. Thanks to digital data, we can now separate fuel usage into two distinct phases:

- **Transport fuel**: from the central site to the field
- **Operational fuel**: consumed during fieldwork

By refining cost and revenue calculations at the **parcel level**, it becomes possible to determine each parcel's **contribution margin**. This data is extremely valuable to management because it supports strategic decisions such as **ranking rented land parcels by profitability**.

Currently, the only official valuation measure for arable land in Hungary is the "**golden crown**" (**aranykorona**) system. This value is often used as the basis for:

- determining **rental prices** for farmland,
- **credit evaluation**, and
- **tax assessments**.

However, research by Szabó et al. (2018) and others confirms only a **weak positive correlation** between the golden crown value and the actual market price of farmland. Farmers and business owners often encounter discrepancies between this indicator and the **real income-generating capacity** or **economic value** of a plot.

Thanks to digital technology, however, a **modern, data-driven valuation model** could now be developed, one that surpasses the outdated golden crown system and reflects **actual profitability** and **economic potential** based on real-time operational data.

4. CONCLUSION

In this study, we examined how Agriculture 4.0 impacts accounting information systems and how these systems have evolved as a result. In the context of financial accounting, inventory valuation is of great importance for production enterprises, particularly for those operating in agriculture.

We found that the availability of big data supports the accurate valuation of work-in-progress inventories—especially **field inventories**—within the domain of financial accounting. At the same time, the **digitalization of machinery** has brought significant advantages for **management accounting** as well. It enables more precise cost calculations and the assessment of **profitability at the parcel level**.

The data generated through precision farming further allows for the development of **comparative analyses** between different parcels in terms of profitability. This opens the door to designing a **new land valuation model** that could serve as a more accurate and economically meaningful alternative to the currently used **golden crown** system.

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AUTHOR'S ADDRESS:

Rita Koroseczné Pavlin: Hungarian University of Agriculture and Life Sciences, Institute of Rural Development and Sustainable Economy; Kaposvár, Hungary, koroseczne.pavlin.rita@uni-mate.hu

Veronika Gál: Hungarian University of Agriculture and Life Sciences, Institute of Rural Development and Sustainable Economy; Kaposvár, Hungary, gal.veronika.alexandra@uni-mate.hu

Irén Wickert: Hungarian University of Agriculture and Life Sciences, Institute of Rural Development and Sustainable Economy; Kaposvár, Hungary, wickert.iren@uni-mate.hu

POSSIBILITIES OF ARTIFICIAL INTELLIGENCE (AI) IN PRODUCT DEVELOPMENT: IMPLICATIONS FOR MARKETING, COMMERCE, AND ECONOMICS

SZŰCS RÓBERT SÁNDOR - FÖLDI KATA

ABSTRACT

This paper explores the transformative role of Artificial Intelligence (AI) in product development, marketing, and commerce. AI technologies enable personalized marketing strategies, enhance customer engagement, and optimize sales through advanced analytics and recommendation systems. In product development, AI accelerates innovation cycles, reduces costs, and improves efficiency by automating tasks and augmenting human creativity. Despite these benefits, challenges such as high implementation costs, data privacy concerns, and skill shortages hinder widespread adoption. The study highlights real-world examples of AI-driven product innovation and discusses AI integration's broader economic and sustainable impacts.

Keywords: Artificial Intelligence, Product Development, Marketing Strategies, Personalization, Innovation, Economic Impact

1. AI IN MARKETING AND CONSUMER ENGAGEMENT

AI technologies enable highly personalized marketing by tailoring advertisements to individual consumer preferences, improving relevance and conversion (Lee et al., 2024). Generative AI can create individualized content based on minimal data, boosting customer engagement by delivering the right message at the right time (Lee et al., 2024). AI-driven campaigns adapt to consumer behavior; studies show that AI-generated ads are perceived differently across demographic groups, underscoring the need to align content with audience expectations (Nesterenko & Olefirenko, 2023). AI is also transforming the customer experience. Incorporating AI features into products and services allows more interactive and responsive consumer interactions. New research finds that AI elements in products significantly alter how customers perceive and engage with offerings, which means firms must update their approaches to managing customer satisfaction (Wang et al., 2024). Notably, AI-driven marketing strategies can boost interest in sustainable products while improving efficiency, as seen in retail where AI increases engagement with eco-friendly offerings (Salhab et al., 2025). AI enables marketers to deliver more engaging, tailored experiences, strengthening customer engagement and brand loyalty (Business Wire, 2025).

2. AI IN COMMERCE AND SALES OPTIMIZATION

AI is boosting sales in commerce through advanced analytics and personalization. In e-commerce, recommendation engines leverage customer data to suggest products tailored to each shopper, improving the shopping experience and conversion rates (Zhang & Xiong, 2024; Wang et al., 2024). AI is also applied in dynamic pricing and demand forecasting, where algorithms adjust prices and predict real-time sales trends to maximize revenue and optimize stock levels. On the operations side, AI enhances supply chain efficiency. Intelligent forecasting helps ensure the right products are stocked at the right time, reducing overstock and waste. AI-driven distribution planning, for instance, can optimize logistics and routing, streamlining deliveries and cutting excess inventory (Salhab et al., 2025). In sum, integrating AI into commerce leads to more innovative pricing, better inventory management, and more effective sales strategies, improving operational efficiency and customer satisfaction.

3. ECONOMIC IMPACT OF AI IN PRODUCT DEVELOPMENT

Adopting AI in product development can significantly lower costs and boost productivity. Early adopters report faster innovation cycles and shorter development timelines from AI use in new product projects (Paliwal et al., 2024). By automating labor-intensive tasks and augmenting human creativity, AI accelerates time-to-market – studies indicate development times can be cut by up to 50% (Zhang et al., 2021). These efficiencies also translate into cost savings, as projects require fewer resources to reach completion. Furthermore, AI analytics help optimize resource allocation by identifying high-potential ideas and reducing the risk of costly project failures (Cooper, 2024). In short, AI allows companies to innovate more efficiently and effectively. These productivity gains can scale up to broader economic benefits. Evidence links greater AI utilization with higher new product success rates and quality improvements (Zhang et al., 2021). This suggests that industries could see higher overall innovation output and productivity as AI adoption grows. However, AI use in product development remains limited – only about 13% of companies have broadly implemented it so far (Cooper, 2024) – so much of the potential economic upside is still untapped.

4. AI-DRIVEN PRODUCT INNOVATION: CASE STUDIES

Real-world examples highlight AI's role in product innovation. One notable case is Coca-Cola's limited-edition Y3000 soda, which was co-created by human designers and AI. Coca-Cola used AI to analyze how consumers envision the future, guiding the creation of a novel “futuristic” flavor for Y3000 (Coca-Cola Company, 2023). This collaboration helped Coca-Cola craft a unique product and marketing story centered on AI innovation. Another example is Hell Energy's “HELL A.I.” energy drink, advertised as the world's first beverage fully developed by artificial intelligence. AI handled the entire development cycle in this case: the system formulated the recipe based on consumer preference data, selecting ingredients and even taste-testing variations without human input (Southey, 2023). The AI then generated several prototype flavors and identified the best one – a fruity blend – marking the first time AI created an energy drink end-to-end (Southey, 2023). These cases show how AI can move beyond assisting humans to generate product ideas and formulations, giving companies new ways to innovate and differentiate their offerings. Other industries are also harnessing AI in product innovation. For instance, IBM and McCormick & Company utilized IBM's AI for product composition to accelerate flavor and food product development. This collaboration created a new line of “ONE” Dish Recipes seasonings, designed to enhance the cooking experience and flavor (McCormick, 2019). P&G uses machine learning algorithms to develop new products that are more effective and environmentally friendly. For example, AI helps in the development of perfumes using the Perfume Development Digital Suite, which creates new fragrances up to fifty times faster. P&G uses AI-based sensors and cameras on the production line for real-time quality control, reducing waste and manual labor. This allows every product to be inspected on the line rather than just sampling. P&G uses AI to analyze consumer behavior and develop personalized solutions. AI helps better understand consumer needs and preferences, aiding in product development (PG 2024, Canino 2024, Dominguez 2024, Michu 2024). In the automotive sector, BMW integrates AI into their product development process. BMW uses AI technologies like AIQX and Car2X to automate and optimize manufacturing processes. Car2X enables real-time communication between vehicles and manufacturing systems, while AIQX performs acoustic and visual quality checks. AI-powered cameras assist in quality control on the production line, detecting defects that human inspectors might miss. BMW utilizes AI to accelerate product development, such as simulating and predicting vehicle performance. This allows developers to test new technologies more quickly and efficiently. (BMW Group, 2023, Estes, 2024, Filipsson 2025). Additionally, Adidas, in collaboration with Carbon, developed the Futurecraft 4D shoes using AI to analyze years of running data. This helped design a midsole that offers optimal performance tailored to runners' movements, significantly reducing time to market. Adidas uses AI to develop new products rapidly. For example, AI helps the company design new shoes and apparel in days, compared to weeks or months previously (Nexttech3D 2023,

Thomas 2023). Alibaba uses AI to predict customer purchases and generate product descriptions, enhancing its ability to meet consumer demands efficiently. Amazon, Google, Apple, Baidu, Facebook, Microsoft, and Tencent have integrated AI into their corporate processes. (Marr, 2025). These examples demonstrate AI's extensive capability to assist and drive the product development process, providing companies with new ways to innovate and differentiate their offerings.

5. CHALLENGES AND LIMITATIONS OF AI ADOPTION IN PRODUCT DEVELOPMENT

Despite its promise, significant barriers exist to implementing AI in product development. High implementation costs and uncertain returns make firms hesitant to invest (Cooper, 2025). There is often no compelling business case, or companies lack the necessary skills and organizational readiness to integrate AI (Cooper, 2025). Smaller enterprises usually lack resources and risk tolerance; many cite high costs, cybersecurity fears, and past failures as reasons for the slow uptake of AI (Cooper, 2025). Data and ethical issues further limit AI adoption. Effective AI systems require large, quality datasets, but using extensive data can raise privacy concerns, and algorithms may introduce bias without careful oversight (Salhab et al., 2025). In addition, a shortage of skilled AI professionals and inadequate IT infrastructure makes deployment challenging for many organizations (Amankwah-Amoah & Lu, 2024). Thus, without strong leadership support, investment in expertise, and proper governance, firms may struggle to realize AI's full potential in product development.

6. MATERIAL AND METHODS

Before conducting the planned consumer survey in the future, I consider it essential to explore how internationally relevant literature views the relationship between AI, product development, and marketing. For the literature review and analysis, I used the Web of Science database. The investigation took place in March 2025. During the survey, I conducted a search on the Web of Science platform using the term "AI product development marketing." This search yielded 787 results on the Web of Science platform. I used VOSViewer version 1.6.18 to explore the interconnections among the scientific articles listed, through the exportation of bibliographic data from the results list (Visualisation of Similarities - VOS). VOSViewer is a data mining application capable of visually displaying various citation statistics and their relationships based on publication and citation structures of specific journals, leading authors, institutions, countries, and even keywords. Essentially, the methodology is a bibliometric analysis, which examines bibliographic sources using quantitative methods (Martínez-López et al, 2018). In addition to text mining, the software is also suitable for clustering tasks.

7. RESULTS

During the processing, the first step involved bibliographic preprocessing, followed by clustering and merging contents using metrics applied to matrices describing the contents/documents. The analysis parameters were co-occurrence - full-counting – author keywords, and I requested at least 2 occurrences of a given expression in the corpus. This setting only considered those keywords that appeared at least twice about the term "AI product development marketing." This setting created a good harmony between striving for completeness and finding the most critical keywords. The setting resulted in 24 keywords. The co-occurrence map reveals the total number of keyword occurrences across all documents. It identifies the "hot spots" in the specialities, in our case, in writings concerning AI, product development, and marketing. Figure 1 shows the relationships between the keywords of the publications examined in the paper. Each keyword is color-coded by group, with larger circles representing the most occurrences of a keyword. Shorter distances between clusters indicate stronger relationships, while greater distances between clusters symbolize weaker relationships.

includes strategic business concepts such as "competitive advantages," "business models," "B2B," and "customer involvement." This suggests that AI is a pivotal element in reshaping business strategies to enhance competitive positioning in the market, improve customer relationships, and drive business-to-business engagements. Other notable links to "branding," "social media," "perceptions," and "customer acceptance" emphasize the role of AI in transforming marketing communication strategies. These links illustrate how AI tools are utilized to manage brand perceptions across various channels, optimize social media interactions, and enhance customer engagement through tailored content. Overall, this network map is an intricate depiction of the multifaceted interactions between AI, product development, and marketing. It underscores the expansive impact of AI across different sectors, emphasizing its role in driving innovation, enhancing economic and sustainable development, and revolutionizing marketing and consumer engagement strategies.

8. CONCLUSIONS

Integrating Artificial Intelligence (AI) in product development, marketing, and commerce has revolutionized how businesses innovate, engage with customers, and optimize operations. AI technologies have proven instrumental in enhancing marketing strategies by delivering personalized experiences that boost customer engagement and brand loyalty. In product development, AI accelerates innovation cycles, reduces costs, and improves efficiency, leading to faster time-to-market and increased productivity. Real-world case studies, such as Coca-Cola's AI-created Y3000 soda and Hell Energy's AI-developed energy drink, demonstrate AI's capability to assist and drive product innovation. These examples illustrate how AI can generate novel product ideas and formulations, offering companies new avenues for differentiation and growth. However, despite these benefits, significant challenges impede the widespread adoption of AI in product development. Significant barriers include high implementation costs, data privacy concerns, and a shortage of skilled professionals. Addressing these challenges requires substantial investment in AI expertise, robust data governance, and strategic leadership support. As AI continues to evolve, its potential to foster economic growth and contribute to sustainable development through more efficient resource use and enhanced decision-making processes will become increasingly important. Future research should focus on overcoming the current limitations of AI adoption and exploring its applications in diverse sectors, including healthcare and automotive industries. Ultimately, the successful integration of AI into product development and marketing will depend on companies' ability to navigate these challenges while harnessing AI's transformative power to drive innovation, improve customer experiences, and enhance operational efficiency.

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AUTHOR'S ADDRESS

Szűcs Róbert Sándor: University of Debrecen, Faculty of Economics and Business, Institute of Marketing and Commerce, Hungary, 4032 Debrecen, Böszörményi út 138., associate professor, PhD., szucs.robert.sandor@econ.unideb.hu

Földi Kata: University of Debrecen, Faculty of Economics and Business, Institute of Marketing and Commerce, Hungary, 4032 Debrecen, Böszörményi út 138., college associate professor, PhD., foldi.kata@econ.unideb.hu

LITERATURE REVIEW AND SECONDARY RESEARCH ON THE POSITIONING OF ELECTRONIC CIGARETTES IN HUNGARY

FÖLDI KATA - SZŰCS RÓBERT SÁNDOR

ABSTRACT

E-cigarettes are rapidly growing in popularity but face regulatory and perception challenges. In North America, youth usage scandals create volatility, while Europe remains stable. In Hungary, their positioning is shaped by social perception (health concerns, quit aid doubts) and regulation (flavour bans, excise taxes, limited advertising). Though seen as less harmful and a smoking alternative, effectiveness and safety remain debated. Strict rules and youth appeal complicate their market image. keywords: E-cigarette, Harm reduction, Youth vaping, Regulation, Social perception, Nicotine dependence

1. INTRODUCTION

The use of electronic cigarettes (e-cigarettes) has exhibited a dramatic increase over the past decade worldwide, particularly among young adults and adolescents. These products, introduced as technological innovations, simultaneously promise reduced smoking-related harms while creating new public health challenges (Acosta-Peñaloza et al., 2024; Bodnár, 2019). The e-cigarette market is rapidly evolving, with products containing nicotine salts, "tobacco-free" labelling, and youth-targeted marketing campaigns further complicating consumer perceptions (Ma et al., 2025; Zulkiewicz et al., 2024).

Numerous studies indicate that e-cigarettes cannot be considered harmless: risks of nicotine addiction, neurobiological changes, and respiratory and cardiovascular problems persist, even if to a different extent than traditional tobacco products (Merz et al., 2022; Bene-Alhasan, 2024). Users—particularly youth—are often unaware of these risks, further exacerbated by product presentation and positioning in retail settings (Gaiha et al., 2024).

The relevance of this research topic is underscored not only by health concerns but also by regulatory challenges. The rapid development of e-cigarette technologies, the spread of synthetic nicotine, and the ongoing adaptation of marketing strategies necessitate continuous legislative adjustments (Hajdu, 2023; National Public Health Center, 2024). In this context, bibliometric methods offer an opportunity to systematically map the scientific discourse and identify primary research directions.

2. LITERATURE REVIEW

2.1 HEALTH EFFECTS OF E-CIGARETTES

Regarding health impacts, the discussion includes nicotine addiction, neurobiological effects, respiratory and cardiovascular risks, and perceptions of associated health hazards.

According to the first long-term study published in 2019, although e-cigarettes are less harmful than traditional tobacco products, their use still increases the risk of developing chronic respiratory diseases (such as asthma, bronchitis, and emphysema) by 30%. Among dual users (both smoking and vaping), the risk is even higher (Bodnár, 2019). E-cigarettes constitute a significant source of nicotine, which is especially detrimental to the developing brain of adolescents. Nicotine exposure can lead to structural and functional changes in the brain, negatively impacting memory, attention, and mood (Acosta-Peñaloza et al., 2024). Nicotine addiction can develop more rapidly in this age group and

may result in long-term mental health problems such as depression and anxiety (Acosta-Peñaloza et al., 2024). Inhalation of e-cigarette vapour introduces various toxic substances into the body, potentially causing respiratory irritation and decreased lung function (Merz et al., 2022). Additionally, nicotine and other components play a role in the development of cardiovascular diseases by damaging blood vessels and impairing cardiac function (Acosta-Peñaloza et al., 2024). While the health risks associated with e-cigarettes are generally lower than those of traditional tobacco, they are not negligible (Merz et al., 2022).

A large-scale American study published in 2024 found that e-cigarette users face a 19% higher risk of heart failure compared to those who have never used them (Dentistry.co.uk, 2024). Researchers found that this correlation was independent of age, gender, or conventional smoking status, cautioning that e-cigarettes may not be as safe as previously assumed. These findings underscore the need for further investigation into the cardiovascular effects of e-cigarette use. The study, which involved data from 175,667 adults, reported no significant demographic moderators influencing the relationship (Bene-Alhasan, 2024).

Among youth, awareness of health risks remains low, and many do not perceive e-cigarettes as harmful or addictive (Zulkiewicz et al., 2024). The marketing of "tobacco-free nicotine" products, in particular, may reduce risk perception, as the label "tobacco-free" may misleadingly imply a healthier alternative (Zulkiewicz et al., 2024).

2.2 SOCIAL PERCEPTION AND CONSUMER ATTITUDES AMONG YOUTH

Among young adults and adolescents, e-cigarette users often receive positive social appraisals, which can influence their usage behaviour. For instance, studies conducted in the United States demonstrate that among military youth, e-cigarette users are perceived as "cool" and "attractive" prototypes. In contrast, in other demographic groups—such as women and ethnic minorities—the perception tends to be more negative (Pebley et al., 2023). These positive social prototypes may increase the willingness to use and the general acceptance of the product. This is illustrated in Figure 1.

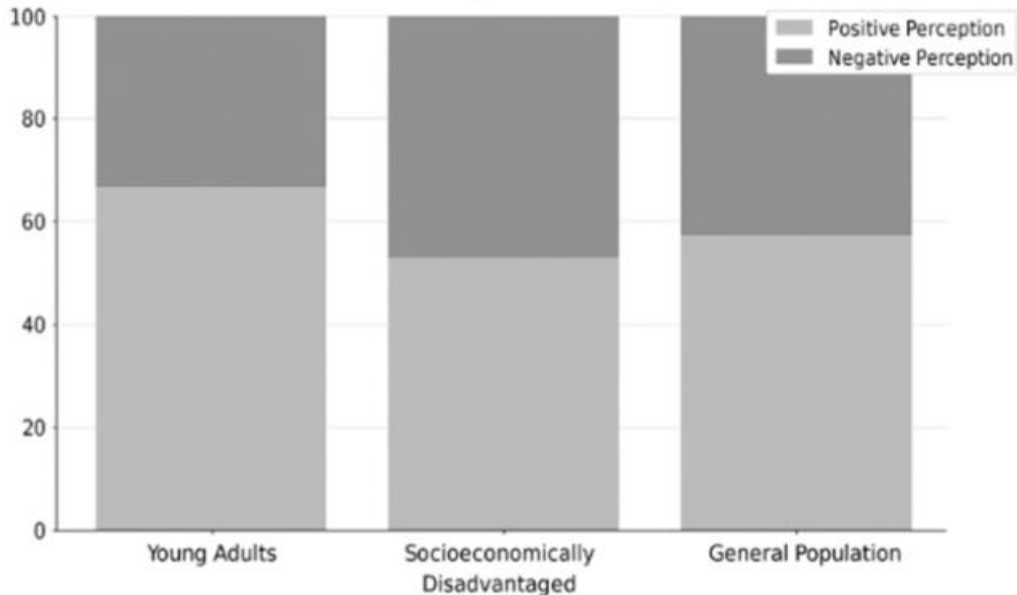


Figure 1. Distribution of Perceived E-cigarette Use by Social Groups
Source: Acosta-Peñaloza et al. (2024)

Consumer awareness and misconceptions regarding "tobacco-free nicotine" products are also significant factors. A portion of the youth population believes these products are less harmful or less addictive compared to traditional nicotine-containing products, which may elevate both the intention

to use and the likelihood of initial experimentation (Zulkiewicz et al., 2024). Research conducted during the COVID-19 pandemic indicated that users perceived a lower risk of contracting the virus or experiencing more severe outcomes, which may have further encouraged e-cigarette use during the pandemic period (Merz et al., 2022).

2.3 MARKETING AND PRODUCT POSITIONING

One of the most significant arenas for e-cigarette marketing is the retail environment, where products are often prominently displayed—for instance, behind checkout counters or so-called "Tobacco Power Walls" (Gaiha et al., 2024). These marketing tools—including flavoured samples, discounts, and promotional offers—substantially contribute to young consumers' purchase intentions and product acceptance.

The e-cigarette market is characterized by continuous product development, particularly in terms of nicotine forms (freebase vs. nicotine salts) and nicotine sources (tobacco-derived vs. synthetic). Synthetic nicotine and "tobacco-free" labels function as marketing instruments that may mislead consumers regarding the potential harms of these products (Ma et al., 2025; Zulkiewicz et al., 2024).

2.4 REGULATORY ENVIRONMENT

Globally, and especially in the United States, increasingly strict regulations have been implemented to limit e-cigarette use and marketing targeting youth (Acosta-Peñaloza et al., 2024). The U.S. Food and Drug Administration (FDA) closely monitors marketing and distribution practices; however, regulatory frameworks still face significant challenges due to the rapid evolution of e-cigarette products. Initially, products made with synthetic nicotine were not covered by FDA regulation, which enabled manufacturers to exploit regulatory loopholes for market expansion (Zulkiewicz et al., 2024). The "tobacco-free" label can mislead consumers and complicate effective regulation by obscuring the real risks. Although healthcare providers can play a crucial role in reducing e-cigarette use among youth through screening and counselling, in practice, such interventions are less common—especially among minority groups and in underserved areas (Acosta-Peñaloza et al., 2024). The relationship between regulatory interventions and youth e-cigarette use is illustrated in Figure 2.

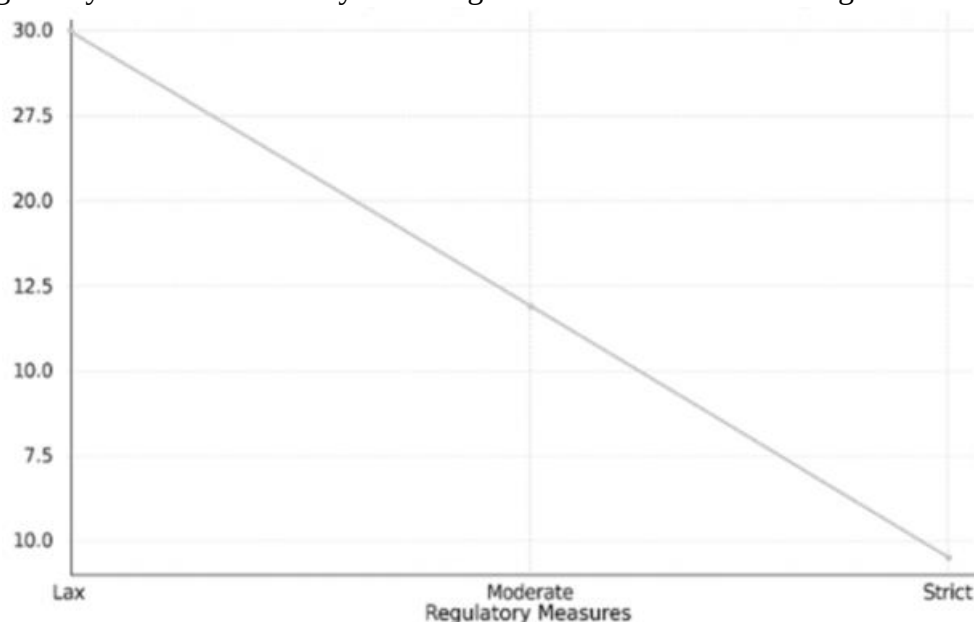


Figure 2. The relationship between regulatory interventions and youth e-cigarette use
Source: Acosta-Peñaloza et al. (2024)

In Hungary, e-cigarettes are regulated under the European Union's Tobacco Products Directive (TPD), which includes restrictions on flavoured products and advertising bans. However, significant regulatory gaps remain, particularly regarding products containing synthetic nicotine—especially those labelled "tobacco-free"—still being exploited by market segments (National Public Health Center, 2024). E-cigarettes in Hungary are governed by multiple legal acts, such as Act CXXV of 2012 on the distribution of regulated tobacco products and Ministerial Decree 52/2018 (XI. 15.) on the marketing of electronic cigarettes (Hajdu, 2023). Decree 47/2013 of the Ministry of Human Capacities applies to cessation support tools, while Decree 16/2017 of the Ministry for National Economy addresses taxation issues. Notably, no specific regulations exist for the "tobacco-free nicotine" category (Hajdu, 2023).

The increase in e-cigarette use in Hungary is primarily observed among adolescents and young adults, similar to trends in other European countries. According to 2023 data from the Hungarian Central Statistical Office (KSH), between 15% and 18% of individuals aged 15–24 report using e-cigarettes—marking a significant increase over the past five years. This trend presents considerable challenges for public health prevention and regulatory efforts (KSH, 2023). According to Statista (2023a; 2023b), the e-cigarette market in Hungary is projected to reach USD 106.8 million in revenue, with an annual growth rate of 3.34%. Although underdeveloped compared to Western European countries, Hungary's per capita revenue is USD 11.98 (Statista, 2024b). Globally, the e-cigarette market is forecasted to generate USD 27.2 billion in revenue by 2025, with an annual growth rate of 3.73% (Statista, 2024a). Among young adults in Hungary, social acceptance of e-cigarettes is increasing, raising further public health and regulatory concerns.

In Romania, Eurobarometer data show that e-cigarette use has risen rapidly in recent years, especially among those aged 18–24, where usage rates have reached 20% (Eurobarometer, 2023). Although Romanian health authorities follow EU regulations, enforcement and local implementation are less stringent, making it easier for young people to access e-cigarettes—especially colourful, flavoured variants (Ministry of Health Romania, 2024). In 2024, Romania passed a law banning all advertising of electronic cigarettes, nicotine pouches, and heated tobacco products on television, near educational and healthcare institutions, cinemas, and media targeting minors (Maszol, 2024).

3. MATERIALS AND METHODS

The primary aim of this study was to map the key themes and network structures within the scientific discourse surrounding e-cigarettes, particularly at the intersection of consumer behaviour, health impacts, and regulatory aspects. A bibliometric network analysis was conducted using the Web of Science database to achieve this.

The query was executed in May 2025 via the Web of Science Core Collection interface. The following keywords were used during the search: "e-cigarette," "vaping," "tobacco harm reduction," "regulation," "youth," and "public health." The inclusion criteria were restricted to peer-reviewed scientific articles and review papers published in English. The results were exported in .txt format with "Full Record and Cited References" selected, and these files were subsequently imported into the software VOSviewer (version 1.6.18).

Within VOSviewer, a keyword co-occurrence network was constructed with a minimum occurrence threshold of 2. The software applied the "Full Counting" method, which assigns equal weight to all occurrences. During the network construction, cluster analysis was conducted, whereby thematically related keywords were grouped into colour-coded clusters. In the visualization settings, the size of each node corresponded to its frequency; the distance reflected the strength of the association between concepts, and the colour indicated cluster membership.

4. RESULTS

The network created using VOSviewer identified four distinguishable clusters, each representing thematically distinct aspects of e-cigarette-related research. Thirty-one relevant keywords were analyzed, appearing at least twice in the selected scientific publications. The total number of occurrences was 351, resulting in an average frequency of 11.3 per keyword. The keyword "e-cigarette" was the most frequently mentioned, with 58 occurrences confirming its central role in the network. The statistical characteristics of the clusters are presented in Table 1.

Table 1. Statistical Characteristics of the Clusters

Cluster	Number of keywords	Most frequent keyword	Average occurrence	Main Them
1.	9	e-cigarette (58)	17,9	Product use and types
2.	8	youth (34)	13,5	Youth and usage patterns
3.	7	harm reduction (29)	11,1	Health-related approaches
4.	7	regulation (22)	9,7	Governmental regulatory measures and strategic approaches

Source: VOSviewer, 2025

Cluster 1 (9 keywords): Product Use and Types

This cluster focuses on the technological characteristics of e-cigarettes, patterns of use, and forms of nicotine delivery. Representative keywords include e-cigarette, vaping device, nicotine delivery, and flavour preference. Research in this group investigates user preferences, the role of flavouring, and the impact of technological variations on consumption behaviour.

Cluster 2 (8 keywords): Youth and Usage Patterns

This cluster centres on e-cigarette use among adolescents and young adults. Key terms include youth, adolescent, initiation, and peer influence. Studies within this domain examine the social influences driving experimentation, initiation, continued use, prevention strategies and school-based education.

Cluster 3 (7 keywords): Health-Related Approaches

This cluster addresses the health effects of e-cigarette use and harm reduction strategies. Prominent keywords include harm reduction, lung function, nicotine dependence, and clinical outcomes. The research evaluates to what extent e-cigarettes may be considered less harmful than conventional tobacco products.

Cluster 4 (7 keywords): Governmental Regulatory Measures and Strategic Approaches

This cluster explores the regulatory landscape and public health interventions. Important keywords include regulation, public health, marketing restrictions, and labelling. Studies examine the legal status of e-cigarettes across different countries and assess the effects of regulation on marketing practices and usage trends.

The clusters' structure and associated terms are visualized in Figure 3.

Potential future research directions include longitudinal studies on perceptions of "tobacco-free nicotine," qualitative analyses of youth risk perceptions and motivations for use, quantitative assessments of regulatory impact across market environments, and the exploration of links between e-cigarette use and adolescent mental health.

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AUTHOR'S ADDRESS

Földi Kata: University of Debrecen, Faculty of Economics and Business, Institute of Marketing and Commerce, Hungary, 4032 Debrecen, Böszörményi út 138., college associate professor, PhD., foldi.kata@econ.unideb.hu

Szűcs Róbert Sándor: University of Debrecen, Faculty of Economics and Business, Institute of Marketing and Commerce, Hungary, 4032 Debrecen, Böszörményi út 138., associate professor, PhD., szucs.robert.sandor@econ.unideb.hu

DETERMINANTS OF CONSUMER INTENTIONS TO ATTEND THEATRE PERFORMANCES: THE CASE OF CSÍKI JÁTÉKSZÍN

SZŐCS ATTILA

ABSTRACT

The classical marketing management literature operates under the assumption that the marketing concept can be freely applied to any type of activity, celebrating the extension of this concept as one of the most significant achievements in the evolution of marketing. However, the world of the arts and theatre rejects this approach; at the very least, representatives of auteur (director-led) theatre firmly oppose the definition of theatrical performance as a product.

My article identifies and systematizes the three major clusters of factors that hinder the full development of cultural marketing as a distinct academic discipline within theatrical practice. It then analyzes specific audience motivations using empirical data, with the aim of providing a comprehensive understanding of how the model of factors influencing theatre attendance relates to the domains of the identified structural challenges.

1. INTRODUCTION

Since the seminal announcement by Kotler and Levy (1969), marketing literature has largely assumed as a default that marketing would play an equally valuable role in the world of the arts as it does in business practice.

There are several reasons why the marketing concept has not been integrated into the theatre world in its original meaning and thus cannot be applied mechanically to the arts or theatrical practices.

While arts and cultural marketing initially emerged and spread as an applied branch of marketing, it has evolved into a more mature form through the development of creative and critical approaches (Fillis 2011; El-Ansary 2018; Walmsley 2019). Nevertheless, it has not developed into a fully independent academic discipline—an issue explored in detail across the first three subsections of this paper.

This article calls for a reconsideration of traditional marketing paradigms, a process that has already begun and gained momentum across various domains, both within marketing (Vargo & Lusch 2004) and in economics (Throsby 1994).

However, this creative and critical process (Fillis 2011) has produced specific and unique outcomes. The paradigm shift addressed by Vargo and Lusch (2004) highlights the growing importance of experience creation and co-creation within traditional business contexts. As a result, Bilton (2017) argues that the very notion of the "product" is disappearing, noting that global corporations such as Apple, Google, and Facebook have transformed their experience-driven business models so effectively that they have monopolized consumer attention—thereby pushing cultural service providers to the periphery.

Although Bilton (2017) primarily examines the status of platform-dependent creative service providers, the phenomenon partially affects theatres as well, both through the competition for public attention and via their partial reliance on digital platforms (such as websites, online communication campaigns, ticket sales, and live streaming).

Emphasizing the proactive role of audiences and consumers, Andrew McIntyre (2017), Managing Director of international cultural strategy consultancy MHM, suggests that we are now operating in a post-marketing context. The central element of McIntyre's (2020) argument is audience-centricity,

he contends that everything must be done to meet audience needs, as we have not yet fully achieved this goal. His standpoint is intriguing in several respects.

He argues that the era of marketing is over, claiming that marketing has trapped cultural institutions in a cycle of money and metrics, rendering them financially vulnerable in their pursuit of revenue. This assertion is particularly striking, given that the core principle of marketing is the consistent identification and satisfaction of needs, precisely the source of the tension between marketing logic and artistic thinking, a tension McIntyre (2017, 2020) overlooks.

Nonetheless, the increasing prominence of the field of Audience Management and its strong political support lends weight to the arguments advanced by McIntyre (2020) and Walmsley (2019).

2. THE CONTRADICTIONARY RELATIONSHIP BETWEEN MARKETING AND THEATRE PRACTICE

2.1 The birth of cultural marketing

Cultural marketing emerged as a response to the influential article by Kotler and Levy (1969), which proclaimed the extension of the marketing concept beyond the realm of business. Despite the underdeveloped nature of their article, Kotler and Levy's proposition has been widely embraced and continues to be supported by the marketing education community to this day (El-Ansary 2018).

However, this proposition received immediate criticism. Like the present author, Luck (1969) pointed to the lack of a solid theoretical foundation. A scientific discipline cannot be constructed on simplistic analogies; the nature of transactions cannot be projected onto any activity, such as the operation of a church diocese with the casual ease typical of everyday reasoning. A church does not "sell" its services, even if certain parallels can be drawn between the selling of products and the provision of spiritual guidance.

Bartels (1974) interpreted the extension of the marketing concept as leading to an identity crisis within the discipline. He warned that marketing might lose its definitional boundaries, thereby also losing its coherent meaning. The generalization offered by Kotler and Levy (1969) rests on identifying marketing with exchange processes. However, such analogies allow for overly broad interpretations, which ultimately erode the scientific significance of marketing as a discipline. If we follow their logic, every exchange process would have to be considered a marketing process. But not all exchanges are marketing processes, as stock market transactions, for example, are clearly not.

It should be noted that marketing does indeed work successfully in many cases within the arts and theatre sectors, thanks to its proper application, sound decision-making, and systematic implementation. The value generated by marketing for many nonprofit organizations is undeniable. This critique does not target the nonprofit field per se but rather focuses on the dominant role and uncritical acceptance of the Kotlerian perspective. In fact, nonprofit sectors have often provided the foundation for the boldest advertising campaigns partly because top management is not constrained by fears of falling short in sales. At its core, this is a philosophy-of-science issue.

"This does not exclude marketing from nonbusiness institutions. Individual marketers may lend their talents to United Fund drives, political campaigns, or church program planning; however, marketers *qua* marketers do not perform these activities by definition." —Luck, 1969

A certain discipline gains validity when its application is grounded in a well-developed theoretical framework and a comprehensive methodological toolkit, something the superficial and anecdotal assertions of Kotler and Levy (1969) cannot substitute. Marketing can indeed be extended, but not unconditionally to any domain, as doing so risks the loss of its boundaries and identity (Luck 1969). The broadening of the concept undoubtedly brought certain benefits: it invigorated marketing by pushing it beyond economic processes. Yet, by their very nature, such ventures are risky. The conceptual expansion diverts attention from marketing's original, core function and as Bartels (1974) warned, the field may dissolve to the point that its original form might reemerge under a different name.

Arndt (1978) approached the issue from the opposite direction. He questioned not whether marketing can be extended to non-business fields, but whether these extended applications should be regarded as an organic part of marketing. As if to affirm his thesis, the field of Audience Management has quietly emerged.

The most fundamental challenge remains the absence of a robust theoretical framework and a well-constructed empirical model. Fortunately, several initiatives and theoretical breakthroughs offer promising avenues for developing such a foundation. In 2018, El-Ansary et al. responded to the identity crisis identified by Bartels (1974) by proposing the systematic and comprehensive adoption of marketing systems theory. Furthermore, the concept of co-creation of value, introduced by Vargo and Lusch (2004), provides a far more suitable foundation for applying marketing within theatrical practice.

Bourdieu's (1993) field theory likely resonates more with artistic directors and proponents of auteur theatre. However, it lacks a framework for modeling business transactions and describing exchange processes. Nevertheless, considering the clear discomfort of artistic directors and the obstacles posed by their sense of artistic identity, the sociologist Bourdieu (1993) offers a powerful interpretive framework that could serve as a basis for implementing a comprehensive marketing system (Vigerland & Borg 2018; Tapp & Warren 2010). Such a system could resolve existing tensions while preserving the business utility generated by cultural marketing.

Throsby's (1994) dual value theory in cultural economics deliberately engages with the tensions outlined in this article, and its formal framework offers a potential means to reconcile the conflicting interests of art and commerce. It presents a clear and sufficiently simple guide for bridging the gap between the unique nature of cultural value and the formal models of business processes.

Cultural marketing has long played a valuable role in the world of theatre. If it can resolve the tension inherent in its dual nature, it may strengthen its position and ultimately reconcile philosophical/sociological traditions with the formal models of economics. Indeed, this integrative role has long secured its relevance and central place among the social sciences.

2.2 RESISTANCE OF THE ARTS

The emergence of cultural marketing and the extension of the concept of marketing (Kotler & Levy, 1969) was based on the assumption that the exchange processes modeled by marketing could be applied to cultural institutions—that it would be sufficient to align the elements of the marketing mix with some apt characteristic of the specific field.

However, the world of the arts and theatre vehemently resists describing theatrical activity using business terminology and firmly rejects the notion of defining a performance as a marketable product. The process of exchange cannot be described because the value is intangible, cannot be stored, and is only born when the audience receives it. Unlike services, this value depends on the qualities of the recipient. Marketing creates value by best satisfying consumer needs, but theatre seeks precisely the opposite. Even in commercial theatre practice, there is an aspiration toward performance, not to serve but to shape needs.

“We’re not a shop. It’s unfortunate we need people’s money, but we’re not selling something. That’s why I hate the word ‘production’: it’s not produced, it’s a ceremony, it’s a ritual, it is something which is very important for your mental strength, and you should go out of the theatre stronger and more human than when you went in.”

— Mnouchkine (in Dickson, 2012), one of the world’s most influential theatre directors, and the only female recipient of the Ibsen Award.

In extending marketing, we applied its concept mechanically to the world of the arts and theatre, without developing an appropriate theoretical framework that would integrate theatrical thinking into cultural marketing. Thus, we had the misleading impression that we had created a new paradigm, while we placed theatre in an abstract space where seemingly sensible conclusions about the operation of the marketing mix could be drawn, conclusions that are not necessarily relevant to theatrical

practice or operation. In other words, the tension and conflict between marketing and theatrical functioning stem from the fact that the theoretical and professional foundation of artistic and cultural marketing was provided by marketing itself, not by the arts (Walmsley, 2018).

The Consumer

Even the most fundamental concept of marketing—consumption—is not applicable here. Interpreting theatre using market metaphors instinctively repels those who see themselves as creators. Defining the viewer as a consumer creates fundamental contradictions and conceptual conflicts since the viewer is not a consumer but a proactive participant (Zsigmond, 2016).

The viewer cannot be defined as a consumer because the basic definition of consumption does not apply to the reception of a theatrical performance. While a product wears out or is consumed during use, in theatre, something emerges from little—or from nothing (Mnouchkine, 2010; Zsigmond, 2016).

Product

“A performance is not a product. On one side, it is the precious moments of seventy-five people’s lives; on the other, of six hundred.”

— Mnouchkine (2010, in Zsigmond, 2016)

Communication

In his seminal book, Berger (2008) criticizes the systems that sustain consumer society, labeling advertising as uneventful—something detached from the advertised event that awakens unfulfillable desires. Thorpe (2014), analyzing *The Orphan of Zhao*, concludes that a specific communication practice became an event in itself and was capable of inducing social discourse.

Communication has a distinctive role. Creative brand development—such as that seen at the New Theatre in Australia or the Saint-Étienne Opera House—and inventive, dramatized viral and PR campaigns play an increasingly central role.

Sales

By default, there is no sales activity in the conventional sense because the essence of a theatre performance—the experience and the unique, personal emotional process within the viewer—is intangible and cannot be made part of the sales process. This is further complicated by the fact that the experience undergoes a post-event maturation, which may be enriched by related readings, reviews, or conversations. Only the framework can be sold—therefore, if we seek to define marketing’s role, it must be examined on multiple levels.

Pricing

The main sources of theatre funding are municipal or state subsidies and sponsorships. Income from ticket sales only complements these. In this sense, price cannot be clearly analyzed as a competitive tool. Despite earlier assumptions stemming from this logic, econometric research confirms the clear price elasticity of demand.

The resistance of theatre creators to applying market metaphors and extending marketing is not universally shared. Zsigmond (2012) distinguishes three types of theatres: popular theatre, director’s theatre, and authorial (participatory) theatre. Of these, the latter two types strongly reject the marketing framework due to artistic pride, while popular theatre is more open, as it openly seeks to serve its audience.

The resistance of creators, the rejection of the marketing mix metaphor, and the market-based interpretation are understandable to a certain point. Theatre is a world of its own, its operations, language, and mindset cannot be reduced to marketing terminology.

Yet the market reality is still there lurking beyond the theatre’s gates. Competition exists: between theatres in large cities, and for people’s attention in small towns. Audience demand exists, and theatres need income even if they are maintained through funding because they must legitimize their

activities to their funders. The theatre needs revenue. Therefore, we must respond to this existing problem, and cultural marketing must find its rightful place.

2.3 Viewers' complex motivational system

A further dimension of the challenges faced by theatre marketing lies in the unique nature of theatre audiences. Despite longstanding academic interest in the topic, there remains no widely accepted explanation for the complex motivational dynamics underlying theatre attendance (Pincus, 2004; Walmsley, 2011).

The complexity of the phenomenon is underscored by the evolution of audience research itself. For a long time, demographic variables were regarded as the primary explanatory factors for demand. However, empirical practice has revealed the limitations of this approach and led to the recognition of lifestyle variables as more robust predictors of theatre-going behavior (Andreasen & Belk, 1986; Seaman, 2006). This shift is particularly important given that theatre attendance is a time-intensive activity that must, to some extent, be integrated into one's lifestyle.

While traditional research often suggested that theatre audiences are demographically elite, more recent findings paint a more nuanced picture. Evidence suggests that theatre audiences are heterogeneous along several dimensions (Belk et al., 1980; Seaman, 2006). Interest in the performing arts is a learned behavior; the more frequently an individual is exposed to live performance, the stronger their interest tends to become. Attendance at various types of performances can thus serve as a key explanatory variable for engagement in specific genres. For example, a significant portion of opera audiences report openness to other genres, while theatre audiences tend to be "monogamous," showing relatively little overlap with audiences of other performing arts (Belk et al., 1980; Fisher & Preece, 2002).

A substantial body of research has aimed to capture this motivational complexity, examining multifaceted drivers such as socialization, entertainment, family bonding, escapism, and novelty-seeking (Nicholson & Pearce, 2001). Many of these studies focused on audiences of festivals or cinemas, where factors such as escapism and hedonistic experience play a more prominent explanatory role (Bergadaà & Nyeck, 1995; Unger & Kernan, 1983).

In the context of museum attendance, Slater (2007) identified escape from everyday concerns as the primary motivational factor, contrasting with earlier emphasis on the educational dimension. However, this conclusion has been challenged by other researchers who highlight the importance of shared communal experiences (Bourgeon-Renault, 2000; Arai & Pedlar, 2003).

Swanson et al. (2008), employing factor analysis to examine motivational scales, identified six distinct factors and found that relaxation and appreciation of artistic value were the most important drivers, while learning and self-confidence were of lesser significance. Similarly, Walmsley (2011) emphasizes the preeminent role of emotional impact, questioning the findings of earlier studies that prioritized escapism, learning, entertainment, and socialization.

Leko Šimić and Pap (2019) explored the role of satisfaction by measuring the gap between expectations and actual experience. In their study of the HNK Osijek theatre, they identified repertoire limitations as the primary source of dissatisfaction. Boerner et al. (2011) also investigated satisfaction, focusing on the methodological challenges of measuring it. Their findings, consistent with those of Swanson et al. (2008), indicate that emotional response is among the most significant determinants of overall satisfaction.

3 ANALYSES

The empirical part of this research sought to identify the most influential explanatory factors behind the intention to attend theatre performances, as well as to capture how the tension between theatre

creators and the extended concept of marketing is perceived at the audience level. The aim was to develop a framework that meaningfully bridges these two domains—artistic creation and marketing—while being grounded in a robust, methodologically sound theoretical foundation. Data collection took place in 2024, during the period between the end of one theatre season and the beginning of the next, targeting audiences of *Csíki Játékszín* theatre. A total of 626 respondents participated in the survey, including both regular theatregoers and individuals who do not typically attend the theatre.

The questionnaire was designed to assess a range of variables that may explain theatre attendance (such as satisfaction, motivation, attitude, lifestyle, and demographics), as well as to evaluate factors related to the applicability of the marketing concept in the context of theatre.

3.1 DETERMINANTS OF CONSUMER INTENTIONS TO ATTEND THEATER

To understand the factors influencing theatre attendance, I examined both general satisfaction and specific satisfaction dimensions—such as satisfaction with the theatre-going community, staff, and actors—along with satisfaction related specifically to communication practices. In addition, I measured audience attitudes, motivations, and demographic variables. Lifestyle-related factors played a central role in the analysis. These were partly adapted from Andreassen and Belk (1980), as were the attitude scales, while the motivational scales were based on the work of Swanson (2007). In the first step of the analysis, I conducted a principal component analysis (PCA) on lifestyle scale items. From the original set of 17 variables, six distinct factors emerged, collectively preserving approximately 60% of the total variance. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.616, which, while not ideal, is within the acceptable range. Furthermore, Bartlett's test of sphericity was significant. The six resulting factors were interpreted and labeled as follows:

Active

This factor represents a lifestyle characterized by spending time outdoors and being open to new experiences.

Passive

The second factor relates to leisure activities centered on rest or even idleness.

Informed and Family-Oriented

This factor combines a high demand for information with a strong emphasis on family time.

Cultured

Individuals scoring high on this factor value reading and make time for cultural events, perceiving these as meaningful ways to spend their time.

Creative Activity

This factor reflects a drive for productive engagement in activities such as running a business or gardening. Similar to the "Active" factor, it represents purposeful time use, though it is motivated more by initiative and less by recreation or sports.

Community-Oriented

The sixth factor captures the importance of social presence and time spent with friends, incorporating motivations that may also include religious engagement.

3.2 The model

To analyze the combined effects of the identified factors in context, I constructed a Generalized Linear Model (GLM) using Poisson regression.

Although the dependent variable—number of theatre visits in the past year—does not critically deviate from a normal distribution (skewness = 0.608, kurtosis = 1.54), the variable's discrete nature and the results of the Shapiro-Wilk test justify the use of the more appropriate Poisson regression model.

According to the Omnibus test, the full model is statistically significant ($\chi^2(20) = 71.592$, $p < .001$), and it demonstrates a strong fit (Deviance/df ≈ 1.036 ; Pearson/df ≈ 0.88).

However, the initial version of the GLM model appears unstable. While multicollinearity could be a potential cause, this is not confirmed by the correlation matrix.

Table 1. Full modell of determinants

	<i>Wald Square</i>	<i>Chi-</i>
<i>Constant</i>	56.23	0.000
<i>General satisfaction</i>	12.39	0.054
<i>I personally care about what people think of the Csíki Játékszín.</i>	8.61	0.072
<i>Activity</i>	3.18	0.074
<i>Support of culture</i>	3.22	0.073
<i>Creative activity</i>	2.85	0.091
<i>Income</i>	18.65	0.001
<i>The theatre's communication</i>	12.11	0.007

A recurrent issue in the analyses is that, despite their theoretical importance, satisfaction and motivational variables consistently exhibit non-significant effects. Similar to the findings of Andreasen and Belk (1980), stable and significant model fits are observed only when the predictors are limited to the two lifestyle factors (Activity and Cultural Support) and Income. However, the fit of this simplified model is notably inferior (Deviance/df $\approx$ 1.122 and Pearson/df $\approx$ 0.979). Comparative model fit statistics present a more ambiguous picture: while the Log Likelihood and AIC favor the full model, indicators such as AICC, BIC, and CAIC penalize model complexity and thus favor the simplified specification.

Table 2. Simplified modell

	<i>Wald Chi-Square</i>	
<i>Constant</i>	1024.372	0.000
<i>Income</i>	20.417	0.000
<i>Activity</i>	6.838	0.009
<i>Support of culture</i>	5.944	0.015

I accept the full model, as it aligns with theoretical assumptions and can fulfill its intended role by offering a more nuanced understanding of the factors influencing theatre attendance. At the same time, it is important to note that this study represents a preliminary stage of a broader research project; therefore, the model is expected to evolve as methodological refinements and new waves of data collection are implemented.

When examining the individual predictors, it becomes evident that those who attend the theatre most frequently are also the least satisfied with their communication efforts. Attendance is highest among individuals earning less than 1,300 RON (a group largely composed of students with subscriptions), followed by those with incomes exceeding 6,000 RON, and then by those earning below 2,000 RON. A similar pattern emerges with respect to age: the highest frequency of attendance is observed among individuals under 17 and over 66 years of age. Notably, the overall average frequency of theatre attendance is lowered by employees, who constitute the largest demographic group in the sample.

4. CONCLUSIONS

As the phenomena described by the explanatory variables produced increasingly contradictory results, researchers—albeit cautiously—began to suggest that the demand for culture may be driven by multiple motivations (Slater, 2007), and that different individuals may participate in the same activity for entirely different reasons (Thyne, 2001). These findings form the conceptual foundation of our research. Beneath them lies a certain scholarly disorientation and frustration: we are unable to explain something that initially seems straightforward.

There appears to be no simple answer, as a single decision may be explained by a range of motivations, and these motivations are heterogeneous at the individual level. The same person may be driven by different motivations when attending two different performances. Often, the core decision is not shaped by the actual motivations. Paradoxically, for every contradictory relationship observed, there exists both a plausible explanation—and no explanation at all.

Representatives of auteur or participatory theatre, including some artistic directors, often find it difficult to accept frameworks that might constrain their artistic freedom. Even more contentious is the idea that their creative output might become a mass-market commodity. In this sense, marketing thinking—and the broader marketing concept—is unlikely to take root in its original form within the theatre world; instead, it remains a supportive service, often limited to advertising campaigns.

Conversely, the position of many creators and directors also reveals a certain hypocrisy. They need marketing, yet they want it to create value discreetly, to remain in the background, to refrain from claiming visibility or recognition, to stay unnoticed so that directors and artistic leaders can easily forget its presence.

Even more striking is the position of those aligned with the audience management or audience-centered paradigm. They often demand from marketing what has always constituted its essential core. This underscores the pressing need for a systematically constructed theoretical framework for cultural marketing, one that integrates the audience-centered perspective, a cornerstone of marketing, with artistic modes of thinking.

We must resist projecting marketing's traditional terminology onto the theatre. A performance is not a product; the viewer is not a consumer; and the experience of a performance is not consumption. The mechanical application of marketing mix metaphors to the world of theatre does not constitute scholarly insight. Let us speak of the "spectator" rather than the "consumer," for the spectator has never been a passive consumer, but rather a proactive participant whose presence directly influences the quality of the performance. Thus, a performance is not a product; technically, what is sold in the transaction is the right to enter the theatrical space.

This is the most difficult part: we must indeed offer something to the spectator, but this is part of a shared process of learning. We cannot erect a wall between promotional activity—audience development, marketing—and the creative process. Practitioners in these domains must be aware of each other's work. Spectators must be brought into the auditorium; without them, there is no theatre, no emergence of experience. "We must always listen to the audience, but we must not always obey them" (Mnouchkine, 2010; Zsigmond, 2016).

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Author's address

Szőcs Attila

University of Sapientia, Faculty of Economics, Socio-Human Sciences and Engineering

Piața Libertății 1, Miercurea Ciuc

Email: szocsattila@uni.sapientia.ro

THE TOURISM APPEAL OF LOCAL FLAVOURS: AN ANALYSIS OF GASTRONOMIC FESTIVALS IN SZEKLERLAND

KINGA KATALIN SZÉKELY

Abstract

Gastronomic festivals play an increasingly important role in the tourism offer of rural regions, especially in culturally distinct areas such as Szeklerland. This study aims to explore how these events contribute to strengthening local identity, supporting economic actors, and enhancing the touristic positioning of the region. The research is based on content analysis, examining the communication practices of several gastronomic festivals in Szeklerland. The study interprets gastronomic festivals within the framework of the endogenous rural development paradigm, highlighting their role in activating local knowledge and cultural heritage.

Key words:

endogenous rural development, gastronomic festivals, culinary tourism, communication

Introduction

Gastronomic festivals have become significant cultural and tourist events in many regions, offering excellent opportunities to discover local traditions, flavors, and culinary heritage. Besides providing culinary experiences, these events also contribute to increasing the tourist appeal of a settlement or region and support local producers, hospitality businesses, and food manufacturers.

In Szeklerland, gastronomic festivals play a key role not only in preserving local gastronomy but also in strengthening community identity and promoting tourism. While showcasing local flavors, eating habits, and unique culinary offerings carries significant cultural value, these events can also become tourist attractions.

This study examines the role of gastronomic festivals in Szeklerland within the context of the endogenous development model, with particular focus on building local identity, economic impacts, and tourism positioning.

In recent decades, a new approach has become dominant in rural development, moving beyond the traditional top-down (exogenous) development logic. According to the so-called new rural development paradigm, rural areas are not merely peripheral spaces, but multifunctional socio-spatial units built from their own internal resources. This approach emphasizes active participation of local communities, reinterpretation of cultural values, and sustainable, quality-based development (van der Ploeg et al., 2002).

An integral part of this paradigm shift is the endogenous development strategy, which bases development on the knowledge, traditions, economic and cultural potential of the local society (Ray, 1998; Woods, 2010; Káposzta, 2018). Instead of applying externally "imported" solutions, the endogenous approach builds on the self-organizing power of communities, social capital, and the activation of local identity and heritage (Shucksmith, 2000; Csurgó – Szatmári, 2014). This model focuses on exploring local conditions, transforming them into resources, and utilizing them (Bodnár G., 2013; Ludescher G., 2016). A key role is given to the revaluation of local knowledge and cultural practices – such as local gastronomy – that can transform local values into tourism and economic resources. As Bessière (1998) points out, traditional foods and eating habits can become tools for rural development, enriching the concept of "place" with new meanings.

Gastronomy can be understood as a local resource that contributes to preserving local identity, passing on cultural heritage, and sustainable development of local communities. It is a value expressing the uniqueness of places, as gastronomic traditions arise from the combination of local people's knowledge, cultural traits, and geographical characteristics (Bessière, 1998; Ravenscroft–Westering,

2002; Rinaldi, 2017). However, gastronomy is not only culturally significant but also carries economic potential, especially in terms of tourism and local branding, as it contributes to increasing tourist appeal (Everett – Aitchison, 2008). Food-related experiences play an increasingly important role in creating the identity and competitiveness of destinations (Lai et al., 2018), as tourists seek not only sights but authentic, experience-based destinations – among which gastronomic experiences are one of the most prominent (Ellis et al., 2018). Gastronomy can be not only a complementary element but also a primary motivation for travel (Quan – Wang, 2004).

Gastronomic experiences – especially festivals and thematic events – can create emotional bonds with visitors, which in the long term contribute to the positive image of the region, repeat visits, and even recommendations. Accordingly, gastronomy can become a strategic tool for local brand building (Kavaratzis – Ashworth, 2006). Through local products, culinary heritage, and local gastronomy, the uniqueness of regions can be communicated.

One of the most prominent forms of gastro-tourism is the appearance of gastronomic events and festivals, which offer not only culinary experiences but also community, cultural, and entertainment programs. Gastronomic festivals function as development tools and platforms that can connect local identity-forming elements (foods, traditions, language, community rituals) with economic actors (producers, artisans, hospitality providers, accommodation services), thereby offering a sustainable development framework for a region (Derrett, 2003).

According to the definition by Bottyán (2015), a gastronomic festival is any one- or multi-day event whose main purpose is to showcase local gastronomy, agricultural raw materials, and produce. This definition clearly emphasizes conveying local values, preserving cultural heritage, and strengthening economic actors operating in the field of gastronomy.

In the case of Szeklerland, gastronomic festivals play an important role in nurturing and presenting local identity. Events related to traditional Szekler dishes serve not only to increase interest in food but also to support the region's cultural self-representation. In this way, gastronomy as an endogenous development tool creates value not only economically but also socially and culturally.

Methodology

During the process of identifying gastronomic events, I considered any event to be a gastronomic festival if its name included some characteristic local dish, product, produce, or food production process, or if it contained a reference indicating that the purpose of the event was to promote local gastronomy or particular food item. First, I searched for such events on official websites presenting tourism services and programs (www.visitcovasna.ro, www.visitharghita.ro, and www.visitmures.ro), then on additional regional and local event portals. In total, I identified 16 events (see Table 1).

1.table: Gastronomy-related events in Szeklerland

	Location	Edition
Sausage Festival of Nicolești	Nicolești (Csíkszentmiklós)	12
Cea1 Borsec Festival	Borsec (Borszék)	7
Tusnad Gastro Blues Fest	Tușnad Băi (Tusnádfürdő)	3
Stuffed Cabbage Festival Praid	Praid (Parajd)	27
The Famous Cabbage Fair and Festival of Lazărea	Lazărea (Gyergyószárhegy)	17
Csángó Festival of Polenta with Cheese	Valea Rece (Hidegség)	19
Onion Festival Siculeni	Siculeni (Madéfalva)	14
Potato Festival Miercurea Ciuc	Miercurea-Ciuc (Csíkszereda)	24
Raspberry Harvest Festival	Vârșag (Székelyvarság)	45
Plum Days of Dealu	Dealu (Oroszhegy)	17

Flavors and Traditions of Mures Festival	Târgu-Mureș (Marosvásárhely)	1
Sausage Festival Zăbala	Zăbala (Zabola)	19
Festival of Sweet Flavors	Sfântu-Gheorghe (Sepsiszentgyörgy)	6
Pumpkin Festival	Sovata (Szováta)	9
Lanka Gastronomic Festival in Niraj Valley	Hodoșa (Székelyhodos)	1
Taste of Transylvania	Valea Boroș (Borospataka)	3

Subsequently, for each event, I examined their online communication and filtered out those events that only contained gastronomic references in their name but, based on the program offerings, could rather be classified as village fairs or community events. I also excluded festivals that had not been organized in the past 1–2 years.

Regarding online presence, I investigated what proprietary communication channels were used to present and promote the event (website, social media pages), whether they had distinctive, identifiable visual branding elements, and I also considered the language of communication. Besides their proprietary channels, I checked whether these events appeared in the tourism offerings of the region or individual settlements, as possible program suggestions.

For five selected festivals, I conducted further content analysis. I examined the textual content available online using thematic coding, based on six criteria: (1) Local identity and tradition, (2) Culinary heritage, (3) Tourism positioning, (4) Community experience, (5) Promise of experience / program offerings and (6) Support of the local economy.

Since not every event has its own website, and the existing ones are often incomplete, I also analyzed the texts of posts published on their Facebook pages and statements appearing in the press, in addition to the textual content of the websites.

I examined the following festivals: Festival of Sweet Flavors (Sfântu-Gheorghe/ Sepsiszentgyörgy), Sausage Festival (Zăbala / Zabola), Onion Festival (Siculeni / Madéfalva), Stuffed Cabbage Festival (Praid / Parajd), Csángó Festival of Polenta with Cheese (Valea Rece / Hidegség). The Taste of Transylvania gastro-festival was excluded from the study because, although it aims to promote Transylvanian gastronomy, it is an off-site event and it lacks any direct connection to Valea Boroș / Borospataka, where it is held.

Results

Online Presence of Gastronomic Festivals in Szeklerland

Examining the online communication activities of the selected events, it can be concluded that they primarily rely on social media platforms, with Facebook being the most commonly used communication channel. The use of Instagram and TikTok is completely absent. Periodic presence is the most typical pattern: the pages become more active in the weeks and days leading up to the event and then posts become less frequent after the event concludes. In several cases, these pages function as community advertising platforms during the remaining time of the year, especially for festivals where the organizer or co-organizer is the local municipality. They operate as supplementary, supportive municipal communication channels.

Even during active communication periods, visual content dominates the communication. Posts mostly contain photos, occasionally videos, accompanied by short, descriptive texts, but sometimes no comments are added at all. The photographs “tell the story” of the events; detailed textual information about the programs or activities taking place during the events is generally missing. Occasionally, general but mostly outdated descriptive information about the festivals is available in the Facebook page descriptions.

Few events have their own websites, but those that do are updated, informative, and available in multiple languages. However, even in these cases, the textual content that would provide detailed descriptions of the event's history, goals, and programs is relatively limited.

Communication is mostly bilingual (Hungarian and Romanian), but this mainly applies to events aiming to engage the local Romanian-speaking population. It is rare that Romanian is used specifically to address tourists.

Regarding visual branding, it can be concluded that all festivals have unique visual identity elements that enhance recognizability and strengthen their visual presence.

I considered it important to examine whether the individual events appear in the region's, area's, or even local tourism offerings. For this purpose, I reviewed the three official tourism websites, where a brief description was available for each event. However, on the websites of the municipalities, none of the events were mentioned among the information intended for tourists as potential tourist attractions. Some festivals do appear on a few mainly Hungary-targeted aggregator sites (such as programturizmus.hu, szekelyfoldiprogramok.hu), but even on these platforms, very little information is available about the events.

Among the festivals examined, the communication practices of the Csángó Festival of Polenta with Cheese stand out from the others in several respects. Firstly, this event, which has been held for 19 years, was initiated and is organized by a local tourism entrepreneur, whereas in most other cases the main organizer is usually the local municipality. It is the only festival among those studied that does not have any dedicated online communication channels or distinctive visual branding elements. Press communication is practically the only method used annually to promote the event.

Representation of Local Identity and Tradition

During the content analysis, I examined whether the textual narratives made references to the "Székely/Szekler" cuisine, folk dishes, or traditions. I looked for the presence of these elements as potential attractions or whether they were mentioned in the festival descriptions or program presentations. In all five examined events, such elements were identified. However, these usually did not appear on the festival's own communication platforms but rather in press materials and statements.

References were made to traditions, indicating that these events are connected to traditions either by showcasing such products (*"Visitors could get a taste of Szekler traditions, folk music and dance, and of course, the carefully, attentively, and lovingly prepared stuffed cabbages"*) or by highlighting that certain programs revive traditions (*"The festival's aim is to celebrate traditions in a festive framework and to motivate young people to revive this agricultural sector"*). The Szekler identity (*"The festive cake of Szekler families"*) is also mentioned in several places, as is the Csángó folklore (*"The event aims to nurture and showcase traditions; with authentic Csángó folklore!"*).

Presence of Culinary Heritage

Culinary heritage – meaning the dishes, recipes, expertise, and traditions developed in a particular region or culture and passed down through generations – is understood as a defining cultural value and a potential resource for a region. Therefore, I considered it important to examine whether the festivals' communication makes any reference to traditional recipes, local ingredients, food production processes, or methods.

Analyzing the texts, it can be concluded that these elements are not explicitly mentioned. However, from the program descriptions and published photos, it can be inferred that these events provide space for demonstrating traditional food preparation (such as chimney cake baking, sausage stuffing, stuffed cabbage making, and polenta cooking). There are no references to local, characteristic recipes; instead, the more general term "traditional recipes" is used: *"Chimney cake prepared based on a traditional recipe."*; *"Stuffed cabbage made according to traditional recipes."*

The narrative does not specify how individual ingredients or foods relate to a particular place; mostly, only general references are found: *"Polenta cooking – a cooking competition that promotes the cult*

of the local dish.”; “Sausage stuffing – evokes the excitement of winter pig slaughter and communal sausage making.”

Tourism Positioning

Whether a festival is considered a tourist attraction or rather a local community-building event also depends on how it defines itself, to what extent it regards “outsiders” as a potential target audience, and whether it addresses them at all. Does the narrative mention whether the event is distinctive and interesting enough to attract visitors?

Examining the textual content of the five festivals, it can be concluded that although a few sentences suggest these events are open to welcoming tourists, they primarily target the local community: *“Local communities, the ‘tizesek’ (groups of ten), organize their own celebrations and invite visitors for tastings, which worked very well; both locals and visitors had excellent experiences.”; “Honoring polenta boosts regional tourism and the shepherding businesses.”*

While the communication implies that the primary audience is the local community, several slogans appear that could position the events from a tourism perspective: *“Szeklerland’s, and Romania’s first gastronomic festival; a unique event distinctly connected to Praid.”; “The oldest gastronomic event in Szeklerland; with this event, we want to spread the fame of Szekler cuisine far and wide.”*

Promise of Community Experience

To define the main role of the festivals, in addition to tourism positioning, it is important to also examine how much emphasis is placed on community programs and community building in their communication. This can indirectly indicate who the primary target audience is.

The communication content clearly suggests that in the case of the examined festivals, the community experience – and the promise of it – plays a more prominent role than gastronomy. *“A generational event offering programs and activities for everyone from the youngest to the oldest... contributing to strengthening family bonds.”; “Community and flavor festival.”; “The residents of the village need times when they can stop, be together, and have fun.”*

Various reports, program descriptions and reviews suggest that these events are much more about the joy of being together than about the gastronomic experience – at least this is what is emphasized in their communication.

Program Offerings

The attractiveness of the festivals is largely determined by the program offerings and the experiences promised to visitors. Therefore, during the text analysis, it was examined what kind of program descriptions the festivals provide and whether they promise unique gastronomic or other experiences. It can be observed that gastronomic program points barely appear in the descriptions; folk-style programs related to the preservation of traditions are much more heavily emphasized: *“Folk music, folk dance, and tradition preservation come to the forefront.”; “Folk music programs await participants.”; “The program includes performances by folk dance groups, folk costume presentations, and concerts.”* Consequently, press materials also mainly highlight and promote these programs.

There is a noticeable association between gastronomic events and village fairs; none of the festivals focus solely on gastronomy. In every case, accompanying programs are also organized: sports events, concerts, lectures: *“Concerts, exhibitions, sports events, and folk music programs await visitors.”; “Cultural, tradition-preserving, and gastronomic programs, as well as sports events, welcome visitors.”* Information about gastronomic experiences is mostly available through program booklets and the shared visual content.

Conclusion

The analysis also highlighted that most of the examined gastronomic festivals have a significant history, which may explain why the organizers do not feel the need to precisely define the goals and

nature of the events. Most organizers take it for granted that “everyone” knows these events, so they do not emphasize repositioning, presentation, or preparing more detailed descriptions. It is easy to observe that year after year the same communication frameworks, scripts and content appear, often adopted unchanged by the local press. The repetition of programs and the template nature of the content can become an obstacle to development.

These events primarily target local communities and do not consciously address tourists—although their potential would allow for this. The incomplete, mainly visually focused communication, along with underrepresentation on tourism portals, also indicates that information transfer primarily occurs informally within the community. These festivals mostly do not appear in the official tourism offerings of their settlements.

Moreover, it is noticeable that culinary features often take a backseat to community and entertainment-oriented programs. Gastronomic offerings do not always receive adequate emphasis in communication, and there is a lack of thematic focus that would allow visitors to expect a genuine gastronomic experience. Thus, the festivals often “blend” with other types of local events, such as village fairs, which can weaken gastro-tourism brand building.

Szeklerland’s gastronomic festivals play a significant role in preserving local identity and cultural heritage, yet in their current form, they are less suitable for positioning as tourist attractions. Conscious steps toward renewal, strengthening unique themes, targeted experience-based communication, enhancing narrative elements, and emphasizing culinary content could contribute to these festivals being recognized not only as local events but also as attractive, identity-bearing tourist attractions for a broader audience, becoming complex tools for rural development.

Future research directions could include tracking the life cycle of gastronomic festivals and examining how to balance community and tourism objectives.

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LEADING THE FUTURE: INNOVATIONS AND CHALLENGES IN MODERN MANAGEMENT

BEYOND THE WHEEL: MANAGING INNOVATION AND CHALLENGES IN THE AUTOMOTIVE SECTOR

NOÉMI LÓRINCZ, MÁRTA KISS, GERGELY BALÁZS

Abstract

Today, the automotive industry is experiencing a lifetime transformation alongside one of its most significant challenges. As electric and self-driving technologies become familiar, the industry's future is shaped by accelerated technological changes and the war for raw materials due to availabilities and sustainability guidelines transforming the competitive landscape (Calza et al., 2017). The adoption of electric vehicles is primarily driven by environmental policies to combat climate change and initiatives that encourage using renewable energy to power these vehicles (Llopis-Albert et al., 2021). With the introduction of the ESG (environmental, social, and governance) law by the European Union, sustainability has become a legal obligation, imposing environmental requirements on companies and their suppliers, which is also driving operational adoption. As a result of this complex transformation process, there are new regulations and many new entrants with modern solutions on the market who disrupt the current business operations (Simonazzi et al., 2020). Innovations like generative artificial intelligence (GenAI) and a wide range of software solutions create new company opportunities (Haridasan–Jawale, 2024). GenAI is a key part of this change because it improves design, makes supply chains more efficient, and improves predictive maintenance. From an environmental standpoint, the proliferation of the circular economy significantly contributes by providing a systemic solution within the automobile sector through the reevaluation and reorganization of the entire product life cycle. This approach emphasizes the importance of extending the life of products through design for durability, reuse, and remanufacturing and prioritizes recycling materials to minimize waste (WEF, 2024). These trends empower suppliers to cut costs, reduce waste, and drive innovation faster. Industry players must adjust to the evolving landscape (Llopis-Albert et al., 2021). Companies that fail to embrace innovations in quality management, knowledge management, performance management, project management, and data visualization will face a significant competitive disadvantage in the market (Dumitrascu et al., 2020).

This research offers valuable insights for automotive industry managers while inspiring future scholars to explore AI applications across various sectors, including planning, manufacturing, sales, and after-sales processes. It also highlights the challenges of ESG compliance and the opportunities and expectations the circular economy offers.

Keywords – artificial intelligence (AI), technology management, innovation management, circular economy, ESG

1 Introduction

The automotive industry is one of the fastest-growing industries, a significant employer and investor, and one of the most important industrial sectors in the European Union (EU) (Tabajdi, 2025). Research and development (R&D) accounts for 31% of overall expenditures, and its revenue represents 7% of the EU Gross Domestic Product (GDP). It employs 13.8 million Europeans, both directly and indirectly, representing 7% of all occupations in the EU (Reuters, 2025; ACEA, 2024). The 21st century has brought significant changes to the industry through digitalization and lower-emission propulsion, primarily through a shift towards electrification, which can be described as

megatrends in the automotive industry (Delanote et al., 2022; Pavlínek, 2023). The forced transition to electric vehicles caused by EU CO2 emission guidelines presents a significant challenge for car manufacturers. They will have to overhaul their existing production processes completely, including raw material procurement and supply chains, because electric cars require different components. In addition to the apparent effects on product solutions, digitalization and electrification significantly impact the European automotive industry's production map (Tabajdi, 2025). These trends are shaping companies' international work and activity organization, development, investment, and location decisions, as well as any relocation decisions, and the determinants are considered when making these decisions (Grievesson et al., 2021; Pavlínek, 2023). Besides emerging technologies, sustainability initiatives, protectionist measures, and customer preferences are also driving a reconfiguration of the automotive sector these days. The European growth of Chinese electric car manufacturers and Trump's unpredictable foreign policies, including protective tariffs, complicate matters for the European automotive industry, which is already undergoing significant upheaval. The widespread adoption of electric cars requires the development of appropriate infrastructure and a reliable, high-capacity electricity grid, so closer cooperation between the automotive industry and electric utility companies is likely in the future. Changing consumer tastes are also a concern that cannot be overlooked since younger generations, particularly those living in cities, are less interested in having a car, and the proliferation of car-sharing firms is impacting demand for automobiles.

This paper, on the one hand, identifies the likely uptake of AI in the automotive industry and its impact on manufacturing processes, including predictions of production line failures, logistics, and employment in Europe. These measures are implemented to improve product quality, control costs, and improve productivity. On the other hand, the other main topic of the research paper is sustainability, including measures, opportunities, and challenges related to the circular economy and environmental, social, and governance (ESG) regulations, which also significantly impact companies' competitive position. These impacts on production processes, supply chains, productivity, and industrial relations will be explored through questionnaires and semi-structured interviews with automotive industry actors and experts. This study will also explore the implications of digitalization and the adoption of artificial intelligence on employment patterns and evolving skill requirements within the automotive sector, particularly in light of increasing investments in automation and predictive analytics.

The paper will contribute to answering the following questions.

Topic AI:

- What is the current level of AI adoption across different functions in the automotive manufacturing sector?
- What are automotive companies' most significant challenges in integrating AI technologies?
- How do industry players envision the role of AI in shaping the future of the automotive industry over the next decade?

Topic Sustainability:

- What strategies do automotive players employ to comply with sustainability requirements while maintaining profitability?
- What challenges do companies face in meeting ESG obligations, and how do they address them?
- What circular economy initiatives can be observed among automotive manufacturers?

The study's focus on Europe makes it an intriguing case study because of the significance of the automotive sector, the high number of original equipment manufacturers (OEMs), and the substantial R&D expenditures, including sustainability and artificial intelligence. The vast and wide-ranging

supplier network enables an analysis of the entire supply chain from the standpoint of AI and sustainability. However, as mentioned earlier, the industry faces several challenges, including the need to comply with strict CO2 emission limits, the transition to electric vehicles, growing competition from Chinese manufacturers, and the uncertain geopolitical situation. For these reasons, the European Commission has launched strategic discussions to increase the industry's competitiveness and ensure long-term growth (European Commission, 2025).

The article is structured as follows: After presenting the relevance of the European automotive industry, it outlines the latest challenges and opportunities facing the automotive industry, including the spread of artificial intelligence and the green transition, including the circular economy and environmental regulations such as ESG. The data comes from databases, scientific journals, and interviews, and the research illustrates with examples the impact of research and development and other green initiatives on various areas of the automotive industry. Potential applications of AI, sustainability initiatives, the effects of green policies and the research approach are listed in Section 2 (Material and Methods). It offers pertinent literature and illustrates how these impact specific labour and trust components. The study's primary findings are presented in Section 3 (Results and Discussions), and the key conclusions, restrictions, and potential avenues for further research are outlined in Section 4 (Conclusion).

2 Material and Methods

2.1 Material

Real-time planning considering rivals' activity and market trends is required because markets are very competitive, and all organizations have a global presence. Companies can no longer operate in markets that require only quarterly or annual planning (Koricanac, 2021). Only by early adoption of new technologies can automotive companies gain a significant competitive advantage by successfully implementing Artificial Intelligence (AI). Regarding working conditions, qualifications, and skill requirements, the importance of smart manufacturing in the automotive industry has also been extensively documented (Moniz et al., 2022).

2.1.1 Artificial intelligence (AI) in production processes in the automotive industry

One of the key subjects covered in this article is artificial intelligence, which includes technologies such as cyber-physical systems, intelligent automation, robots, and the Internet of Things (European Commission, 2020). AI is a machine or software program that can think, understand, and make decisions like human beings. Though AI has not yet reached its full potential, several systems have been used in various sectors of different industries. The automotive industry will ultimately be transformed by employing more sophisticated AI systems. The applications of AI in the automobile industry are not just limited to the manufacturing plant or the assembly line, as is the case in other sectors. Almost all parts of the automotive industry, including suppliers and, even more broadly, even regulators, have a tremendous untapped potential for applying AI (Kamran, 2022).

A recent example of using artificial intelligence in the automotive industry: General Motors employs AI to create prototypes for their automobiles. This technology, known as Dreamcatcher, was recently employed to build a new seatbelt holder that is 40% lighter and 20% stronger than its original design (Capgemini Research Institute, 2019).

Internet of Things (IoT)

The Internet of Things (IoT) enables the connectivity of industrial resources such as sensors, machinery, and other equipment, improving interconnectivity among components while reducing human engagement. IoT allows for real-time, accurate monitoring of product quality, equipment, and manufacturing processes. The real-time data stream enables early problem detection and improves

insight into the movement of materials and goods (Msakni et al., 2023). Furthermore, cloud computing makes data accessible to other systems with powerful resources, such as servers, storage, and software (Lee & Lee, 2015). There are several benefits to using IoT solutions in the automotive industry. For example, by removing the rejection of harnesses (19%), there is a verified considerable improvement in quality (21%) and productivity (15%) and cost savings through IoT-based solutions that enable operators, supervisors, and managers to reach defect spots in the shortest amount of time, helping to reduce communication delays and allowing for prompt treatment of products that have defects (Vishnu-Keshav, 2023).

Machine Learning

Machine learning (ML) is a computer program that is said to learn from experience ‘E’ concerning some class of tasks ‘T’ and performance measure ‘P’ if its performance at tasks in ‘T,’ as measured by ‘P,’ improves with experience ‘E’ (Mitchell, 1997). Machine learning, a possible development in manufacturing, permits decentralized, autonomous, real-time decision-making without human intervention. It provides the advantage of handling large and complicated operations while allowing for ongoing quality improvement. It helps to handle intricate and extensive procedures and enables continuing quality improvement (Dogan-Birant, 2021). This program is employed at numerous levels of industrial processes in Industry 4.0, such as anomaly detection, process optimization, predictive maintenance, quality control, diagnostics, and resource management (Roblek et al., 2016). AI and ML aim to eliminate inefficiencies and uncertainties within supply chains. AI enables significant optimization through, among other aspects, superior planning, improved safety conditions, and significant cost reductions resulting from higher output (Koricanac, 2021).

One notable case study involves General Electric (GE), which has integrated IoT and AI-driven analytics into its industrial operations. GE has reduced maintenance costs and improved asset utilization by analyzing real-time sensor data. Other companies, such as Siemens and Bosch, have also developed predictive maintenance platforms that leverage ML for enhanced fault detection (Elvis-Agoro, 2025).

Supply chains

AI in supply chains helps firms improve inventory management accuracy, increase worker safety, optimize warehouse efficiency, reduce operating costs, and ensure timely product manufacture and delivery. Unlike other industries, the automotive supply chain has evolved dramatically, including the most recent technological breakthroughs (Koricanac, 2021). Compared to traditional supply chains, AI supply chains can increase demand forecasting accuracy from 75 to 80% to 90% or even higher, as well as inventory management and turnover 3-6 times per year to 6-10 times yearly. The AI supply chain can decrease overall transportation costs by 10-20%, and optimum usage of resources due to AI in automotive production can help reduce wastage by up to 15-20%, which will lead to cost savings and sustainability (Banerjee et al., 2024).

The automotive industry necessitates a highly complex supply chain system. Each car contains 20,000 parts from several sources (Reidy, 2019). Automobile manufacturers must have exceptionally sophisticated procurement systems to coordinate purchasing several parts for a single vehicle and ensure that the production process is completed on time (Koricanac, 2021).

In conclusion, some benefits of implementing AI into the supply chain include shorter process cycle times, increased operational productivity, and faster continuous improvement across the whole supply chain. Over the next five years, these benefits are expected to triple the level of supply chain automation driven by AI (Jacobs, 2020).

Quality assurance

Maintaining high-quality methods and products is critical to success in a competitive environment. Product quality in manufacturing is related to the product's functioning features, which must be free

of faults and conditions that exceed tolerance. Ensuring that any manufactured product meets the requirements is known as quality control. Products that do not meet the standards are judged to be of low quality and removed from the assembly line. Temperature, humidity, and changes in raw materials and equipment are just a few of the variables that may influence quality during the manufacturing process (Msakni et al., 2023). Quality control, with the help of computer supervision and ML, can decrease the traditional defect rate of 2-5% to 0.5-1% by improving product quality and reducing the cost of rework (Banerjee et al., 2024).

Workforce

AI's development will undoubtedly impact the workforce. As processes become more efficient, automation and robotics will displace many occupations. Furthermore, electric vehicles require fewer parts, which influences and simplifies production processes. Layoffs by established market leaders are important evidence of the industry's substantial transformation. Since November 2019, General Motors has closed five plants and laid off more than 14,000 employees (Koricanac, 2021). On the other hand, a study was made about the workforce implication in Portugal in the automotive industry and found that where salaries are low, recent automation trends, including AI, may not be able to compete in the short and medium term with the wages only if large volumes or high-quality products are needed. In the short and medium term, automation projects will postpone or augment the existing workforce and not replace the current workers (Moniz et al., 2022).

Trust

Given the era in which the age cohorts were raised, the needs and expectations of millennials and Generation Z regarding automobiles would differ significantly from those of previous generations (Koricanac, 2021). These needs are expected to have a critical influence in defining the global automobile industry. Similar generational gaps exist in opinions about AI. Feelings across generations heavily drive the acceptance of AI. Younger people are generally more responsive to and adaptable to AI-powered products due to their higher level of digital literacy. On the other hand, older adults are often apprehensive because they believe these devices are intrusive or impersonal.

2.1.2 Sustainability: Circular economy and ESG regulations

The automotive industry is also experiencing a fundamental paradigm shift from the traditional linear "take-make-dispose" model toward a circular economy framework that emphasizes designing out waste, keeping products and materials in use, and regenerating natural systems (Ellen MacArthur Foundation, 2021). This transformation represents more than an environmental aspiration; it has evolved into a strategic and economic imperative, particularly within Europe, where comprehensive regulatory frameworks mandate systematic adoption across the automotive value chain (European Commission, 2023a). The circular economy paradigm in automotive manufacturing encompasses several interconnected principles that fundamentally alter traditional production and consumption patterns. Design for durability and disassembly represents a foundational shift where modern vehicles increasingly incorporate modular designs, mono-material components, and specialized fastening systems that enable efficient separation during end-of-life processing (Bocken et al., 2016). Concurrent with design innovation, the industry is embracing remanufacturing and refurbishing strategies for high-value components, including transmissions, batteries, and electronic control units, with these components being engineered explicitly for multiple life cycles rather than single-use applications (APRA, 2022). Material recovery and recycling constitute another critical dimension, where advanced sorting technologies and chemical recycling processes enable closed-loop material flows that maintain material quality across multiple use cycles (Dervojeda et al., 2022). Furthermore, product life extension strategies through service-based business models and technological upgrade pathways fundamentally alter traditional vehicle ownership patterns while extending operational vehicle lifecycles (WEF, 2024).

Regulatory Framework and Compliance Imperatives

The European Union's revised End-of-Life Vehicles Regulation, enacted in 2023, represents a paradigmatic shift in automotive circularity requirements that extends far beyond previous voluntary initiatives (European Commission, 2023a). The regulation establishes mandatory recycled content requirements, stipulating that from 2030, new vehicles must contain at least 25% recycled plastic content, with 6.25 % specifically sourced from post-consumer end-of-life vehicles (European Parliament, 2023). This requirement necessitates comprehensive supply chain restructuring to establish reliable sources of high-quality recycled materials.

Extended Producer Responsibility provisions fundamentally alter manufacturer obligations by making OEMs financially responsible for vehicle dismantling and recycling according to environmental best practices. This responsibility extends throughout the product lifecycle and requires manufacturers to internalize previously externalized environmental costs. Digital product passports represent another transformative requirement, mandating comprehensive traceability systems documenting material composition, component origins, and recyclability data throughout vehicle lifecycles. The regulation's expanded scope increases coverage from six to eighteen million regulated units annually by including vans, motorcycles, and light commercial vehicles (European Parliament, 2023). Complementing automotive-specific regulations, the EU Battery Regulation of 2023 establishes minimum recycled content thresholds for electric vehicle batteries, requiring sixteen percent cobalt, six percent lithium, and six percent nickel content from recycled sources by 2030 (European Commission, 2023b). These regulations collectively create a comprehensive framework that transforms automotive manufacturing from a linear to a circular model while establishing Europe as a global leader in sustainable automotive production.

Implementation Strategies Across the Automotive Value Chain

Successful circular economy implementation requires systematic transformation across multiple stages of the automotive value chain, beginning with fundamental changes in design and development processes. Integration of life cycle assessment tools during early design stages enables engineers to evaluate environmental impacts and circularity potential before final production decisions. Material selection criteria increasingly prioritize recyclability, durability, and bio-based alternatives while maintaining performance specifications required for automotive applications. Modular architectural approaches enable component upgradeability and repair capabilities that extend product lifecycles and facilitate material recovery. Manufacturing and supply chain transformation involve comprehensive supplier integration in reverse material flows and core return programs establishing circular material loops. Investment in disassembly and recycling infrastructure represents a significant capital commitment that enables manufacturers to meet regulatory requirements while capturing value from end-of-life materials. Digital twin technologies provide sophisticated material content tracking and optimization capabilities that enable precise management of complex material flows across global supply networks. End-of-life management requires the development of efficient collection and dismantling networks that can process vehicles according to circular economy principles while maintaining economic viability. Advanced material recovery technologies, including artificial intelligence-powered sorting systems, enable precise material separation and quality assessment that supports high-value recycling applications. Establishing regional remanufacturing centers creates local circular economy ecosystems that reduce transportation costs while providing employment opportunities in emerging green economy sectors.

Economic Impacts and Value Creation

Circular economy adoption generates multiple value streams that extend beyond traditional cost-reduction strategies. Material input cost reductions of five to fifteen percent through recycled content utilization provide direct bottom-line benefits while reducing exposure to volatile commodity markets (European Environment Agency, 2023). Production waste reduction of up to fifty percent through process optimization eliminates disposal costs while recovering valuable materials for reuse (EEA,

2023). Remanufacturing operations demonstrate cost advantages of thirty to fifty percent compared to new part production while maintaining equivalent performance specifications (APRA, 2022). New revenue opportunities emerge through innovative business models that capitalize on circular economy principles. Parts-as-a-service models incorporate embedded refurbishment cycles that generate recurring revenue streams while ensuring optimal component utilization. Material sales from recovered high-value materials create additional revenue sources while reducing raw material procurement costs. Subscription-based mobility services designed for circularity optimize vehicle utilization rates while supporting sustainable transportation models. Risk mitigation represents a critical value proposition as circular economy practices reduce exposure to volatile commodity prices and supply chain disruptions that have characterized recent automotive industry challenges. Enhanced environmental, social, and governance compliance reduces regulatory and reputational risks while improving access to green finance and sustainable investment capital that increasingly influences corporate valuation and growth opportunities.

AI-Enabled Circular Economy: Digital-Physical Convergence

The convergence of artificial intelligence technologies and circular economy principles represents a transformative force in automotive manufacturing that creates synergies, amplifying the benefits of both paradigms. AI technologies are essential enablers of circular economy practices, while circular economy requirements simultaneously drive innovation in AI applications and data management systems (Bag et al., 2021). This convergence addresses the complexity inherent in circular economy implementation while leveraging computational capabilities to optimize resource flows and decision-making processes. Predictive analytics applications utilize machine learning algorithms to analyze historical component performance data, enabling optimization of material usage patterns, accurately predicting component failure rates, and determining optimal timing for remanufacturing interventions. BMW's implementation of AI-powered systems exemplifies this approach by predicting when vehicle components will reach end-of-life conditions, enabling proactive collection scheduling and refurbishment planning that maximizes component value recovery (Capgemini Research Institute, 2019). These predictive capabilities reduce waste while ensuring optimal resource utilization across extended product lifecycles.

Intelligent sorting and material recovery systems employ computer vision and deep learning technologies to enable automated identification and separation of materials during vehicle dismantling. AI-powered robotic systems can distinguish between different plastic types, metal alloys, and composite materials with accuracy rates exceeding ninety-five percent, representing significant improvements over manual sorting processes while reducing labour costs and processing time (Zhang et al., 2023). This technological capability is essential for meeting recycled content requirements while maintaining material quality standards.

Supply chain optimization for circular flows utilizes sophisticated AI algorithms to manage complex reverse logistics networks, determining optimal routes for component collection, processing locations for remanufacturing operations, and redistribution channels for circular materials. These optimization systems reduce transportation costs by twenty to thirty percent while improving material recovery rates through enhanced coordination of diverse stakeholders across the circular economy ecosystem (Nascimento et al., 2022). Digital product passports represent a convergence of IoT sensors and AI analytics that create comprehensive digital twins of vehicles and components throughout their operational lifecycles. These systems continuously track material composition, usage patterns, maintenance history, and degradation rates, enabling precise decisions regarding repair, reuse, or recycling options based on real-time condition assessment rather than predetermined schedules (Bag et al., 2021). This capability supports regulatory compliance while optimizing value recovery from circular economy processes. Quality control applications in remanufacturing operations employ AI-powered inspection systems to assess component quality and predict remaining useful life during refurbishment. ML models trained on extensive component degradation datasets can predict the performance reliability of remanufactured parts with accuracy sufficient to ensure compliance with

original equipment specifications (Msakni et al., 2023). This capability addresses quality concerns that have historically limited remanufactured component adoption while building consumer confidence in circular economy products.

2.2 Methods

This study employs a *qualitative methodology* centered on theme analysis of primary interview data as its principal empirical source. The research is based on primary data (3 *semi-structured interviews* with automotive experts) and secondary data (EU industry reports, academic journals, and strategic automotive reports). The research seeks to investigate the degree and potential prevalence of automotive entities employing AI-based technologies in manufacturing. The study examines how these solutions can expedite production processes and decrease costs, including the impact on human resources through diminished personal connection. The research will examine the significance of trust and accountability in formulating solutions within AI. The research also examines environmental compliance concerns and the complexities of enforcing ESG legislation, which must be applied to the supply chain, potentially leading to interruptions. Another pillar of environmental protection is the circular economy and its role in the day-to-day operations of car manufacturers.

An *exploratory study* design combined in-depth interviews to obtain a more profound knowledge of the topic because it was still in its infancy. This methodological technique made it possible to examine participants' viewpoints and experiences in the particular setting of the study (Seidman, 2006)—the study's exploratory component aimed to understand better the phenomenon rather than test preconceived hypotheses. The interview guide was meticulously developed throughout the research process based on a comprehensive literature review that elucidated significant themes and study-related concerns. Without prescribing a rigid format for the questions, such a guide gives researchers a flexible framework that facilitates the collection of comparable data during interviews.

The elements impacting genAI in the manufacturing sector are being examined in increasing amounts of paper. Nevertheless, there is a paucity of literature offering a thorough analysis of the application of AI by auto suppliers and manufacturers. In order to close this gap, this study examines the degree to which artificial intelligence is utilized in the production of automobiles in this region by analyzing top European automakers (OEMs) and suppliers. Furthermore, one of the primary forces behind the current automotive transition is environmental protection and the EU regulations governing it; therefore, the analysis cannot ignore actions taken by automakers in this area. Thus, the circular economy and ESG are also included. Consequently, the following research questions are addressed in the article:

RQ1: How much and for what purposes do automakers and suppliers employ artificial intelligence?

RQ2: How does ESG regulation impact automakers' day-to-day operations and management, including suppliers, and how does the circular economy present itself in general?

The long-term purpose of the project is to investigate these topics using a mixed-methodological approach that combines quantitative and qualitative methodologies. Because the study is still in its early stages, the principal findings are entirely based on professional interviews. As a further step, we will distribute a questionnaire to Europe's biggest auto manufacturers and suppliers to better understand the usage of AI in the industry's manufacturing processes and sustainability measures. The interview consists of 35 questions divided into six major areas: (1) the introduction of artificial intelligence into automotive manufacturing processes; (2) the role of AI in supply chain optimization; (3) the role of AI in production efficiency and quality control; (4) AI challenges and the future of AI in the automotive industry; (5) ESG; and (6) the circular economy. The questionnaire covers similar subjects and includes multiple-choice, Likert scale, and open-ended questions, allowing for quantitative and qualitative data collection. Descriptive statistics and thematic analysis, including

coding for open-ended responses, will be used to identify emerging trends and supplier concerns. The planned 5-10 interviews will primarily focus on senior automotive industry specialists (executive level, e.g., VPs). The questionnaires will be distributed to mid-level professionals (engineers and managers). Overall, the study will target 60+ respondents who will be chosen based on the following criteria: automotive industry operators working in manufacturing, logistics, or technology integration; representation of small, medium, and big businesses; and an emphasis on the European market. Participants will include decision-makers, engineers, and supply chain managers with firsthand experience with artificial intelligence and sustainability challenges. The study will involve a wide range of stakeholders in the automotive AI and environmental field, focusing on consultants and industry professionals with extensive hands-on experience with various automotive-related activities. Working with these professionals serves two purposes: first, it gives a comprehensive picture of current development paths; second, it increases understanding of critical issues such as creating confidence in AI applications and human resource challenges (redundancies, AI training). The interview phase began in the spring of 2025, following a comprehensive review of the available information, and is still ongoing. This article presents some of the outcomes. This stage thoroughly researches the subject and, ultimately, gives recommendations for successfully integrating AI-based technology into the automotive sector and addressing the significant challenges that industry players confront with ESG measures and circular economy ideas.

The interviews were audio-recorded and transcribed to ensure accurate data processing and analysis. The study objectives, data processing techniques, and anonymity were thoroughly described to participants to ensure their comfort and consent. Three in-depth interviews were done with well-known consultants and automotive industry professionals during this research stage. Table 1 outlines the interviewees' professional experience.

Table 1: Details of the interviews - company type and role of interviewees

	Company type	Position
Interviewee 1	An automotive software developer company	Product Director with 8+ years of experience in strategic operations and corporate finance across multiple industries, including automotive software, telecommunications, corporate finance advisory, and banking. Proven track record in supporting senior management, financial reporting, and organizing processes to enhance smooth business operations. Well-versed in structuring poorly defined problems, optimizing processes, and delivering high-quality results with a strong analytical mindset and attention to detail.
Interviewee 2	A top management consulting company	Head of Automotive and Industrial Goods Competence Centre with 12+ years of experience in participating and managing various projects in Automotive, Industrial Goods, and high-tech industries in the field of production, capacity and process optimization, logistic and controlling concept making, and IT system implementation.
Interviewee 3	A major Japanese OEM	General Manager (IMechE Fellow professional senior manager) with 30+ years of experience working in a high-paced manufacturing environment.

3 Results and Discussions

3.1 Applications and challenges of AI in car manufacturing

One interviewee, who was educated in software manufacturing and self-driving automobiles, said the following: AI-based self-driving software is a significant trend, probably personified by Tesla, and in the last year or two, they have seen Chinese companies, primarily electric car makers, gain headway, so it is worth noting that their self-driving software is also AI-powered. As a result, those who can advance this technology can carve out a significantly more substantial place in the market. Regarding the future of self-driving cars, the main question will be who will be the first to put self-driving software into production, without a human driver, in a safe and universally applicable manner (e.g., in the case of Robotaxis). When these features are integrated into mass-produced vehicles, he expects to see significant progress in autonomous driving on highways, which means that when someone gets on the highway, he or she can let go of the steering wheel until exiting, including the ability to change lanes. If there is a traffic jam, they can slow down and maneuver. So, leaping to the conclusion that self-driving cars would work globally is unrealistic; incremental steps are imaginable.

The interviewee makes substantial use of AI technologies at work. They say that while AI can help in some aspects of business, it cannot replace professionals' jobs in others. So, for example, a few years ago, this was standard physical labour. Most of the outsourcing was done in India, where they annotated these very cheaply, and this was a significant step forward for them in recent years because they could outsource the manual work after the entire AI-based annotation and data collection process was solved. However, they still must go to the cars to collect this data. However, from that point forward, the data is entered into an AI-based pipeline, which is highly efficient. The car still has to go out and collect the data, but an AI-based pipeline takes the data and annotates it, which has now reached a level of precision superior to manual annotation.

He generally believes that using AI is not a question of money. It is more a question of literacy or openness. He sees about self-driving or automated driving software that companies that have traditionally been innovative have embraced sooner. In contrast, mass car manufacturers, whether it is Suzuki or an Indian company, do not care if they have a car. However, they do not necessarily look at how much technology goes into it because they are targeting a lower market segment with less demand for technology. They want to make a car but do not necessarily look at how much technology goes into it because they target a lower market segment. There is less focus on premium features like self-driving or fancy navigation systems. Somehow, he sees that innovative companies are better at adopting these things, while those that are not are lagging, but they also realize that as this becomes widespread, they have to keep up. So, it is less about money and more about AI literacy and how widespread it is in corporate culture. Moreover, he added that self-driving automobiles can only be solved in a scalable manner using AI.

The other expert noted that the most significant innovation in manufacturing is the proliferation of humanoid robots. The most prominent players, who have the most capital, are also leading the way here. However, it should be noted that the automotive business is not currently the most competitive, at least in Europe. So there are challenges, and efficiency is undoubtedly critical, but when Trump changes his mind about tariffs daily, management is easily distracted from their focus. Looking down the supply chain, we can observe that smaller companies are less likely to have these advanced solutions. The reason is, on the one hand, that these are capital-intensive. On the other, we are witnessing smaller and smaller amounts of components with less and less added value, for which the return on investment may be slower than in a vehicle plant. So, for example, last week, he was at an automotive supplier, and it was evident that they were performing an inordinate number of seemingly effortless manual operations. An operator sat at a small workstation, soldering circuits, building little units, connecting batteries, threading cables, etc. These are tasks that humanoid robots cannot yet perform or can only accomplish at a significant cost. It is not worth it yet, but we can see that *peda* humanoid robots are on track to cost half as much as they do now on average in five years, and they will be advanced enough to perform fine motor movements like assembly, packing, and

preparation. His experience shows that smaller suppliers are less likely to offer AI-related solutions. For example, they have automated production lines with machine-mounted camera inspections but are still integrating them into their manufacturing. The same is true for previously available machine learning applications; however, large, robust integrated systems may not benefit them because of economies of scale. In the case of larger companies, there are also examples of subsidiaries dealing with AI within the company.

3.1.1 Supply chain optimization

The other respondent noted that, for example, AI is currently quite good at providing three competing bids for a specific offer in procurement processes. AI can easily make short evaluations from the tender material. In the supply chain, several optimization techniques, such as supply and demand planning, are used for medium-term planning. Large firms have long produced planning systems to assist in balancing supply and demand in the medium term, and they can enhance demand forecasting with a machine learning solution.

3.1.2 Production efficiency

Regarding manufacturing efficiency, our interviewees stated that China has surpassed Europe. It appears that they are bringing manufacturing here because Europe still has significant purchasing power; we buy many cars in relative terms, and they do not want to be hit with additional customs duties, so they are bringing manufacturing here, but then BYD comes along, and we are struggling here. However, there should be a few Hungarian suppliers, and they are not interested in extending the Hungarian supplier base because they may have to bring many parts from China, which is more profitable for them in many circumstances. He noted that while he believes it is generally good that the Chinese are generating such rivalry, he is skeptical that this will result in easy entry for European firms.

Collaborative robots first appeared in production ten years ago, when it was no longer necessary to confine robots in cages since they were equipped with sensors and humans could stand next to them and carry out industrial tasks simultaneously. The *humanoid robot* represents the next level.

When asked how AI effectiveness is measured, the answer was regarding *safety, quality, productivity, and costs*. No specific KPIs were established beyond these main KPIs in general.

3.1.3 Quality control

The most prominent example of quality management is machine vision systems, which use AI to handle quality control operations. So, if we look at a car body, for example, dust accumulates beneath the paint, the paint layer is uneven, there is more in some places and less in others, there are scratches and dents, and ways for filtering these out have been around for a long time. Some automotive companies use sensors on conveyor belts to detect where a failure is likely to occur. This disrupts the flow of materials, stopping the production line. Wear and tear on machine tools is another example. Various ML solutions may now anticipate when to maintain a specific wear component or machine, ensuring that any downtime on the production line is planned.

The other respondent stated that they substituted human inspection processes with AI inspection techniques in QA. Moreover, they have equipment capable of performing tasks for two or three persons, for example. They also acquired a little bit of, well, not AI, but they are starting to use the IoT and connecting devices. So, they now have many visualizations of equipment and associated devices. However, the next stage is to implement AI. However, they will not replace people. Finally, it remains highly people-centric. Moreover, one example is a product they are about to launch that is a supplementary mechanism for break leak detection. So, asking a human to look for a tiny brake fluid leak is difficult and stressful. So, they will continue to use humans, but with AI support. So, both the AI and the human are making the decision.

3.1.4 Key development areas: organizational processes, including digitization and data management, and AI literacy

According to the respondents, the following areas should be improved to successfully integrate AI-based solutions into automotive manufacturing processes: enhancing AI skills and optimizing organizational processes, including accelerating digitalization and proper data management and storage.

When questioned about the challenges or impediments to using AI technologies, they stated that one of the most important considerations is the return on investment. Another factor is the human capital necessary for implementation. They are working to transition from a reactive to a proactive approach. There is usually a scarcity of engineers and skilled workers.

3.2 The impact of environmental measures on company operations and supply chains

The impact of ESG laws is being felt in how businesses function. For example, one of our respondents stated that they had software that allowed them to avoid testing self-driving systems in real life since they could get the same result with a software solution. This saves many resources and cuts CO2 emissions to a fraction of what they would typically be.

Our other respondent emphasized that it seems that, due to energy cost optimization and CO2 footprint reduction, several projects are being launched that in some way reduce the energy requirements of factory infrastructure or create alternative energy production opportunities, e.g., the installation of solar panels, closed-loop water systems, green logistics solutions, etc. Moreover, speaking about electric cars as a more environmentally friendly solution, he added that an innovative battery manufacturer has just come up with a solution which, if it becomes available for mass production within a year or two, will allow a person to fill up their electric car in about five minutes, which could be enough to power the car for 500-600 kilometers. Consequently, there is a need for massive infrastructure development in the power grid. So, in this sense, the energy and automotive industries are now closely linked. He added that there are existing concepts for reusing car batteries, such as those used in automobiles, but no longer meet the minimum needed standard, which might subsequently be utilized in smaller electric transportation devices, such as electric scooters.

Integration Challenges and Future Development

Integrating AI and circular economy principles faces several significant barriers that require systematic attention from industry stakeholders and policymakers. Data quality and standardization challenges represent fundamental obstacles as circular economy applications require high-quality data regarding material composition, component history, and degradation patterns. However, data standardization across the automotive value chain remains limited, hampering AI effectiveness and creating compatibility issues between different systems and stakeholders (Nascimento et al., 2022).

Investment and infrastructure requirements for implementing AI-enabled circular economy systems demand significant upfront capital commitments in sensor technologies, computing infrastructure, and data management systems. Smaller suppliers often lack the financial resources for comprehensive AI adoption, creating potential gaps in circular economy implementation across automotive supply networks (Zhang et al., 2023). This challenge requires innovative financing mechanisms and collaborative approaches to ensure equitable access to enabling technologies.

Skills and capability gaps represent another critical challenge as the intersection between AI and circular economy requires specialized expertise combining materials science, data analytics, and sustainability knowledge. This interdisciplinary skillset remains scarce within the automotive industry, necessitating comprehensive education and training programs to develop required competencies (Bag et al., 2021).

Future convergence opportunities include developing autonomous circular systems that integrate AI with autonomous vehicle technologies, enabling self-optimizing circular systems where vehicles automatically navigate to optimal maintenance, upgrade, or end-of-life processing facilities based on

real-time condition assessment. Generative AI applications for circular design could enable the automated generation of vehicle designs optimized for multiple lifecycles, automatically incorporating disassembly requirements, material compatibility, and remanufacturing constraints during the design phase. Ecosystem-level optimization represents the ultimate convergence opportunity where AI enables coordination across entire circular economy ecosystems, optimizing material flows between multiple automotive manufacturers, suppliers, recyclers, and remanufacturers to maximize system-wide efficiency and environmental benefits.

4 Conclusion

This study investigates the integration of AI-based solutions in the automotive manufacturing business, emphasizing their potential to *reduce costs, improve efficiency, and ensure product quality*. A series of interviews with automotive industry professionals revealed that introducing AI-based solutions is essential to maintain competitiveness. They shared the conviction that AI solutions have a key role in optimizing processes and predicting failures in manufacturing. While participants acknowledged that AI has the potential to replace human resources to a significant extent, there is still a need for continuous training of employees to make effective use of AI. They also added that adopting AI-based solutions is still very limited and can only be afforded by larger companies, with even lower uptake in the supplier network. Optimization of resources and processes can result in significant cost reductions for companies using AI-based solutions, such as *predicting manufacturing failures*, which prevents a production line from being down for minutes or hours during recovery, causing a loss of revenue on a massive scale, as generally speaking, a finished car rolls off a production line every 1-2 minutes. The concepts of *responsibility and trust* also come up when discussing AI-based solutions. Liability in the sense that in the event of any failure and loss of revenue, the ultimate responsibility lies with the provider of the AI-based solution or with the employee of the car company who may have failed to manage the services provided by the AI, leading to a failure. Therefore, employee training is a priority. Interviewees also noted that openness to and acceptance of AI varies by generation, with younger people generally being more open to digital tools. Building public trust, therefore, depends on transparent communication, ethical standards, and the active involvement of governments in AI regulation, education, and system design. Beyond the financial constraints, integrating AI into manufacturing processes fundamentally requires the identification of two key areas for success: *optimizing organizational processes, including digitalization and data management capabilities, and developing AI skills for automotive professionals*. Simplified workflows and standardized protocols are essential for effective implementation, and developing digital competencies will ensure that automotive workers can use AI tools confidently and appropriately. Effective management of high-quality, consistent data is also essential to ensure maximum utility and reliability of AI systems. The results suggest that AI is critical for automotive players to stay ahead of the competition. Automation will undoubtedly have substitutes for human resources, but it will also require a skilled workforce to fully exploit AI's competitive potential. As we discovered throughout our investigation, sustainability is equally important to automakers as AI solutions and is becoming increasingly widespread among them. Further research could be conducted to explore the practical application of AI in the context of other business processes (e.g., HR, IT, and not just manufacturing), focusing on quantifiable results such as internal efficiency gains. In addition, longitudinal studies could assess how AI spreads among industry players, mainly how it spreads to the supplier network over time.

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Author's address:

Corvinus University of Budapest,
 Institute of Strategy and Management, Department of Strategic Management
 1093 Budapest, Fővám square 8., Hungary

Noémi Szilvia Lőrincz, PhD, noemisilvia.lorincz@uni-corvinus.hu

Márta Kiss, ms.kissmarta@gmail.com

Gergely Balázs, gergely.balazs@uni-corvinus.hu

TRAVEL DECISIONS IN THE TOURIST PROFILE OF GENERATION Z

MÁRTA KÓRÓDI – KATALIN VARGÁNE CSOBÁN

ABSTRACT

The four main motivations for tourism travel, as the stress-free relaxation, the activity, the need for variety, and the need for social connection, appear with different significance in shaping the experience expectations of several tourist segments. However, analysing the tourism consumption behaviour of Generation Z, which has recently entered the market, is becoming increasingly unavoidable. The analysis of travel decision-related responses from a sample of 891 Generation Z individuals allows for identifying similarities and differences with previous research results. Based on the emphasis of each motivation, represented in a coordinate system formed by averages, four segments can definitely be distinguished, based on their relationship to the average Z generation tourism consumer behaviour, namely the group of mainly comfort-seeking relaxers, mainly explorers, mainly interaction-oriented and mainly adventure seekers. The results of the research contribute to a more accurate drawing of the tourist profile of Z generation travellers.

KEYWORDS

travel decision, segmentation, generation Z, tourist profile

INTRODUCTION

In order to more accurately define the needs of tourists, in addition to rational factors, subjective factors, including experience expectations, are increasingly playing a role in the modelling of travel decisions (Scott et al. 2014). When formulating experience promises, the experience attitude of the targeted segment must also be taken into account, which significantly depends on the age group of the traveller. The tourist experience attitude is related to the traveller's interest, he may be curious about novelties, known but not experienced attractions, or travel can also motivate as a social activity, and in some cases it can also relieve the fear of the unknown (Larsen et al. 2019). Although generational characteristics are among the segmentation methods based on descriptive market characteristics (Lőrincz – Sulyok 2017), using segmentation based on lifestyle also determines adequate communication for the segments (Csóka et al. 2020).

Generation Z members were born around the turn of the millennium or after, and their generational identification depends not only on the period 1995-2009, which can be used as a reference, but also on the influencing effects of place of residence and cohort (Nagy – Kölcsey 2017). At the time of their first encounter with digital technology, social networks were already fully present, so this generation differs from its predecessors on the one hand through digital socialization and online behaviours, and on the other hand, they are also active participants in the online space, consuming information and creating content. They are characterized by multitasking, and accordingly, they make decisions quickly, learn, make friends and have fun differently (Tóbi 2013), as their information acquisition and communication strategies are completely new (Székely 2014). Based on all this, it is likely that their travel decisions also differ from previous generations, mainly due to the differences in the processing and use of information. During the mediatized leisure time spent in the home environment (Nagy – Kölcsey 2017), the motivation to leave home and travel is specific. However, the elements of the travel decision-making process are the same for them as well, they also have to decide on the destination, the method of travel and accommodation, the duration, time and travel organization, taking into account the potential experience content (Horner – Swarbrooke 2007).

LITERATURE REVIEW

Studies analysing the tourism consumer behaviour of Generation Z – about 23% of the world's population – follow each other frequently, which supports the strength of the desire to learn and the deviation of typical behaviour from the habits of previous generations, which were similarly shaped by specific cultural, technological and economic factors (Kökény – Jászberényi 2022). The results of the latest research on the expectations of Generation Z regarding hotels and tourism services were published at the end of January 2025 and presented at the congress of the Austrian Hotel Association (ÖHV) in Innsbruck. According to the study, the new tourism map of young travellers is social media, which is also used as the main channel, and hotels that are not listed on them do not exist for the generation (Preveden 2024). Based on the 360° analysis of the guest journey (Guest Journey), they seek, expect and use solutions supported by digital technology from booking, or rather inspiration, through the hotel stay to check-out, and also for communication regarding the entire experience chain (online check-in, rooms equipped with smart devices), while at the same time they make use of the possibility of digital personalization (GD Consulting 2025). In addition to all this and the opportunities offered by global access, the credibility of digital platforms is also a decisive factor for them, they are experienced in distinguishing between forcedness and authenticity (Turizmus online 2025). The impact time on digital platforms is quite short, there is no time to dream about what they have seen, it is more difficult to form experience images, because the next impulse comes (Turizmus Online 2019). According to the American magazine Travel and Leisure (Elek 2024), Generation Z young people travel differently, their habits have changed in terms of both the frequency and duration of trips, the former due to the ease of organization. Impulse buying is lower compared to previous generations. According to a study by Expedia, 72% of Generation Z travellers use social media with its visually driven content as the main source of inspiration for their travel plans. Social media influencers and travel bloggers provide insights into unique locations, accommodations and niche experiences with their curated content that best meets the need for authenticity and personalization (Expedia 2023). They make conscious choices while taking into account immersion in local culture, networking, self-discovery and personal development (Booking.com 2024). Generation Z prefers flexibility and spontaneity, they are more prone to last-minute bookings and impromptu adventures (Forbes 2023). Generation Z loves to travel to TikTok-compatible locations to make their dream video, which achieves a recommended rating (Turizmus Online 2023). The emergence of mobile applications and online travel platforms has allowed them to book accommodation, transport tickets, programs on the go, taking advantage of discounts and offers available through digital channels (Skift 2024). According to the philosophy of life of Generation Z, good things happen to those who take action, even if they take risks, brag about failure, and are committed to less comfortable, unconventional things, which on the one hand means adventure, on the other hand, a departure from the usual, a kind of temporary escapism (Turizmus Online 2015). Mastercard research shows (Turizmus Online 2021) that for young people socializing on convenient digital technologies, the importance of interactions is paramount, and they are also sensitive to social and environmental sustainability. For American Generation Z youth, traveling is more attractive than saving (Pitrelli 2023). They consume less alcohol, use cheaper accommodation, but do not spare money to buy experiences, in other words, a new generation of value-based travel behaviour has emerged (TravelPerk 2024).

MATERIAL AND METHODS

To explore the factors determining the travel decision that shape the tourist profile, the pre-trip attitude survey method was applied through an 891-item sample (cleaned, containing complete answers) reaching only Generation Z respondents. The applicability of the methodology was supported by two preliminary measurements that were not restricted to age groups (Kóródi et al. 2023; Savella et al. 2022). The questionnaire research was conducted between 15.10.-14.11. 2024 with a mixed survey, online, via link sharing on social media, or via e-mail, and with a paper-based

self-completion method, with the help of interviewers (students of the Tourism and Hospitality Department of the University of Debrecen). In accordance with the previous research, the tourist consumption habits of the age group were analysed on the questionnaire according to 26 criteria of seven variables that play a role in the travel decision. The criteria included travel experience expressed in annual travel frequency and the method of organizing the trip according to the intensity of using package offers as a simple choice question. Two ranking questions related to the basic motivation for travel and the degree of desire for experience. Two questions suitable for self-identification assessed planning and co-travel habits, as well as their organization, and finally the determination of genders, which generally play a different role in travel decisions, was followed. Descriptive statistical methods, cross-analysis, and comparative methods for analysing correlations were applied to the database processing on the MS Excel interface. The results were also compared with the results of the previous, non-generation-specific survey (Kóródi et al. 2023), from the similarities and differences of which the characteristics of Generation Z could also be determined.

RESULTS

The 891 Gen Z respondents identified themselves based on travel habits, experience motivations and experience expectations, and most of them created useful preference rankings. The advantage of the large number of items is that the gender distribution is favourable despite the greater willingness of female respondents to complete the questionnaire. Although they are in a larger proportion (59.7%) among the respondents, the relatively high proportion of men (40.3%) made the Gen Z sample suitable for identifying similarities and differences in experience behaviour between the genders. As the first factor of travel behaviour, the frequency of travel is the first element, presumably travel routine and experience are related to the attitude towards experience. According to the single choice between the four travel frequencies, the largest proportion of respondents (42.6%) rarely participate in a trip with an overnight stay, 1-2 times a year. This option was chosen by men in a higher proportion than the original distribution, as was the very frequent travel per year, which is typical for 14.6% of the respondents (Figure 1). Women are found in a higher proportion in the 28.7% share of frequent travellers, while among infrequent travellers (14.0) the proportion of women also exceeds the original gender distribution of the population. Taking into account the balancing effect of very infrequent and very frequent travellers, the diagram also shows the division of the generation, on the one hand, its openness to travel experiences, and on the other hand, possible independence and income limitations may also be reflected in the restraint in travel frequency.

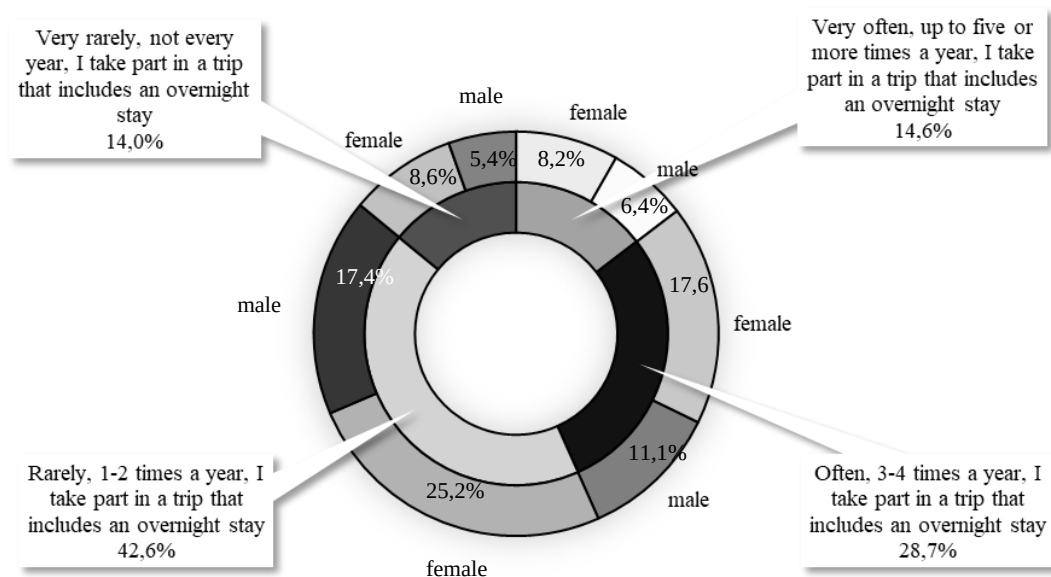


Figure 1: Distribution of respondents based on annual travel frequency by gender(%), (n=891)
Source: authors' survey and compilation

Compared to the mixed-age comparison responses, Generation Z travels more frequently, frequently, and rarely, while their share of very rare trips is lower than the mixed-age distribution (Figure 2). Overall, however, Generation Z clearly follows the age-based consumer behaviour in the diagram.

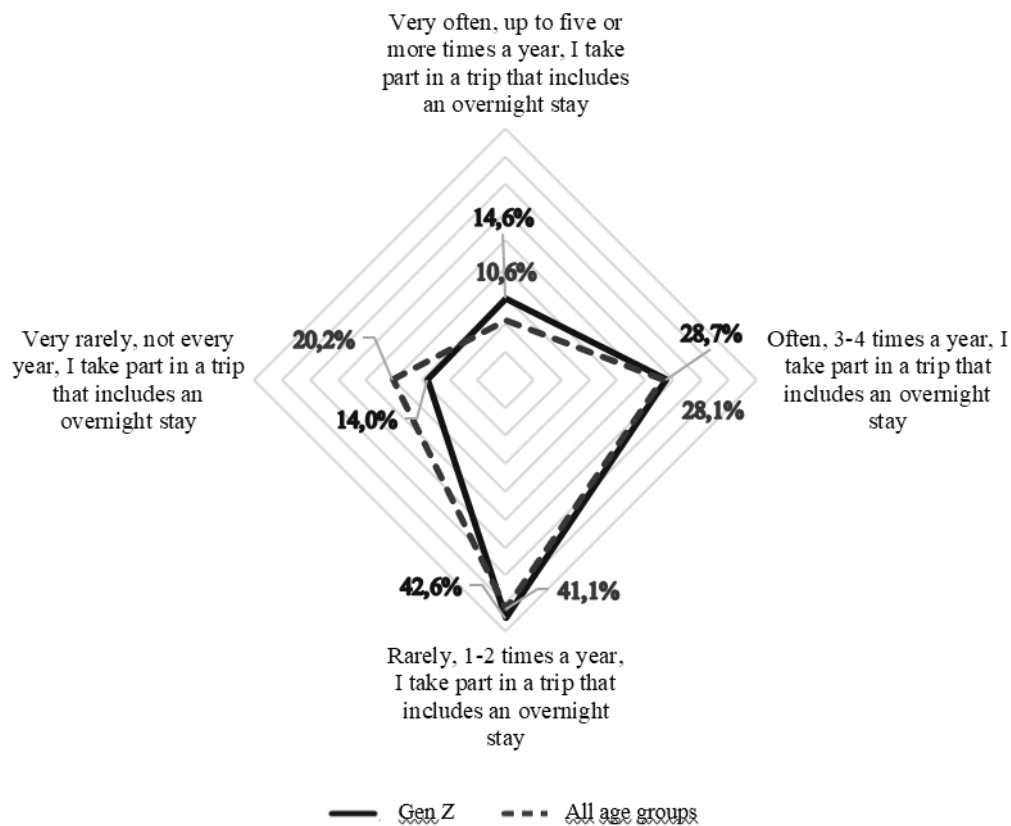


Figure 2: Comparison of annual travel frequency habits between Generation Z and the age-independent sample (%)

Source: authors' survey and compilation, Kórodi et al. 2023

The method of organizing a trip determines the experience expectations. When reviewing the organized trips of travel agencies, the potential traveller encounters more targeted but fewer promises of experiences than if he or she puts them together himself or herself based on the offers of service providers. The respondents identified the most (46.8%) with the fact that they organize their trip themselves, relying on their travel experiences, and spend a lot of time on obtaining the necessary information. Self-identification as a tourist with little experience, mainly choosing between packages, and as an experienced tourist, who organizes his or her trips easily thanks to his or her routine, resulted in the same proportion (22.3%). 8.6% of the respondents need and ask for help with organization. Compared to the sample of the entire age group, based on the Generation Z sample, young people cannot be considered undecided when it comes to travel decisions, they organize their trips independently to a greater extent, 69.1% compared to 64.4% (Figure 3).

In the group of respondents who consider themselves experienced travellers and who can easily navigate the organization of their trip, the proportion of very frequent and frequent travellers is higher than average, which may be due to their experience (Figure 4). The members of the group who have travel experience but are preparing their new trip thoroughly are not frequent travellers, and there is a higher than average proportion of rare or very rare travellers among them. Those who buy comfortable travel packages are grateful to the tour operators to the extent that they travel very often or frequently above average despite the accumulated travel experience, acknowledging their professional work.

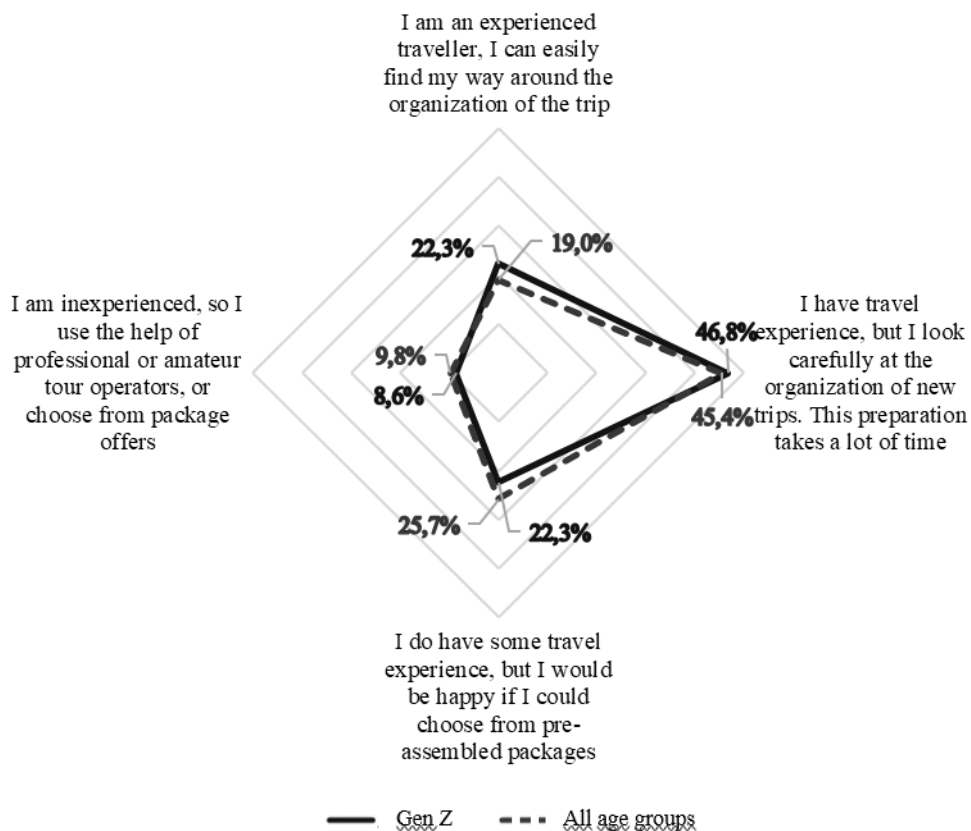


Figure 3: Comparison of travel organization characteristics between Generation Z and the age-independent sample (%)

Source: authors' survey and compilation, Kóródi et al. 2023

The difference in the travel frequency of inexperienced travellers from the average differs positively from the average in the two extreme cases, which can be explained on the one hand by the justified request for help, and on the other hand by the comfortable travel organization provided by the tour operators, which, if satisfied, may encourage them to travel again.

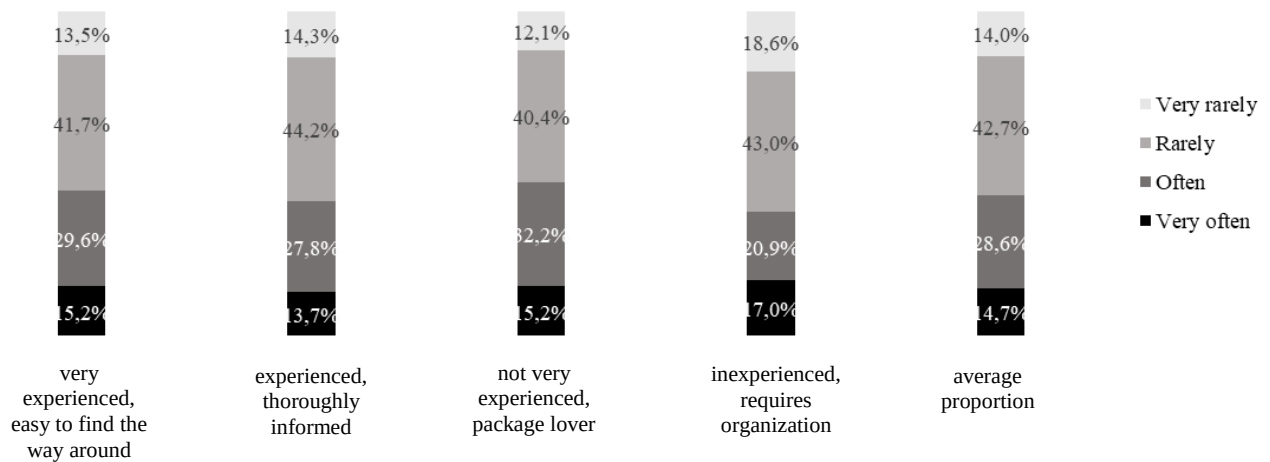


Figure 4: Relationships between travel organization and travel frequency among Generation Z travelers (%), (n=891)

Source: authors' survey and compilation

When ranking the four main travel motivations, the youth of Generation Z respondents appears, with variety being valued similarly, but slightly higher, compared to the age-independent responses, and they also placed it at the top of the ranking. The further order was reversed in the generational responses in favor of stress-free travel versus activity. The need for connection, getting to know people in the area visited, is in last place. This is the same for both age-independent and age-independent responses, with nearly similar ranking averages, although it is clear that direct connection and conversation are valued slightly higher in the case of Generation Z, presumably because they are open to leaving their otherwise active virtual relationships (Figure 5).

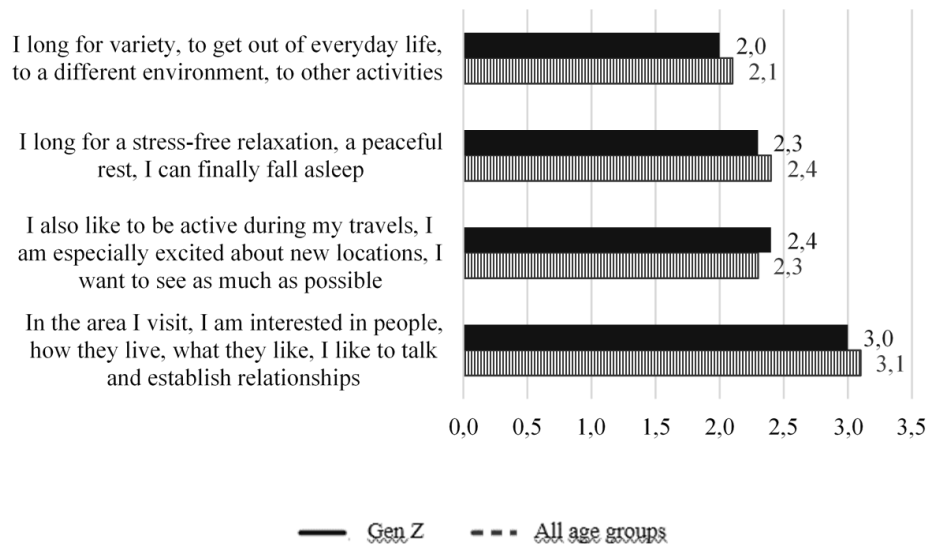


Figure 5: Average ranking of Generation Z tourism motivations compared to age-independent results (n=891)

Source: authors' survey and compilation 2025, Kóródi et al. 2023

The ranking of experience attitudes characterizes the influence of experience acquisition on travel decisions (Figure 6). The different experience expectations of Generation Z are clearly visible. Respondents primarily prefer experiences that can be experienced in company, and company guarantees the experience to a greater extent for young people (ranking 2.1). The other elements of the ranking were given the same importance value, and it is not possible to differentiate other experience attitudes based on Generation Z responses, unlike the age-independent sample, where the intellectual experience attitude, i.e. acquiring new knowledge, skills and expertise, represents a higher valued experience in both nature and culture. Visiting places that offer unique, exotic experiences, or the adrenaline attitude that is predestined to be tempting for young people, i.e. exciting, adventurous trips, does not represent an extra attraction either. All three attitudes appear with the same and high ranking (2.5), differing from the results of the age-independent sample.

In terms of experience planning, the largest proportion of Generation Z respondents (40.9%) limit themselves to seeing only the most typical attractions and feeling the atmosphere of the place. They chose the option (38.3%) to see what is absolutely necessary to see in a given place, fearing that they will not get there again. The less typical experience planning behaviour (11.2%) is to use travel agency organization and tour guidance, thereby maximizing the experience. The smallest proportion of respondents (9.6%) does not plan anything in advance, relying on locals, trusting their knowledge. Compared to the entire age group sample, a kind of hedonism emerges, the proportion of choosing a limited, i.e. the most typical and local-based attraction is lower, while the proportion of choosing to see everything as much as possible, either alone or with a tour guide, has increased (Figure 7).

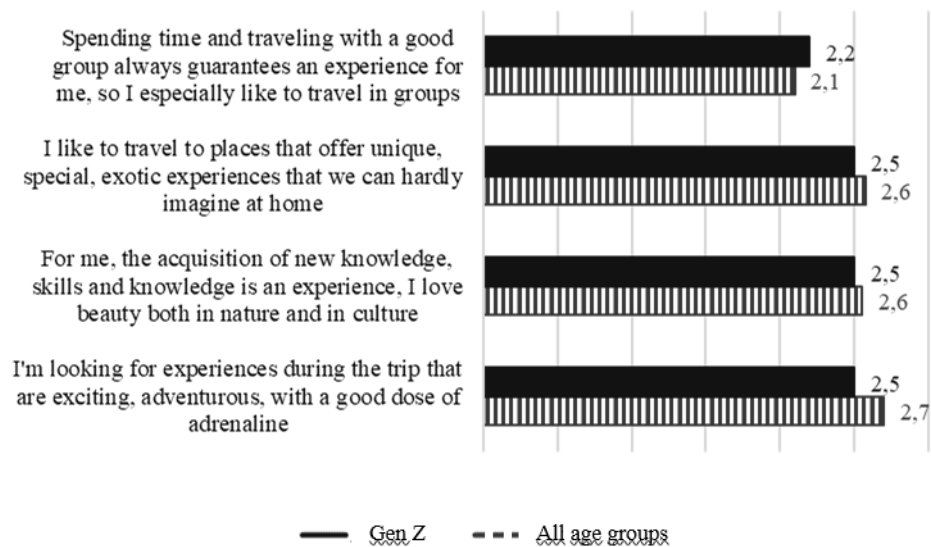


Figure 6: Average ranking of experience attitudes playing a role in Generation Z's travel decisions compared to age-independent results (n=891)
Source: authors' survey and compilation, Kóródi et al. 2023

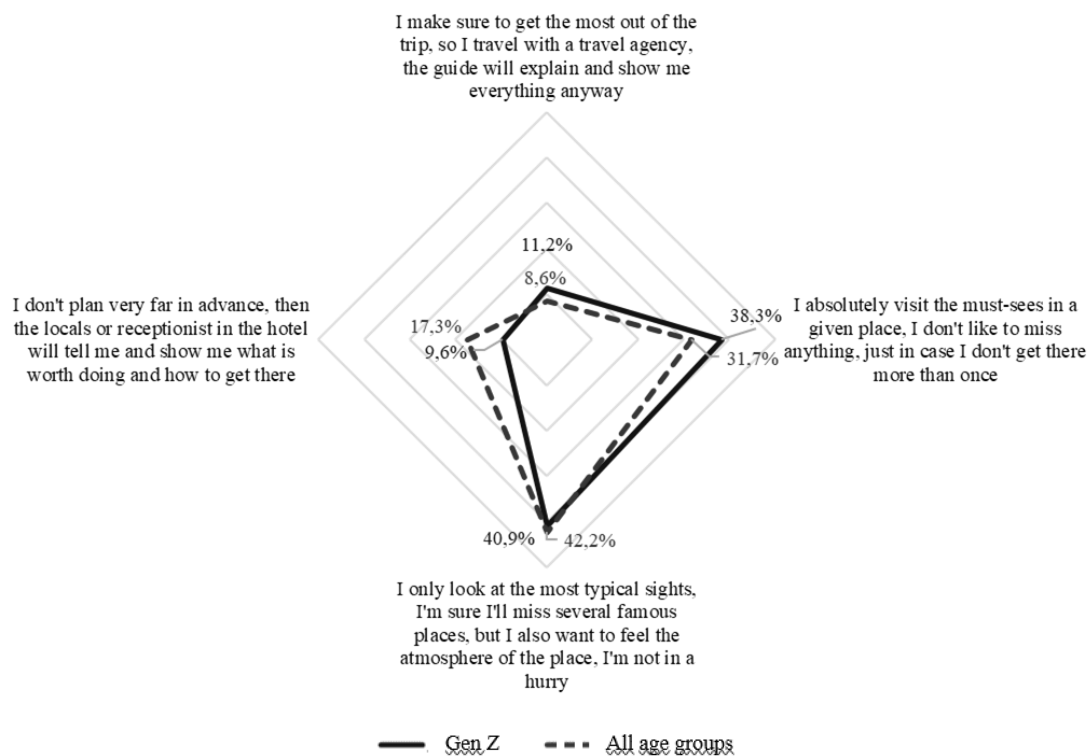


Figure 7: Comparison of experience design behaviour characteristics between Generation Z and the age-independent sample (%)
Source: authors' survey and compilation, Kóródi et al. 2023

If we further break down the Generation Z results according to experience attitude, in the middle two categories, those who consciously plan, the social experience is conspicuously decisive (clear bar) (Figure 8). In the case of visiting exotic places, spontaneity is characteristic to a large extent, but adrenaline and adventure are more guaranteed on organized trips.

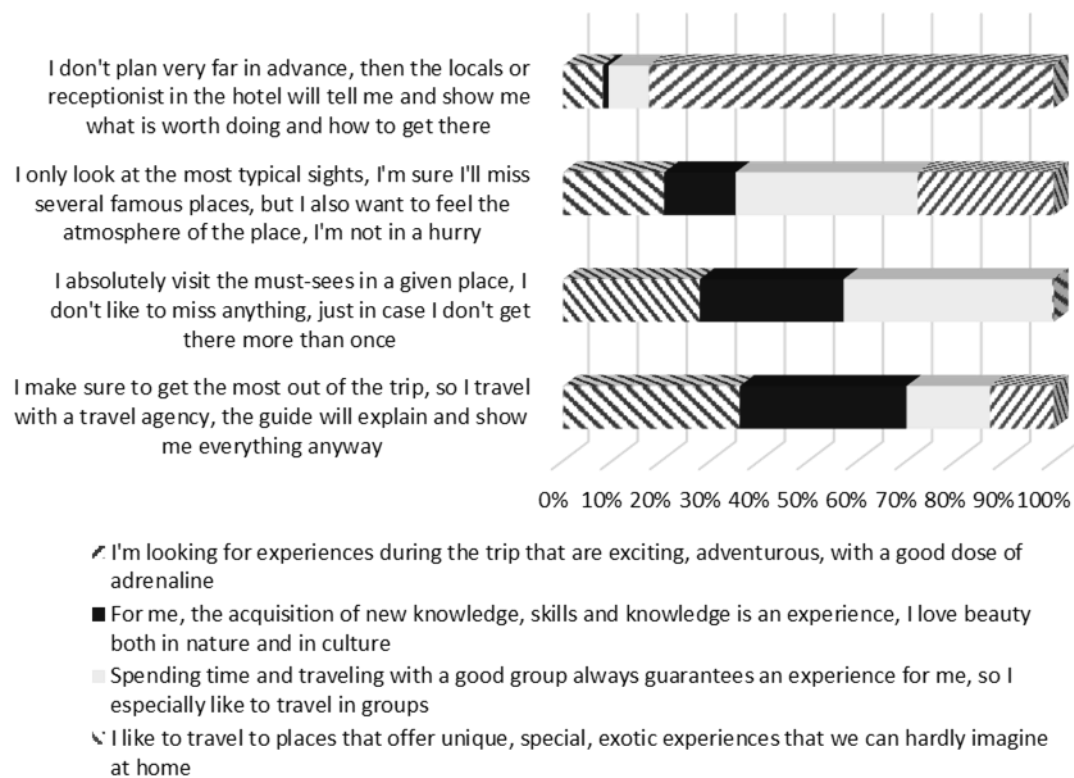


Figure 8: Correlations between experience attitudes and experience expectations (%) (n=891)
Source: authors' survey and compilation

To summarize the study, the segmentation of Generation Z based on experience intensity and activity intensity was carried out in a coordinate system that shows the weighted value of the intensities per respondent and intersects at the averages (2.55; 2.57). For each respondent, the motivation and experience expectation ranked first on the four-point scale were taken into account with a four-fold weight, and the others were taken into account in decreasing order in the average calculation. Due to the limited variation, there are several identical averages, the points indicate the fact of occurrence and not the frequency in Figure 9. Based on the deviations from the average, different experience behaviours can be identified in the four quadrants, mainly adventure-seeking (above-average experience intensity and activity intensity), mainly relaxing (below-average experience intensity and activity intensity), mainly exploring (above-average experience intensity but below-average activity intensity), and mainly relationship-seeking (below-average experience intensity and above-average activity intensity). The mainly relaxing segment accounts for 27.3% of the Generation Z sample, explorers account for 26.6%, the more active relationship-seeking segment accounts for 24.8%, and adventure seekers account for 21.2%.

The largest proportion of Generation Z tourists is the segment mainly looking for a quiet vacation, for whom relaxation is the focus. They prefer programs with little activity, such as a wellness or a walk on the beach. The purpose of their trip is physical and mental refreshment, regeneration, or retreat. Travelers seeking stress-free relaxation often choose destinations where they can enjoy the environment and read. Comfort, stress-relieving activities, and physical and mental recharge are important to them. The work culture of multinational companies has given rise to the trips of younger travellers seeking a quiet vacation, when they want to get rid of the tensions of everyday life. It is not uncommon for this type of tourist to specifically look for places where there is little stimulus, where they can have a slower, calmer pace of life. During such trips, they often choose all-inclusive accommodations. They do not like to spend a lot of time organizing their trip. Some lovers of exotic places can also be included here, who like to experience unique, special experiences and atmospheres, with little activity. The group of relaxation-oriented, peace-loving travelers longs for relaxation, often traveling with friends or family members. Comfort, quality accommodation, good dining options and

pleasant programs are important to them. This group often returns to the same location that has already proven itself well. They often turn to travel agencies for help to get rid of the stress of organizing. Rushing is not typical for such travellers, so they only see the most typical attractions and do not mind if something is left out. They are the wanderers of relaxation.

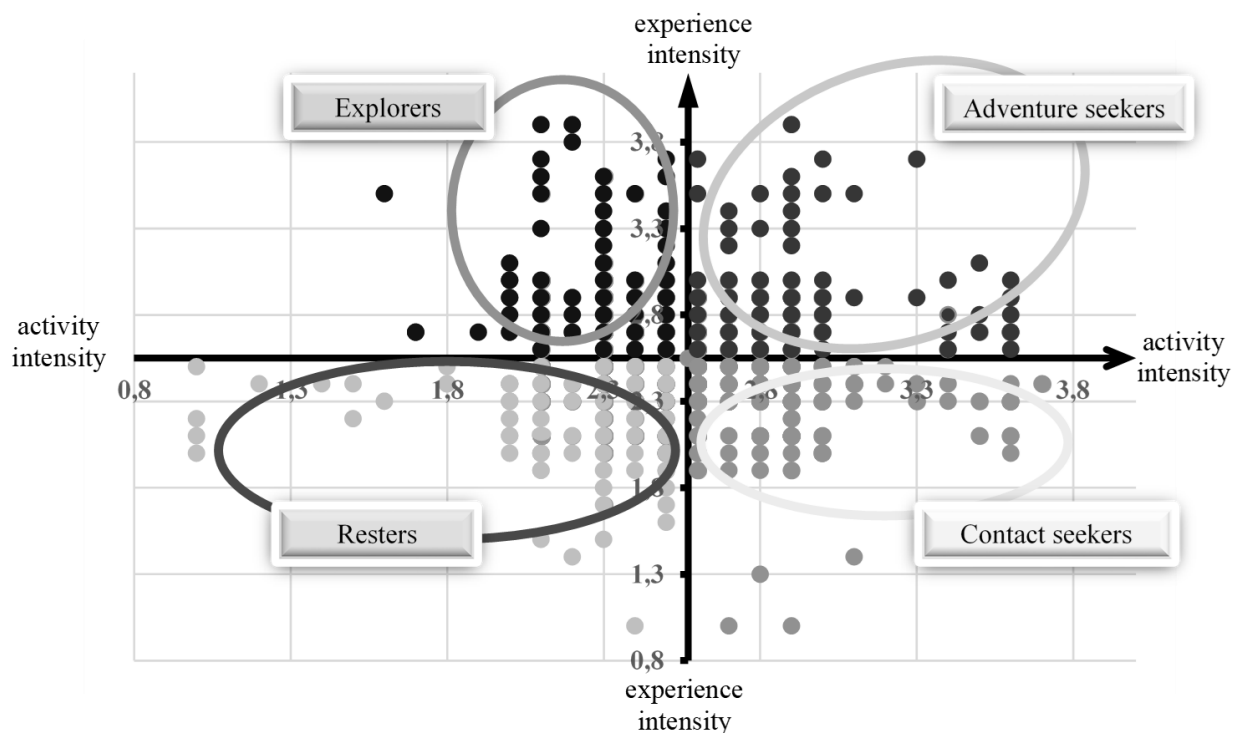


Figure 9: Segmentation of Generation Z based on averages of experience intensity and activity intensity (n=891)

Source: authors' survey and compilation

The desire to learn about the exploring world of Generation Z tourists can be directed towards different areas, it can be general or specialized, cultural or natural. They usually know what they want to see during their trip, they have a narrow program plan. They rarely travel far, they see the most typical attractions, they are not in a hurry, they like to have lasting experiences, to experience the atmosphere of the place. Tourists belonging to the segment of those who like to acquire new knowledge want to gain new knowledge during their trips. They usually want variety, to be in a place that is not similar to their place of residence, their everyday environment. This group includes those who like to participate in detailed sightseeing tours. They look for trips where they have enough time to thoroughly explore local attractions. For explorers, the location, landscape and accommodation will be the main decision-making elements when organizing a trip. They are more likely to travel alone and typically travel less often. Since they have less opportunity to travel, they want to see everything about a given place, get to know the people living there and the different customs. They are happy to choose trips organized by travel agencies, where they can gain experience with the help of a guide. Active explorers are happy to participate in new activities, appreciate variety and are open to authentic experiences. They travel in a way that allows them to visit everything they can, because they may not get there again. It is more important for them to experience experiences during their trip that they can only experience there, and that they would not be able to imagine at home. They prefer local guides, they consider them authentic, and they are looking for special, authentic experiences. They want to experience the atmosphere of the places, they are not in a hurry at all, they also see most of the sights. They usually have travel experience, but they look into everything thoroughly, which takes a lot of time.

Social and interaction-oriented tourists are motivated by making connections. This can be general or thematic, often related to hobbies or studies, but it is definitely typical of extroverted travellers. They prioritize spending as much time as possible during their stay to meet new people, gain insight into their lifestyle, and thus develop relationships. This type of traveller not only wants to relax, but also to enjoy experiences with others. They look for places where there are opportunities for community programs, such as outdoor events, party boats, and shared dinners. Many young adults enjoy traveling with friends, which can include shared experiences, intense entertainment, and partying. They emphasize programs so that they can spend as much time together as possible and with as much variety as possible with their company. Family travellers plan their trip carefully, taking into account the needs and interests of their children. They often choose family-friendly destinations, such as theme parks, beaches, or cities with a variety of activities for children. They prefer family accommodations that are comfortable and spacious. They try to find activities that are fun for everyone. They are usually spontaneous people, they do not plan ahead, and then choose from optional nearby places based on recommendations from locals or hotel staff. The trip should not be long, but rather have more time to stay there. It is important for them that the programs are flexible, giving them the opportunity to explore and follow local recommendations. They look for interactive activities, such as cooking classes or demonstrations of local crafts, which help to gain a deeper understanding of the culture.

The adventure-seeking Generation Z travellers are prepared for unusual, or even standard, challenges, and they like unexpected, unplanned situations. Their main goal is to enrich themselves with new, adventurous experiences. They travel more often with a group of friends, and from a financial point of view, they put the costs of accommodation and travel in the background, but the experience is a priority, for which they are willing to pay more. They are the ones who seek excitement, discovery, and new experiences related to intense physical activity during their travels. They often choose destinations with extreme conditions, and are attracted by mountains, deserts, rainforests, and exotic locations. They do not shy away from the unknown, extreme sports, or even cultural discoveries. Adventure seekers usually organize their trips independently, and do not trust standard tourist packages much, since for them, travel is about discovery and experimentation, which requires flexible, personalized solutions. If they find this personalization in a travel package, they do not close themselves off, and then they prepare for the challenge before the trip. But they also choose destinations about which there is less information, and they research the best programs and accommodations themselves. For adventurous tourists, the point is not to spend their time comfortably, but to challenge themselves and gain experiences that others rarely experience. A diverse program offer, locations close to nature, safety and the qualifications of professional guides are important to them. During their travels, they are risk-takers, constantly yearning for new challenges even if they involve danger, they enjoy high adrenaline levels, they are always open to new experiences, they are independent, purposeful, energetic people, they like to push their limits, step out of their comfort zone, and try something new. They are able to travel long distances to have an experience that few people dare to participate in.

CONCLUSION

The results obtained from the analysis of the surveyed characteristics of the consumer behaviour of the Z generation (the characteristics of planning and organizing the trip, the expectations and attitudes towards the experience, the motivations) offered many opportunities for segmenting the respondents. Despite their young age, the answers show experience in the form of travel frequency, but a more pronounced grouping factor is their motivation and attitude towards gaining experiences. At the same time, the critical age of 18 is also included in the composition of the generation by age, which is the dividing line between those who travel independently, mainly in the company of friends, and those who travel with their family. The Z generation is the age group where parental attention and care are still present to a large extent, so that trips also take place with parents and family, but the other part of them already desires independence, so they prefer the company of friends. This clearly results in a

kind of segmentation. An identical characteristic of both segments is the emphasized shared travel experience. Due to the information routinely accessed and used by the generation, they plan new trips themselves, which can take a lot of time depending on its thoroughness. The generation cannot be considered homogeneous, the proportion of choosing experience attitudes showed some deviation from balance, in addition to showing independence in travel planning, Online Travel Agencies and travel consultants appeared in terms of travel organization in accordance with the generational characteristics. The social nature of travel and the need for traveling together are emphasized in the age group. It is advisable to take into account the segments limited by experience intensity and activity intensity during product development and communication. At the same time, it must be taken into account that the given age group may identify with the experience behaviour of another segment as it enters a next life cycle stage.

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AUTHORS' ADRESSES

Dr. Kóródi Márta PhD
college professor
University of Debrecen, Faculty of Economics and Business
korodi.marta@econ.unideb.hu

Dr. Vargáné Dr. Csobán Katalin PhD
senior lecturer
University of Debrecen, Faculty of Economics and Business
vargane.csoban.katalin@econ.unideb.hu

MINERAL WATER AS AN ASSET IN THE LAND OF WINE WATERS: RESULTS OF AN EXPLORATORY STUDY

TELEGDY BALÁZS – NISTOR LAURA

ABSTRACT

The article is based on exploratory research and presents the attitudes of the local population in central Romania towards the mineral waters which are mainly perceived as a common good usable free of charge. An online questionnaire was conducted to reveal the value-orientation towards the mineral water springs. The analysis shows that the attitudes can be classified in some well-defined fields, from the attributes of the local identity and the gift of nature till the hazards which these springs can be for locals. The exploratory research results reveal a basic sociological knowledge towards a freely reachable natural resource and open the field for further exploration.

Keywords: mineral water; natural resources; attitudes; value orientation, Szeklerland, Romania

1. INTRODUCTION

In October 2019, in the framework of an interdisciplinary research program¹, we conducted a questionnaire survey to explore some aspects of mineral water consumption in Szeklerland (the central part of Romania, Europe). Among other things, we also asked how the respondents relate to the mineral waters of the region and settlements and to what extent mineral water is a value and resource for them. The question was based on several approaches, mainly from geological, balneological, or economic points of view, which state that one of the important natural treasures, tourist attractions, and economic resources of Szeklerland is mineral water.

These analyses, which are based primarily on the inventory and microbiological and balneological descriptions of the mineral waters of the region, date back more than a century (e.g., Hanko, 1891) and have prompted a number of researchers to provide up-to-date inventories and descriptions of the mineral waters of Szeklerland (e.g., Cluster of Mineral Waters in Szeklerland, borviz.org, or the current project). The research on mineral waters in this part of Romania rarely considers the social component, the way in which the inhabitants of a region or a particular settlement relate to mineral waters. To our knowledge, no comprehensive sociological survey has yet been carried out on how the population thinks about mineral waters and how and why they are valued.

There are, of course, many historical facts linked to mineral waters, handed down through generations of common knowledge, which are intended to preserve, at the level of the spoken word, the pride associated with mineral waters. Here we can mention, for example, the fact that the balneological centres near the mineral waters of Szeklerland have hosted important figures from European cultural history and the fact that at the 1873 Vienna World Exhibition, Franz Joseph described the mineral

¹ A complex study of thirty popular mineral water springs in Szeklerland (2019-2021), identifying number: KPI: 21/3/12.06.2019

water of Borszék² as the queen of mineral waters (Feru 2012). This historical event is still exploited today in the marketing of bottled mineral water from Borsec: the product label now reads in Romanian that Borsec mineral water is the Queen of Mineral Waters³. This superlative probably contributes to the fact that Borsec has been the strongest mineral water brand in Romania⁴ for years. The BrandRO research analyses⁵ at consumers' brand perception, and so the brands are not evaluated on their economic performance but on their marketing and PR performance, which clearly shows the attractiveness of bottled mineral water with good marketing among Romanian consumers.

Based on the above-described context, we thought it would be worthwhile to investigate, on a smaller scale, at the level of the Szeklerland, what attitudes exist towards mineral waters. In our online questionnaire survey, which is not representative but, due to the large number of respondents, is well suited for exploratory research, we wanted to find out whether the respondents' opinions reflected the literature's assessment of mineral waters. Our question was therefore whether there is a micro-sociological basis for geological, economic, and regional development efforts that see mineral waters as an attractive resource for the economy and tourism in the region.

After a brief overview of the definition of mineral water and the research and regional development efforts related to mineral waters in the region, we will present the approaches to mineral water as a local product, the methodology of the empirical research, and the answers to the above question.

1.1. BRIEF OUTLOOK

According to the colloquial term, mineral water does not refer to all bottled water, but it is also true that not all mineral water is bottled. On the other hand, given the experts' definitions, mineral waters are those that are derived from natural sources, have a mineral content obtained by subsurface processes, contain at least 1000 mg/l of dissolved minerals, may have pharmaco-dynamic properties, may contain a certain amount of gas, and some mineral waters may have a temperature above 200°C (Czellec 2014). In Szeklerland, the term mineral water is replaced or added to the term "wine water"⁶, which in a narrower sense refers to carbonated, iron-rich waters from springs (Czellec 2014). However, in everyday usage, the term wine water is also used as a synonym for all mineral waters. In our research, we did the same: the focus of our questionnaire was on mineral water consumption habits in Szeklerland, so we used the terms mineral water and wine water interchangeably.

Many spring waters meet the above criteria, but not all of them are commercially available in bottled form. János et al. (2009), for example, mention more than 2,000 springs of small and large size in Szeklerland, but there are 9 bottling plants in the narrower Szeklerland (Harghita and Covasna counties, in the central part of Romania) (Czellec 2014). Of course, these figures do not necessarily illustrate the underutilization of mineral waters in Szeklerland: many springs would not be suitable for commercial use due to their low yield, insufficient microbiological purity, or geographical and infrastructural location. However, these small and large springs are important components of local water consumption: from the mineral water sources, which are often known only at the level of local knowledge, local inhabitants obtain the water they need daily, which is usually used for thirst quenching, drinking cures, and spa treatments (Kisgyörgy 1977).

The region of Szeklerland, and especially the southern part of the Harghita Mountains, is the most mineral-rich region in Central and Eastern Europe (Czellec 2014), so the region can be rightly called

² Currently, the town of Borsec is part of Romania, so we use the official name of the town. But at the time of the above-mentioned event, Szeklerland was a part of the Austrian - Hungarian Empire, and then the official name of the town was Borszék (in Hungarian).

³ Borsec, Regina Apelor Minerale (in Romanian).

⁴ Revistabiz.ro

⁵ <https://www.unlock-research.com/>

⁶ Mineral water in Hungarian is colloquially called "borvíz", where the "bor" by itself means wine, and "víz" means water.

the home of mineral water e.g., (Bányai 1955) or (Jánosi, Berszán és Péter 2009). Mineral waters are an important natural resource of the region and an important tourist resource, and since the 18th century, this resource has been exploited with varying degrees of success, mainly through the establishment of spas and bottling (Hankó, 1891; Botos, 2005; Csinta, 2018).

The fact that the success of commercial exploitation is not clear can be explained, among other things, by the often informal, low-competitive nature of the early bottling and balneological services (Hanko 1891); but it is also worth mentioning that during the years of socialism and then transition, many springs and bathing areas were run down, and unclear ownership rights left them looking like a desolate place. Large-scale bottling is not clearly profitable for the region either; even though more than half of the approximately two billion liters of mineral water bottled in Romania originate from the Szekler region, only a fraction of the profits remain in the region due to the abuses of the mining law (Csinta 2018).

The issue of existing but under-exploited natural resources has therefore long been a thematic issue in the region, and in recent years there have been several initiatives to properly exploit the mineral water potential. On the one hand, there are scientific works aimed at an up to date (re)inventory and microbiological description of mineral water sources in Szeklerland (e.g., Jánosi et al., 2009; the Szeklerland Mineral Waters Inventory; Harghita County Council, 1999, etc.). On the other hand, initiatives aimed at the exploitation and marketing of mineral waters for tourism can be found here. Two important initiatives can be mentioned here: the EU-funded project called “The Road of Wine Waters”, which involved the rehabilitation of the region's springs, the creation of spa and SPA centres, and the restoration of old baths and springs through a civil initiative, based on voluntary work⁷ (Czellecz 2014).

County governments are using place marketing (Nagy 2013) to exploit the mineral water potential of the region. Mineral waters are an important component of tourism promotion programs in both Covasna⁸ and Harghita⁹ counties, and the example of Harghita County shows that mineral water is not only a tourist attraction with balneological value but also a local food. Thus, the Harghita Pearl mineral water also represents the gastronomic traditions of the region.

Presenting mineral waters as local products is even more important because it can symbolize sustainability efforts in the polluting bottled water market. Indeed, a major issue at the global level is that bottled (mineral) water, in addition to its many benefits (Howard 2003) (convenience, health reliability), is a huge global business with many ethical problems (e.g., privatization of water as a public good) and environmental concerns (see, e.g., the summary of Wilk, 2006).

In the global bottled water market, spring water from local sources can thus be understood as a local food and can be part of the social and geographical space (terroir) in which it is a mediator of local values and traditions (Kloppenbergh, Hendrickson és Stevenson 1996). The consumption of water from local sources, or the consumption of locally bottled mineral waters from local sources, corresponds to the concept of a short supply chain (Lockie 2009), and can also be understood as a response to the global food market (Tischner és Kjaernes 2010). This logic underpins several internationally recognized local mineral water projects, such as the US Native Water¹⁰ project, which is implementing environmentally friendly bottling of mineral waters from local sources.

The long-term success of Szeklerland's mineral water promotion programs may therefore also depend on the extent to which sustainability requirements are integrated into the program. For the time being, the success of the programs so far is questionable in several cases: besides the deservedly successful projects, a simple inspection of the area shows that there are unfinished reconstructions, springs whose surroundings are in a state of disrepair, baths (ponds) recently renovated with the help of the civil movement are crumbling, SPA centres are struggling with operational problems, etc.

The question is therefore to what extent the above-mentioned renovations will be successful in the

⁷ <http://www.polgartars.ro/programok.php?id=19>

⁸ https://visitcovasna.com/hu/places?cat_type=ape-medicinale_1500530059

⁹ <https://visitharghita.com/hu/places/asvanyvizek-gze7ujjcbgctga>

¹⁰ <http://nativebrandscompany.com/>

long term and to what extent the mineral water exploitation project will constitute a sustainable program in the region (Czellec 2014). In this context, it is of course also a question of how far the regional and county-level programs can gain community and local support: to what extent do people living near the sources see value in their mineral waters and what kind of vision they associate with them? Our research sought to answer these questions.

2. MATERIALS AND METHODS

To learn more about Szeklerland's consumption patterns of mineral water, an online questionnaire survey was carried out in October 2019. The online survey was disseminated over many channels. Convenience sampling was the basis of our research instead of random samples; thus, anyone who lived in Szeklerland and thought the topic was interesting may complete the questionnaire. As a result, our research cannot be referred to as representative because the findings only represent the respondents' perspectives and cannot be generalized. Despite these drawbacks, the field (e.g., Leiner, 2016) acknowledges the validity of convenience sample surveys and believes that their use is warranted, even when conducting exploratory surveys. When there is no previous information available, using online surveys is also justified for reasons of cost-effectiveness (Sue és Ritter 2012). Thus, the exploratory nature of the research in our case also justified the use of an online questionnaire approach based on convenience sampling, in addition to the methodological flaws mentioned above. We are certain that our results, while perhaps not universally applicable, are complimentary as they illuminate a hitherto undiscovered aspect of the Szekler region, given the volume of 1174 survey replies that we received.

In the present methodological chapter, we do not go into a comprehensive characterization of our respondents (for more details see Telegdy & Nistor, 2020). We merely highlight a few key points below.

Our study only included responses from the counties of Covasna, Harghita, or Mures because it was centred on wine water consumption in Szeklerland. Considering the aforementioned data, 980 survey responses were ultimately examined. However, for a few questions – like the one covered in the upcoming chapter – we were only able to analyse replies from respondents who were regarded as regular users of mineral water¹¹.

2.1. DESCRIPTIVE STATISTICS OF THE RESPONDENTS

In terms of gender, the proportion of women was higher, with 61% of respondents being female. By type of settlement, the responses were skewed towards the urban half of the population: 70% of respondents named a town as the place where they had spent most of their time in the last year, compared to the other 30% who had lived in a village in the last period. In terms of respondents' educational attainment, those with tertiary education were over-represented, with more than half of respondents (55.7%) in this category. Those with a secondary or post-secondary education accounted for more than a third of respondents (35.7%), while the remaining 8.6% were respondents with no secondary education. By ethnicity, nearly two thirds (63%) of respondents considered themselves Hungarian, nearly one third (31%) Szekler, with a negligible proportion of Romanian respondents (2%). 2% of the respondents did not classify themselves in any ethnicity category, while the remaining 2% mentioned other.

Most respondents placed their household's monthly income in the lower-middle range.

In our questionnaire on mineral water consumption, we covered bottled and non-bottled water consumption from natural sources and several aspects of these, which are not analysed in this report.

¹¹ We considered a regular mineral water consumer, who drink at least once in a month this type of water. The result was 496 cases.

In what follows, we present the results in relation to the questions we have asked to find out whether there is a deeper specificity of wine water consumption rooted in local culture. To this end, a series of statements about wine water were included in the questionnaire, and respondents were asked to indicate the extent to which they agreed with these statements.

3. RESULTS: MINERAL WATERS THROUGH THE EYES OF RESPONDENTS

In our questionnaire, we asked respondents to rate ten statements, each of which made a statement about wine waters (the list of statements was drawn up based on public discourse, media, and literature indicated in the theoretical chapter). Respondents were asked to indicate how much they agreed with these statements. As a first step, we present the data as a whole. Exploratory factor analysis was used to examine whether there is a coherent internal structure to the responses to the statements we examined. As a first step in our analysis, we examined the KMO test score. This showed a value of 0.650 after inclusion of the ten variables, so the variables are statistically suitable for factor analysis. The variables were analysed using the principal component analysis method, which resulted in four factors. The factors explained 53.85% of the total variance. To interpret the results more accurately, the factors were rotated. For the rotation, we used the Varimax procedure, which maximizes the variance of the variables classified in each factor.

Table 3. Exploring the internal structure of statements about non-bottled wine waters (N=462).

Statement	1 st factor	2 nd factor	3 rd factor	4 th factor
Wine waters are a treasure of nature.		0.560		
Wine water should be bottled and sold.		0.741		
The potential of the medicinal properties of wine waters is sufficiently exploited in the area.			0.764	
The potential of the medicinal properties of wine waters is sufficiently exploited in the area.			0.717	
Wine water springs are also community gathering places.	0.496			
I am proud to live in a place where there are wine water springs.	0.670			
Wine waters are part of our culture.	0.759			
Wine waters mean nothing to me.				0.676
Uncontrolled consumption of wine water is dangerous to health.				0.775
Wine waters could be a symbol of our region.	0.736			

Data source: own research

As can be seen in the table above, four distinct sets of values emerged from the factor analysis among respondents:

- The first factor encapsulates statements that wine waters are an integral part of local traditions and a building block of local identity.
- The second factor includes statements that see wine water as a natural resource, like any other subsoil resource.
- The third factor includes statements that also see wine water as a resource, but these relate primarily to health to the medicinal properties of wine water.
- The fourth factor includes statements that are neutral or even negative about wine water.

A detailed analysis of the results based on the four factors is presented below.

As shown in the figure no 1., a large majority of respondents consider wine water to be an important cultural and identity-building element. The overwhelming majority of respondents (82%) are fully proud of the fact that they live in a region with a source of wine water. At the same time, three-quarters of respondents (75%) fully agree with the statement that wine waters are part of our culture. There is also a high percentage (60%) of respondents who believe that wine water is not only an intrinsic cultural element but also a representative element, as they believe that wine water sources could be a symbol of the Szekler region. Finally, the community-forming power of wine springs is also important, although not as popular as the previous three statements, as three-quarters of respondents (76%) fully or partially agree with the statement that wine springs could be a community meeting place.

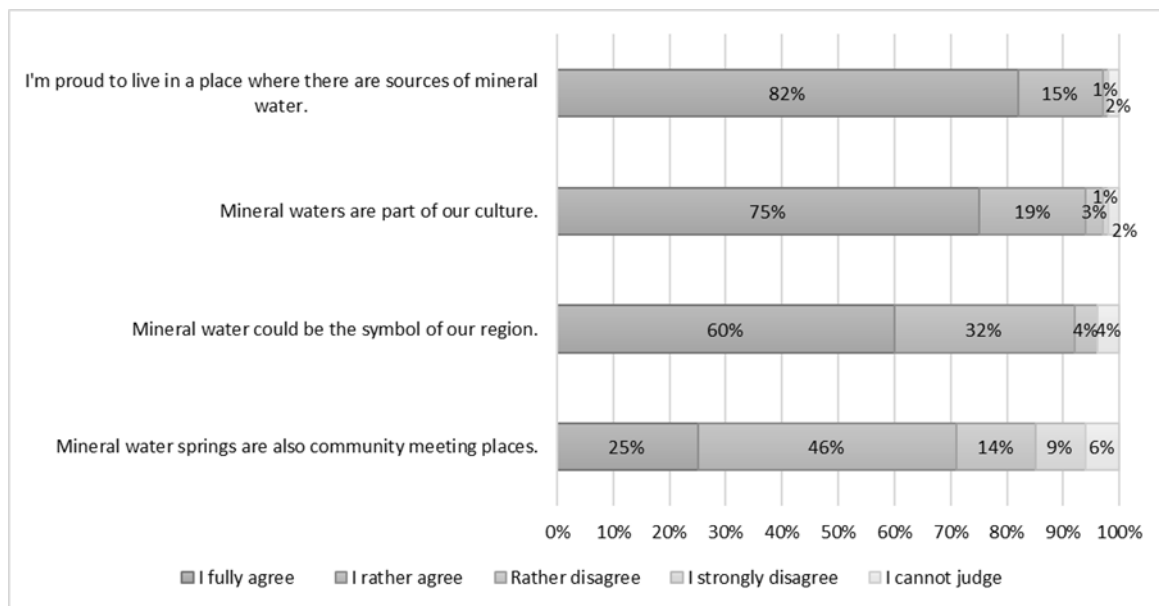


Figure 1. Mineral water springs as cultural and identity building elements (N=462)
Data source: based on own research.

As shown in **Error! Reference source not found.**, most respondents strongly agree that wine water is a natural resource. The picture is much more nuanced according to the second variable of the factor, with almost two-thirds of respondents (63%) believing that wine water should not be bottled and should not be sold commercially. Do these two results contradict each other? Although only hypothesized for a future phase of the research, we believe that these results are not contradictory, as we believe that respondents see non-bottled sources of wine water as a natural treasure that is also a public good that should be shared by all.

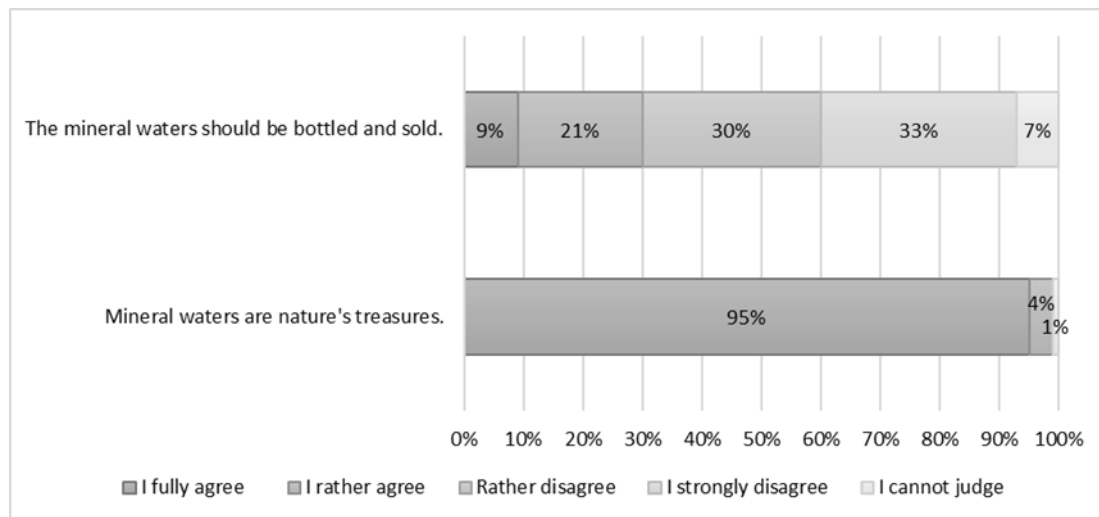


Figure 2. Mineral water sources as a natural treasure (N=462)
Data source: based on own research.

According to Figure 3, most respondents (69%) consider that the medicinal properties of the wine water sources in their area are not exploited at all, and only 3% of respondents fully agree that the medicinal properties of these sources are sufficiently exploited. However, it is also an important finding that most respondents (81%) believe that mineral water is not just a medicine, as it is much more of a resource for the community (see results of factor 1) than a medicinal resource.

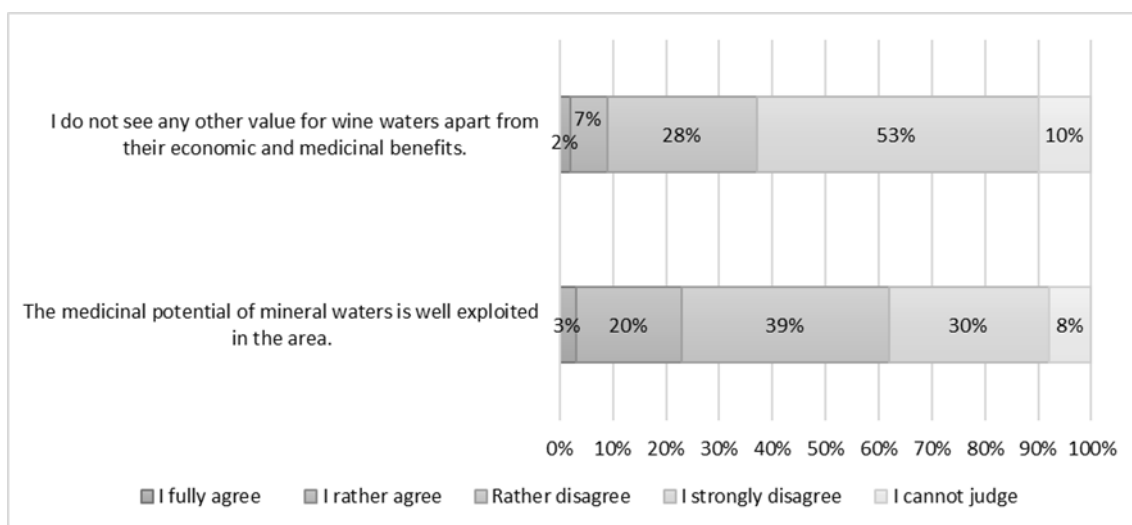


Figure 3. Perception of the medicinal use of mineral water springs (N=464)
Data source: based on own research.

The last factor includes two statements that seek to draw attention to the negative impact of wine water sources. Nearly one-sixth of respondents (16%) strongly agree with the statement that non-bottled wine water should only be used within certain limits and in certain quantities. The second statement shows the lowest percentage of agreement (1%). Reversing this result, 93% of respondents agree that the presence of wine waters means something.

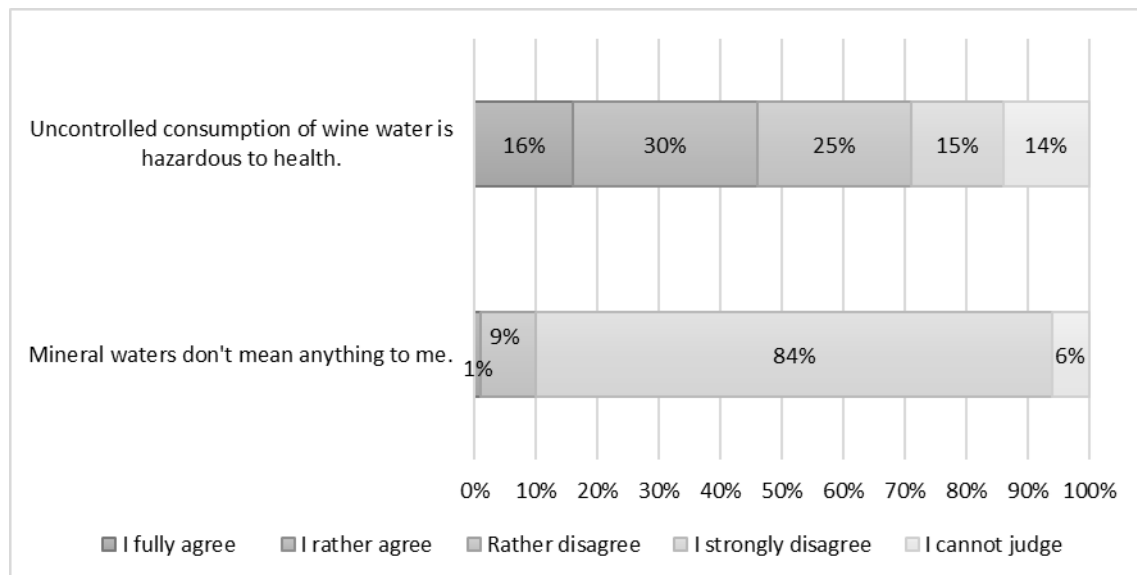


Figure 4. Negative perception of non-bottled mineral waters (N=464)
Data source: based on own research.

4. DISCUSSION AND CONCLUSION

Our research indicates that, at the community level, the narratives that emerge at the policy level about mineral waters are being confirmed. The community perceives mineral waters as a value, specifically a triple value: a cultural heritage, a natural treasure, and a resource for medicinal purposes. These elements also indicate the potential uses that respondents would like to see for mineral waters: mineral waters should be thematized in the context of local society and geography (cf. the concept of *terroir*) as a specific regional cultural and natural resource that can be a symbol of the region, a specific symbol of localism. It is interesting to note, however, that respondents envisage the balneological rather than the bottling of mineral waters as a potential economic-tourist exploitation of mineral waters. The economic profit that comes with bottling is not at all attractive to the community, which can be explained by the negative experiences with the privatization of the public good (Wilk 2006).

This result undoubtedly requires further analysis, as there are probably conditions under which recovery through bottling is acceptable (e.g., environmentally friendly, small-scale, local), but these preliminary results suggest that respondents are more focused on the conservation of wine waters as cultural and natural assets than on the commodification of the resources that wine waters represent. Our research also indicates that the responses echo media reports that the water in the springs is not always tested, or that the springs are not sufficiently microbiologically clean and should be consumed with caution. This result could be interpreted as a signal that mineral waters need to be assessed and their condition monitored.

5. DECLARATIONS

5.1. Funding

The current study was conducted within the following project: “A complex study of thirty popular mineral water springs in Szeklerland (2019-2021)”, identifying number: KPI: 21/3/12.06.2019

5.2. Conflict of interest

The authors declare no conflict of interest.

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Authors addresses

TELEGDY, Balázs, Sapientia University, Faculty of Economics and Socio-Human Sciences and Engineering, Department of Social Sciences, Miercurea Ciuc, județul Harghita, Piața Libertății nr. 1., 530104, telegdybalazs@uni.sapientia.ro

NISTOR, Laura, Sapientia University, Faculty of Economics and Socio-Human Sciences and Engineering, Department of Social Sciences, Miercurea Ciuc, județul Harghita, Piața Libertății nr. 1., 530104, nistorlaura@uni.sapientia.ro

THE ROLE OF TOURISM IN THE HUNGARIAN ECONOMY IN INTERNATIONAL COMPARISON

ÉVA DARABOS – TÜNDE ORSOLYA NAGY – ANITA KISS

Faculty of Economics and Business, University of Debrecen,
Institute of Accounting and Finance, Debrecen, Hungary

darabos.eva@econ.unideb.hu

kiss.anita@econ.unideb.hu

nagy.tunde@econ.unideb.hu

Abstract: The contribution of tourism to GDP is the most commonly used indicator to show the economic role of tourism. However, it is very difficult to show the direct and indirect effects, since the performance of the related sectors – culture, transport, trade, travel, entertainment, etc. – is also reflected in the performance of the sector.

The aim of this research is to present, on the basis of statistical data, the evolution of the main data of the accommodation and catering sector for the years 2019-2023 in European countries, highlighting the performance of Hungary, Romania and Croatia. For all three countries, there was a significant decline in the period Covid-19, but in several areas they approached or far exceeded pre-crisis levels by 2023. For example, Croatia leads the ranking in terms of contribution to GDP, with the sector's share increasing from 25.2% to 25.8%, but Hungary's fell from 8.3% to 7.4% and Romania's from 6% to 5.6%.

Overall, the euro area countries performed well on the most important indicators. Croatia's economy, including tourism, has benefited from the introduction of the euro. In Hungary, the continued weakening of the forint is also contributing to slower growth in the economy as a whole. Romania's leu is more stable against the euro, the economy as a whole is performing well and EU accession opens up new prospects for the country.

Our research is based on publicly available databases from the CSO, Eurostat, OECD. The study focuses primarily on Hungary, with some indicators and areas being compared with data from two neighbouring countries, Romania and Croatia, and with data from EU countries.

Keywords: tourism, crisis, economic growth, employment

1. Introduction

At the beginning of the 21st century, the world was immediately hit by two major crises. The first was the economic and financial crisis of 2008-2009, which started in America in the form of a credit and housing crisis, but quickly spread to almost every country in the world (Losoncz, 2008). While the 2008 global economic crisis mainly affected the economy, living standards and credit, the 2020 Covid-19 epidemic first restricted the free movement of people and then spread to almost all areas of life. The accommodation and catering sector was the hardest hit by the epidemic from the start, with hotels and restaurants closing, and entrepreneurs cushioning the significant drop in demand with layoffs and forced holidays (Darabos et al., 2024)

In 2019, after many years of slow growth, tourism achieved an outstanding performance, reaching peak levels in several areas, but the crisis caused by Covid-19 and the Russian-Ukrainian war led to a drastic decline in European countries and the world as a whole. In 2022, the recovery began, and by 2023 the crisis in the European countries had ended, with the sector's turnover reaching, and in some areas exceeding, the level of 2019.

The aim of the research is to present the evolution of the main data of the accommodation and hospitality sector in European countries for the years 2019-2023, highlighting the performance of

Hungary, Romania and Croatia. For all three countries, there was a significant decline during the crisis period, but by 2023 they had approached or far exceeded pre-crisis levels in several areas. The question arises: why are we looking at the performance of these three countries? For centuries, Hungary has been linked to Romanian and Croatian culture, society, economy, etc., by a thousand links. At the beginning of the 1990s, all three countries experienced regime changes, either peaceful or revolutionary, or as a result of war.

The process of accession to the European Union is complex, involving several steps and strict political, economic and legal requirements (the so-called Copenhagen criteria). After a long period of preparation and negotiations, Hungary concluded an Association Agreement with the European Union in 1994, Romania in 1995 and Croatia only in 2001. Accession took place in the following order: Hungary in 2004, Romania a few years later (2007) and Croatia in 2013. Hungary met the convergence criteria, but later its budget deficit and public debt repeatedly exceeded the Maastricht limits, although it committed to do so, but postponed the introduction of the euro, and has not yet set a target date for its introduction. Romania started from a difficult economic situation, reforms in many areas of the economy and society have been carried out in recent years, the euro has not been introduced yet, but there is a chance of its introduction in the coming years. Croatia joined under more stringent conditions after the South Slavic war, following the reconstruction of the country, but met the convergence criteria by 2023 and adopted the euro 10 years after accession. It joined later but made a bigger step than the other two countries.

Our research is based on publicly available databases from the HCSO, Eurostat, OECD. The study focuses on Hungary, comparing some indicators and areas with data from two neighbouring countries, Romania and Croatia, and with data from EU countries.

2. Specific characteristics of the tourism sector

Tourism has been a dominant and dynamic economic sector worldwide in recent decades. Its importance is recognised and supported by an increasing number of governments. It is also at the heart of EU support policies, e.g. in relation to rural conservation, rural tourism development, sustainability, environmental measures, etc. The sector is of strategic importance for the Hungarian economy in terms of GDP production, balancing the balance of payments and employment, and increasing consumption (Darabos et al., 2024; Tömöri, 2021). The following is a summary of the most important areas without claiming completeness.

One of the best indicators for determining the economic weight of a sector is its contribution to GDP. Tourism accelerates the economic growth of each state, increases government revenues and has an impact on capital investment.

The amount spent by foreign visitors and the amount of money spent abroad by Hungarian travellers is important. While foreigners increase consumption at home, Hungarian travellers spend part of their income abroad. In addition to income, the size of these expenditures is significantly influenced by consumer prices and the exchange rate of the country's currency. On the other hand, spending by foreign visitors increases exports, so foreign exchange earnings improve the current account balance. One of the most important economic benefits of tourism is the increase in income, which directly contributes to the development of local communities. The money spent by tourists not only increases the income of hotels and restaurants, but also has a positive impact on many other industries. For example, tourists buy products from local artisans, artists and service providers.

A specific feature of tourism is the relatively high level of fixed costs, especially in the transport and accommodation sectors. The fixed costs of tourism services do not depend on the number of visitors and are therefore incurred even when demand - and hence the revenue to cover these costs - is low. In hotels and accommodation facilities, maintenance costs, such as heating, lighting, wages, etc., are incurred regardless of the number of guests. The high level of fixed costs in the transport and accommodation sectors, combined with the non-stocking of services and the fluctuations in demand over time, creates a significant capacity planning challenge for the sector.

It also has the potential to reduce regional development disparities by creating jobs and improving employment and local retention.

Temporal fluctuations in demand can occur seasonally, mainly as a result of weather and social factors. Winter and summer tourism in some countries are markedly different e.g. Czech Republic, Romania, Hungary. There are countries where the seasonal difference is evened out, e.g. Austria, France or Italy.

The environmental dimension of services in tourism is very important. Successful winter sports tourism, for example, can only be created in destinations with the right climatic and, to some extent, topographical conditions. The development of heritage tourism, for example, requires an asset from the past - even a physical asset such as a castle or a museum - on which it can be built. While, for example, a logistics centre can be built almost anywhere where space and labour are available, and products stored in a warehouse can be shipped to customers anywhere in the world, tourist destinations are severely limited in their ability to develop their products by their natural and cultural characteristics.

Today, the role of highly skilled workers is growing alongside that of low-skilled workers. With the development of technology, online services have become a dominant feature, e.g. train tickets, airline tickets, hotel reservations, admission tickets, etc.

The provision of accommodation for tourists has become a major "industry" alongside traditional hotel accommodation, with the provision of accommodation for a few nights reducing the supply of available accommodation (e.g. subletting) while increasing property prices.

The large number of domestic and foreign visitors is driving up retail and restaurant prices as demand increases, especially in the larger tourist destinations.

Tourism is also increasingly concerned with sustainability requirements.

Domestic and foreign visitors alike are looking to relax, recharge, recuperate, learn new information, and discover new cities and natural attractions. On the one hand, they increase the income of the country, local businesses and the population through their spending, while on the other hand, they experience increased pollution on public transport, near lakes/resorts, around historic cities and key destinations, and deterioration of natural and cultural treasures.

Today, many large cities, bathing sites, tourist attractions, etc. are threatened by so-called "over-tourism", e.g. Italian and Spanish cities.

3. Tourism and hospitality performance 2019-2023

By 2023, statistics show that in most European countries, the sectoral crisis has been resolved, with turnover almost back to previous levels, and in many areas reaching or well above pre-crisis levels by 2023.

In terms of contribution to GDP, Croatia leads the ranking among EU countries, with tourism contributing almost a quarter of its southern neighbour's economy in recent years. Portugal and Greece are in second and third place respectively, with the sector contributing almost a fifth of both countries' economic performance. Only a few countries, Portugal, France and Denmark, exceeded the 2019 level, while most countries only came close. While in Croatia the sector's share increased from 25.2% in 2019 to 25.8% in 2023, it decreased from 8.3% to 7.4% in Hungary and from 6% to 5.6% in Romania. Slovakia, Poland and Ireland round off the list. Figure 1 shows the ranking of EU countries.

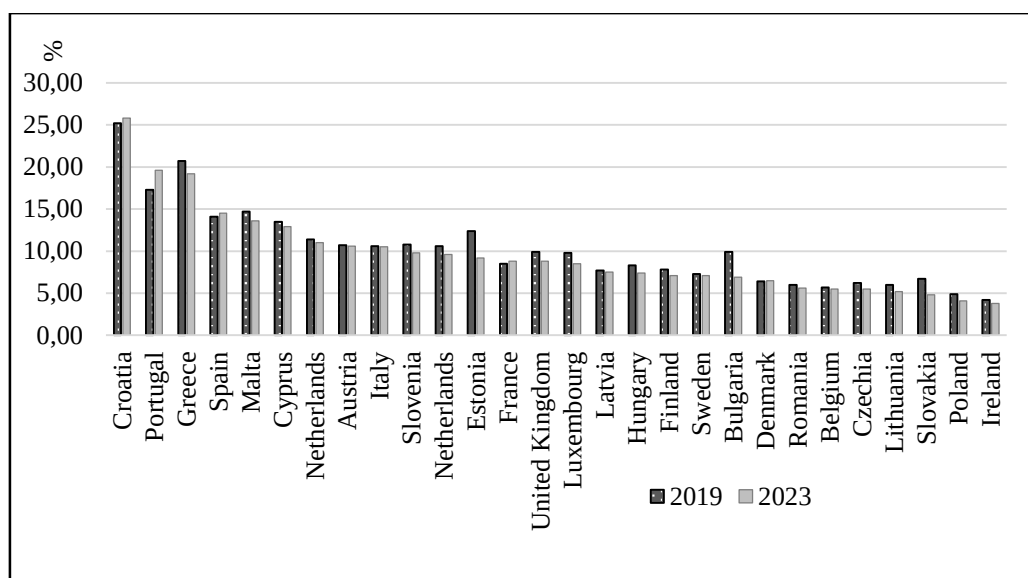


Figure 1. Contribution of the tourism and hospitality sector to GDP in EU countries (2019, 2023)

Source: Internet 1

Note: the above table includes the UK performance.

In 2020, Croatia experienced the steepest decline (8.5%), while Hungary and Romania remained below the EU average. In 2020-21, all three countries experienced growth above the EU average, with Croatia achieving an outstanding recovery of 13%. By 2023, growth had slowed and Hungary was already in recession.

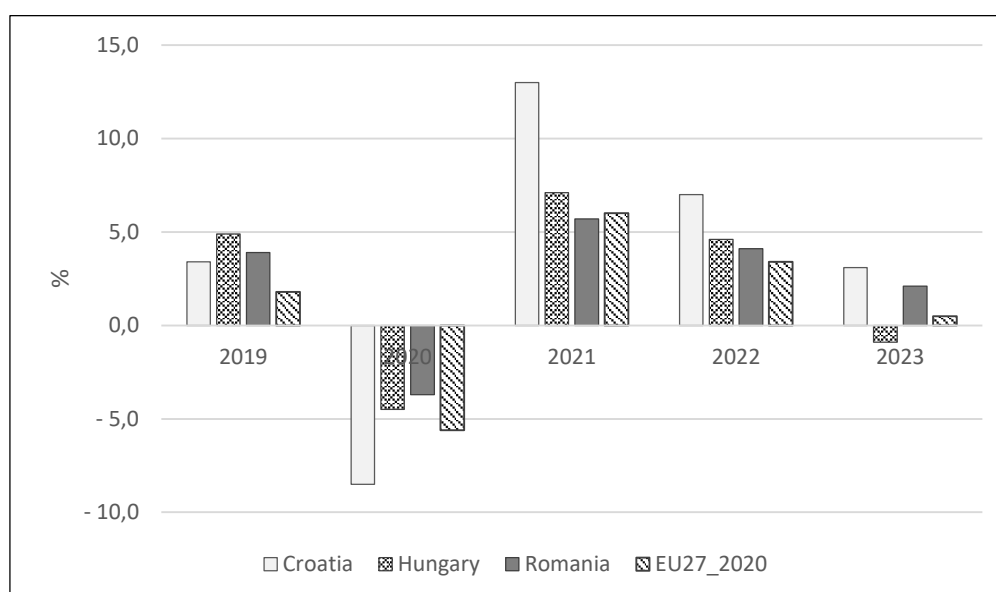


Figure 2. Gross domestic product (GDP) volume change (% , previous year=100%)

Source: Internet 2; KSH, 2025

GDP per capita is a measure of a country's economic development. At the EU level, there is a territorial convergence in the development of the Member States. In terms of GDP per capita at purchasing power parity, the indicator commonly used to compare the development of Member States, Hungary has converged towards the EU average over 20 years (Figure 3). However, compared with countries that joined us at the same time or later, including the Central European countries, Hungary's catching-up trajectory has been among the slowest. GDP per capita at purchasing power parity grew by 59% from 2019 to 2023 in Croatia, 46% in Hungary and 51% in Romania.

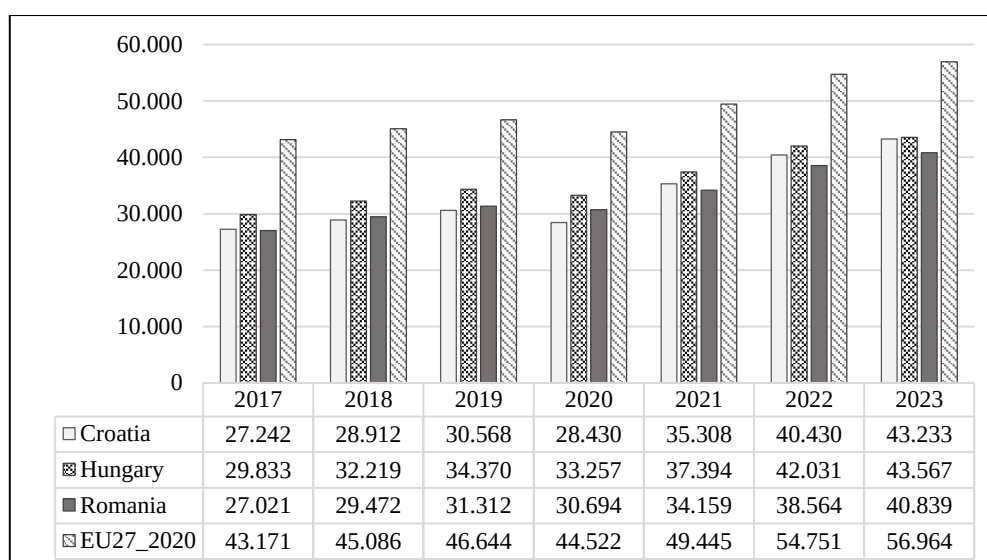


Figure 3. GDP per capita in purchasing power parity terms (USD)

Source: Internet 3

If GDP per capita at purchasing power parity is defined as a ratio of the EU average, the difference in the rate of progress is striking between the countries under study, with the EU average in Croatia and Romania being 63.1% and 62.6% respectively in 2019 and increasing to 75.9% and 71.7% in 2023. Hungary's growth is slower, from 69.1% to 76.5% in 2023, just above the Croatian GDP per capita. Compared with the nine countries that joined us at the same time and the three that joined after us, it is safe to say that Hungary's catching-up has been among the least dynamic in the last 20 years.

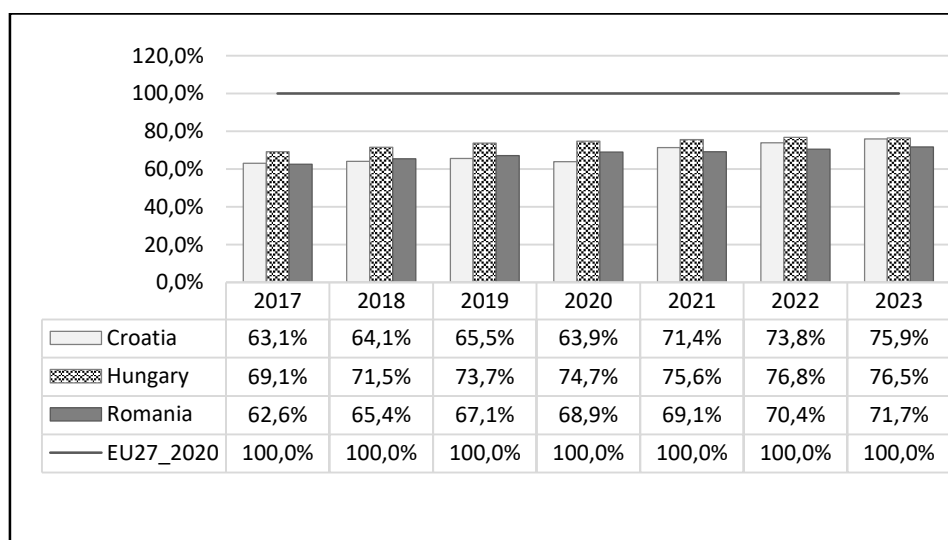


Figure 4. GDP per capita in the EU27 in percentage terms, in purchasing power parity

Source: Internet 4

Although at pan-European level, the number of international tourists has exceeded the 2019 level, this is true for only ten of the 27 EU Member States. Figure 5 shows the ratio of international and domestic tourists to population in 2023. This ranking also shows that Croatia is the country with the highest number of accommodation and leisure visitors, with the Balkan country receiving nearly 4.4 times the population of foreign visitors and 68.2 percent of domestic visitors per year. The next five countries on the list are those with rich archipelagos or major ski resorts (Malta 354, Austria 297, Cyprus 272, Greece 253, Slovenia 219 %).

In 2023, according to Eurostat's database, Hungary received 5.5 million foreign tourists, equivalent to 57% of the population, and 70% of domestic tourists in accommodation and catering establishments, ranking 19th in the EU (Horváth, 2024).

The last three in the ranking are Central and Eastern European countries; Slovakia (37 per cent), Poland (19 per cent) and Romania (11 per cent) in terms of foreign tourists. On average, the EU-27 Member States receive 91 per cent of their population as foreign tourists, or 136 per cent of their population as domestic tourists, every year.

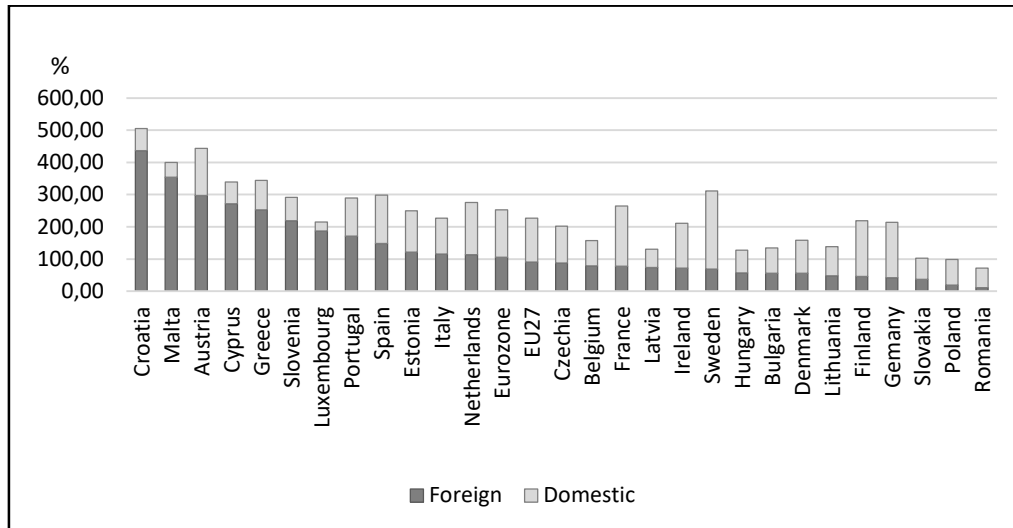


Figure 5. Share of foreign and domestic tourists as a share of total population in EU countries (%)

Source: Internet 5

The number of people employed in the sector has decreased significantly due to the operational difficulties caused by the coronavirus epidemic. In Hungary, the low point was reached at the beginning of 2021, when around 50,000 fewer people were employed in the sector than in the same period in 2019. With the lifting of the epidemic restrictions, the number of people employed gradually increased and by the end of 2022, the number of people employed had exceeded the pre-epidemic level (Zerényi, 2023). However, the economic difficulties and the closure of businesses led to an overall decrease in the number of people employed in 2023. Many looked for work abroad, mainly in Austria, while others found employment in other sectors. In addition, one of the main challenges is expected to remain the shrinking labour force due to adverse demographic trends (Darabos et al., 2024; Fekete-Fábián et al., 2022). Even with steadily rising wages, the number of people employed in the sector is not expected to continue to grow.

The importance of the sector is shown by the share of workers in the sector in relation to total employment in the national economy. Greece (9.1%) and Spain (8.3) have the highest employment in the tourism sector, while Poland, Romania and Lithuania have the lowest. Croatia ranks in the middle with 5.9%, with a slightly lower share of Hungarian workers (3.9%).

4. Sustainability issues in the tourism sector

In several European countries and cities, records were broken in 2023 and 2024, according to the latest statistics. How long is this sustainable? Achieving sustainable tourism is now a priority for all stakeholders in European countries. This requires ensuring an appropriate economic environment, social sustainability and environmental sustainability. After the pandemic, although there were signs of it before, European tourism was faced with a new challenge: the so-called 'over-tourism', its consequences and how to manage and limit it.

While tourism boosts GDP, local residents - especially in big cities - are less happy about the tourist influx, not to mention the fact that consumer prices, real estate prices, are also boosted by the increase in demand. In the three countries studied, two cities in particular, Dubrovnik and Budapest, are affected by the problem of over-tourism.

Árva and co-author (2020) conclude that, while tourism is one of the fastest growing sectors of the economy, it is also the biggest polluter and has become the least sustainable, making further development of tourism in many destinations almost impossible. In this situation, new solutions must increasingly be incorporated into marketing tools, rather than the solutions of the past, and education must play a role in this. Hungary has opportunities in this area, e.g. health, spa and business tourism (Kinczel et al., 2023). Therefore, local communities need to be aware of the growth in tourism.

Sustainability will continue to be a dominant trend in tourism. Increasingly, tourists are looking for destinations and accommodation that are environmentally friendly. Demand for nature-based tourism in Hungary, such as national parks, ecotourism sites, sustainable accommodation and quality tourism, is expected to grow (Németh, 2021). Croatia's coastline offers a long term opportunity for tourism development, which Croatians have managed well in recent years. Romania's historical past, its attractions and not least its rich natural resources offer potential for tourism, but it is worth bearing in mind the experience of neighbouring countries.

5. Summary

In 2023, the contribution of travel and tourism to total GDP in the EU Member States will remain below pre-COVID-19 levels in most cases, but show strong signs of recovery. Overall, Croatia was the EU country with the highest contribution of travel and tourism to GDP in 2023. In that year, these industries directly and indirectly accounted for nearly 26 percent of the country's GDP. Portugal and Greece followed in the ranking in 2023, with travel and tourism contributing 19.6 and 19.2 percent of GDP respectively.

In EU countries, the total number of foreign tourists exceeded the 2019 level, but the share of domestic and foreign tourists in the total population varies between countries. Croatia performed exceptionally well, with Hungary and Romania in the bottom third. At the level of the national economies, the highest shares of employment in the sector are in Greece (9.1%) and Spain (8.3%), Croatia 5.9%, Hungary 3.9% and Romania only 2.6%. In Hungary, there has been a significant outflow of labour, consumer prices, especially food prices, have risen sharply compared to European levels, and many small businesses have closed down due to high energy prices.

Overall, the euro area countries performed well in terms of the most important indicators. Croatia's economy, including tourism, has benefited from the introduction of the euro. In Hungary, the continued weakening of the forint is also contributing to slower growth in the economy as a whole. Romania's leu is more stable against the euro, the economy as a whole is performing well and EU accession opens up new prospects for the country.

Tourism plays a major role in the global economy and has a particularly important impact on the lives of local communities and local people. The arrival of tourists not only brings economic benefits, but can also bring about many social and cultural changes. However, tourism is not without its challenges. Excessive tourism, i.e. the over-exploitation of local resources, can be a major problem that can damage the quality of life and the natural environment of communities in the long term. It is important that local leaders and communities are aware of the impact of tourism and develop strategies to ensure sustainable development.

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ADDRESSING REGIONAL DISPARITIES AND TERRITORIAL CHALLENGES

ENVIRONMENTAL WILLINGNESS TO PAY ACROSS EUROPE. COMPARING ISSP AND EVS SURVEY DATA

GYÖNGYVÉR BÁLINT – LAURA NISTOR

ABSTRACT

Willingness to pay for the environment constitutes one of the most popular measures of environmental concern. Our study compares the results of four questionnaire techniques measuring willingness to pay (WTP) in Europe in the 2017-2021 European Values Survey (EVS) and in the 2020 International Social Survey Programme (ISSP). Through our comparative analysis, we focus on answering the following research questions: Of the four components (paying higher price, paying higher taxes, reduction in standard of living, and giving part of income), which is the one that shows the highest WTP? Are there significant differences between countries in terms of WTP? What are the socio-demographic and attitudinal determinants of WTP's four components? The results show that the four types of measurement lead to different levels of willingness to pay. The most accepted sacrifices are giving away income and cutting back on living standards, while higher taxes are the most likely to reduce willingness to pay. Western and Scandinavian countries “perform” significantly better than Central and Eastern European countries in terms of willingness to pay measures. The different ways in which the willingness to pay is operationalised have partly the same and partly different social backgrounds: high income, interpersonal trust, post-material values, and environmental attitudes significantly increase the willingness to pay for environmental protection in all dimensions measured differently.

Keywords: willingness to pay, Europe, environmental concern, survey

1. INTRODUCTION

Willingness to pay (WTP) studies are part of the so-called contingent valuation (CV) method (Munro – Hanley 1999), which, by directly questioning people about the “economic value they place on a change in the quantity and quality of a specified resource” (Kotchen–Reiling 2000: 94), aims to appreciate the theoretical valuation of those kinds of goods which are not bought and sold on the market (Hanemann 1994), such as the clean environment. Thus, the contingent valuation method usually asks people if they would like to contribute financially to improve specific public goods, through the so-called willingness to pay questions.

The willingness-to-pay questions imply the formulation of a hypothetical market and payment scenario, which describes the environmental goods in question and the measures envisaged, and clarifies what we get in return for payment and acceptance (Ajzen–Driver 1992). Depending on how the question is asked, there are several subtypes of willingness-to-pay questions (Carson et al. 2011). In questions that examine willingness-to-pay at the conceptual level, the respondent is only asked to indicate whether or not he or she would be willing to pay for the environment or environmental protection. In more specific questions on payment and acceptance dispositions, the respondent is also asked to express the extent of the financial sacrifice or compensation accepted (Liebe et al. 2011).

In economic policy approaches, the willingness to make financial sacrifices is usually considered a precursor to actual action. Still, this direct causality only holds under strict requirements when formulating the questions (Monostori 2007). The predictive function of willingness-to-pay surveys on environmental policies thus requires exact questioning. In this context, several recommendations have been made. For example, the formulation of questions should create a conditional market that describes the environmental good as accurately and realistically as possible (Marjainé Szerényi et al. 2005). It is also a standard recommendation that questions should be closed questions; the results on

WTP should be followed longitudinally, and comparing different questioning methods allows for better estimation of the actual WTP (Marjainé Szerényi 2001). According to Kotchen and Reiling (2000), we need to use the respondents' attitudes to help interpret CV survey responses. The underlying assumption is that a person with a solid pro-environmental attitude is more willing to pay for the environment, respectively, that a person who is more willing to pay will do so in a practical payment situation.

A problematic issue associated with contingent valuation and a source of potential response bias is the so-called 'warm glow' (Kahneman–Knetsch 1992), which refers to the respondents' satisfaction ensuing from expressing willingness to pay. A warm glow may be interpreted as impure altruism because respondents usually benefit from their desire to pay for good reasons, such as environmental protection. The warm glow is, in fact, very similar to environmentally desirable responding (cf. Ewert–Galloway 2009) since "respondents in a CV survey attempt to please an interviewer by agreeing (or not agreeing) to pay some amount when they would not do so otherwise, except for the utility gain associated with telling the interviewer" (Carson et al. 2001: 177). This response is also readily observable in comparisons between contingent valuation surveys and effective payments, the latter being usually lower than expected based on contingent valuation results (Diamond–Hausman 1994). According to Hanemann (1994), there are three significant ways to validate contingent valuation results: through replication, comparison with estimates from other sources, and comparison with actual behavior. Considering all the limitations and recommendations mentioned above, WTP is widely used to elicit consumers' valuation of non-market goods (Steigenberger et al. 2022).

Following the above recommendations, the present study compared the willingness to pay for the environment in European countries using two data collections: the European Values Survey (EVS) and the International Social Survey Programme (ISSP). In the EVS, willingness to pay for the environment was measured by a single question (I would give part of my income if I were certain that the money would be used to prevent pollution), while the ISSP approached the question with three variables (Would you be willing to... 1) pay higher prices to protect the environment, 2) pay higher taxes, 3) accept a reduction in the standard of living).

Through our comparative analysis, we focus on answering the following research questions: What is the difference in willingness to pay between the four measures? Which component is associated with the highest and lowest willingness to pay? Are there significant differences between countries in terms of willingness to sacrifice? What are the socio-demographic and attitudinal determinants of WTP's four components (price, tax, living standards and part of income)?

In the following sections, we will describe the two surveys and the questions through which these surveys targeted environmental willingness to pay. We will also present the methods of analysis. Then, the results will be presented and discussed. The paper ends with the conclusions.

2. MATERIAL AND METHODS

Two databases, the ISSP cumulative database (ISSP Research Group, 2023) and the EVS 2017-2021 integrated database (EVS, 2022), were used to analyse the willingness to pay for environmental protection. Both surveys included national representative samples for the participating countries, i.e., 36 countries in the case of the EVS and 28 countries in the case of the ISSP. For the present comparative analysis, we focused only on those 17 common countries that have been included in both surveys, such as Austria, Denmark, Finland, France, Germany, Croatia, Hungary, Iceland, Lithuania, Italy, Norway, Russia, Slovakia, Slovenia, Spain, Sweden and Switzerland.

As stated in the Introduction section, the two surveys measured environmental willingness to pay through different questions, as presented in Table 1 below.

Table 1. The wording of the WTP questions in the two surveys

Survey	Question(s) from the questionnaires		Response variants
ISSP 2000		1) pay higher prices to protect the environment	1. Very willing

	Would you be willing to	2) pay higher taxes to protect the environment	2. Fairly willing
		3) accept a reduction in the standard of living to protect the environment	3. Neither willing nor unwilling
			4. Fairly unwilling
			5. Very unwilling
EVS 2017-2021	I would give part of my income if I were certain that the money would be used to prevent pollution.		1. Agree strongly
			2. Agree
			3. Neither agree nor disagree
			4. Disagree
			5. Disagree strongly

Source: computed by the authors.

As mentioned elsewhere (Nistor–Bálint 2024), the literature on willingness to pay (Carson et al. 2011, Liebe et al. 2011) highlights the importance of dichotomous responses. In our analysis, we have followed this approach, converting the variables measuring willingness to pay into dichotomous variables. In all cases, 0 represents “not willing to pay” and 1 means “willing to pay”. In the bivalent dependent variables of both datasets analysed, the group declaring willingness to pay for the environment comprises those who agreed/were willing or strongly agreed/were very willing with the statements in Table 1. For neutral respondents, we assumed that those uncertain in a hypothetical situation would strengthen the group of non-payers in an actual situation. Although there are precedents in the literature for removing neutral, undecided respondents from the analysis to enhance the dichotomy (e.g., Israel–Levison 2004, Ivanova–Tranter 2008), due to the associated reduction in item counts, we have included them in the “unwilling to pay” group in the present analysis.

In the first part of the analysis, we relied on descriptive statistics to compare the popularity of the differently measured WTPs across the 17 countries. In the second part of the analysis, we used binary regression to investigate the socio-demographic, axiological, and attitudinal determinants of the different WTP questions. A total of 11 explanatory variables were included in the regression models to examine the factors that shape willingness to pay. Gender, age, and place of residence (3 additional variables) were considered control variables. As the research aims to compare the results of the two most recent surveys (ISSP 2020 and EVS 2017-2021), we also aimed to transform the variables (mainly socio-demographic characteristics) in both datasets to make them similar. Table 2 below lists the explanatory variables and their measurements:

Table 2. The explanatory variables of the regression models

<i>Socio-demographic variables (SD)</i>	<i>Datasets</i>	<i>Type</i>	<i>Variables of social attitudes (SA) (5)</i>	<i>Dataset</i>	<i>Type</i>
<i>Age (SD1)</i> EVS: 82=82 years and older	ISSP, EVS	scale	<i>Institutional trust (SA1)</i> Factor score: 4 (ISSP) and 4 (EVS) institutions (education, parliament, news media, economic inst.)	ISSP, EVS	scale
<i>Gender (SD2)</i> Male=1, Female=0	ISSP, EVS	binary	<i>Interpersonal trust (SA2)</i>	ISSP, EVS	binary
<i>Education (SD3)</i> Years spent in full time education (ISSP). Age when ending formal education (EVS, 7=7 years or younger, 70=70 years or older)	ISSP, EVS	scale	<i>Political activity (SA3)</i> Taken part in the latest elections (ISSP, 1=have took part, 0=Haven't). Frequency of participation in national elections (EVS, 1=always, 0=not always).	ISSP, EVS	binary

<i>Income level (SD4)</i> Total net income of household: 1=high (appr. 3 highest deciles), 0=not high	ISSP, EVS	binary	<i>Postmaterialist values (SA4)</i> 1=Postmaterialist, 0=Mixes and materialist	ISSP, EVS	binary
<i>Type of locality (SD5)</i> 1= bigger settlements: small and big cities (ISSP), over 20,000 inhabitants (EVS), 0=smaller settlements	ISSP, EVS	binary	<i>Environmental attitudes (SA5)</i> Factor score (4 types of attitudes towards the environment)	ISSP, EVS	scale
<i>Type of respondents' country (SD6)</i> 1=Western European, 0=East- Central European	ISSP, EVS	binary			

Source: computed by the authors.

When selecting these explanatory variables, we relied on previous literature results, which contend that higher educational attainment is most strongly associated with willingness to pay (Ivanova–Tranter 2008, Franzen–Meyer 2010, Franzen–Vogl 2012). Franzen and Vogl (2013) emphasized the role of higher income in influencing willingness to pay, highlighting that scarce financial resources can be an objective constraint that does not allow for the expression of willingness to pay even if the individual otherwise considers environmental protection important. However, the link between willingness to pay and material situation is somewhat nuanced by research that has found that the in-principle willingness to pay is less dependent on material situation than willingness to pay measured in concrete monetary terms (Liebe et al. 2011).

Inglehart's (1995) post-materialism thesis argues that prioritizing environmental protection is a higher-order demand, that the demand for environmental protection can be defined as a component of quality of life, and that it is linked to post-materialist values. In international comparative analyses based on the ISSP framework, Ivanova–Tranter (2008) and Franzen–Meyer (2010), among others, have demonstrated the association of post-materialist values with the willingness to pay for environmental protection. Research has shown that lower interpersonal and institutional trust reduces willingness to pay (Liebe et al. 2011, Davidovic–Harring 2020). Regarding political left-right orientation, the number of non-responses was quite high across the countries, so we included the variables measuring political activity, assuming that political proficiency is related to the payment disposition towards the environment. If willingness to pay is interpreted along the lines of Ajzen's (1985) intentional action model, it can be said that, in general, citizens with more intense environmental attachments are more willing to pay for the environment (Meyer–Liebe 2010, Liebe et al. 2011).

The research question of the analysis was to explore whether the differently measured willingness to pay variables share the same roots in terms of their socio-demographic and axiological determinants.

3. RESULTS AND DISCUSSION

3.1. The four environmental WTP rates

First, we used data from the two databases to examine the descriptive statistics of four differently measured willingness-to-pay variables across 17 European countries. Based on the relative frequencies of the original 5-point Likert scale responses (see Table 3), the highest level of willingness to pay is observed in the measure based on voluntary income contributions, as recorded in the European Values Study (EVS).

Table 3. Descriptive statistics of the environmental WTP in the 17 European countries

	<i>ISSP-higher prices</i>	<i>ISSP-higher taxes</i>	<i>ISSP-reduction in standard of living</i>	<i>EVS -giving part of income</i>
1. Very willing/Totally agree	5.7	3.6	7	13.8
2. Fairly willing/Agree	29.8	19.5	34.1	36.3
3. Neither willing nor unwilling/3. Neither agree nor disagree	25.6	23	24.4	24.2
4. Fairly unwilling/Disagree	21.8	26.6	18.9	16.2
5. Very unwilling/Totally disagree	17.1	27.3	15.6	9.5
<i>Total</i>	<i>100</i>	<i>100</i>	<i>100</i>	<i>100</i>
N	24818	24608	24839	28948
Mean	3.15	3.55	3.02	2.71
SD	1.186	1.183	1.197	1.172

Source: computed by the authors.

Over one-tenth of respondents across the surveyed countries fully agreed with this support for environmental initiatives. This is followed by willingness to pay measured as a willingness to accept a reduction in quality of life, and then by willingness to pay higher prices for environmental protection. The lowest level of willingness to pay is observed in the case of higher taxes: fewer than one-fifth of respondents expressed definite support for this measure, while more than one-quarter were strongly opposed. The results thus suggest that voluntary contributions are better accepted than constraints, such as paying higher taxes. This result is similar to our previous findings regarding Hungary (Nistor–Bálint 2024) and to the findings of Ivanonva and Tranter (2008) or Sjöstrand (2024). Approximately one-quarter of respondents chose neutral responses across the WTP items. The average values also indicate the same differences and order of willingness to pay, with standard deviations indicating slightly above-average variability in all four cases.

As outlined in the *Materials and Methods* section and following the literature's recommendations (e.g., Carson et al. 2011), we recoded the 5-point Likert scales measuring willingness to pay (WTP)—the central focus of our study—into binary variables. These four recoded dependent variables were then used in the subsequent analysis. Based on this categorization, aggregate willingness to pay (“very willing” and “fairly willing” responses) is highest when framed as a voluntary contribution of income, with half of the population across the 17 European countries expressing support for this option (Figure 1). The second most supported form of financial contribution is a reduction in living standards, followed by a slightly lower level of support for paying higher prices (35.5%). In contrast, fewer than one-quarter of respondents indicated a willingness to support environmental efforts through higher taxes.

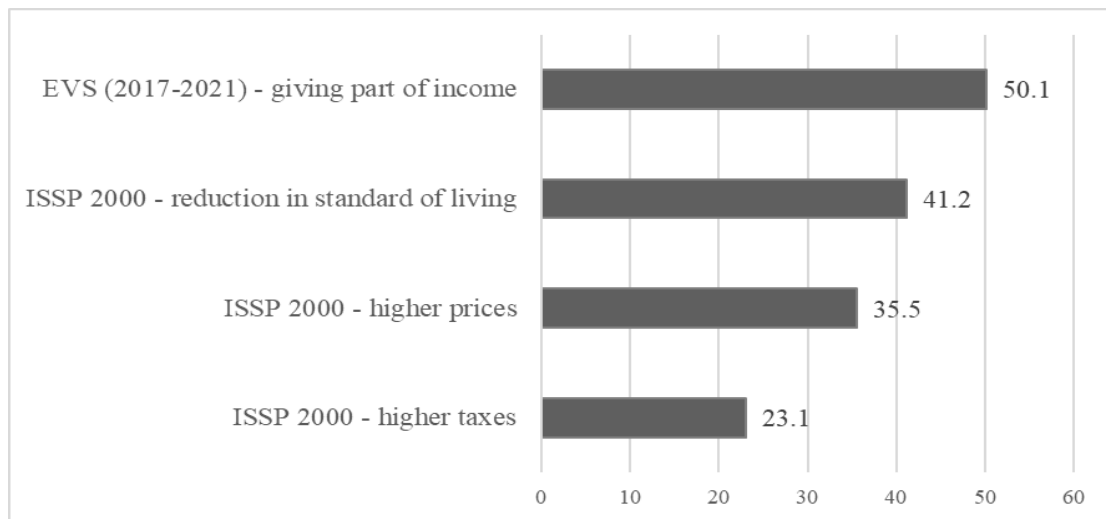


Figure 1. Environmental WTP in the 17 European countries (%)

Source: computed by the authors.

Finally, we examined the correlations among the three WTP measures included in the ISSP dataset. Our analysis revealed that there is a significant positive correlation ($p < 0.001$) among the three willingness-to-pay (WTP) variables, with all correlations exceeding a moderate strength: $r_1 = 0.715$ (paying higher prices – paying higher taxes), $r_2 = 0.598$ (paying higher prices – reducing living standards), and $r_3 = 0.559$ (paying higher taxes – reducing living standards). These results suggest that a higher willingness to pay in one form is also associated with an increased willingness to pay in the other forms.

3.2. Regional disparities in WTP

Next, we examined regional differences in aggregate willingness to pay across the 17 surveyed countries, focusing on the four types of WTP. As expected, significant differences emerged among countries for all four WTP measures ($p < 0.001$; Pearson Chi-Square > 790.528).

Table 4. Country rankings across the different dimensions of WTP (%)

<i>Dimension</i>	<i>1st place</i>	<i>2nd place</i>	<i>3rd place</i>	<i>HU</i>	<i>15th place</i>	<i>16th place</i>	<i>17th place</i>
Higher prices	Switzerland	Norway	Germany	12th place	Croatia	Slovakia	Lithuania
Higher taxes	Norway	Denmark	Sweden	14th place	Lithuania	Russia	Slovakia
Reduction in standard of living	Switzerland	Germany	Austria	16th place	Slovakia	Hungary	Lithuania
Giving part of income	Sweden	Slovenia	Croatia	14th place	Finland	Slovakia	Lithuania
<i>On all the 4 dimensions</i>	<i>Switzerland</i>	<i>Sweden</i>	<i>Norway</i>	<i>15th place</i>	<i>Hungary</i>	<i>Slovakia</i>	<i>Lithuania</i>

Source: computed by the authors.

Swiss respondents demonstrated the highest willingness to pay higher prices and to accept a lower quality of life for environmental protection. Norwegians showed the greatest willingness to pay higher taxes, while Swedes were the most willing to contribute a portion of their income. When considering all four WTP dimensions collectively, Switzerland ranked highest overall. In contrast,

Lithuania ranked lowest in three of the four WTP categories and the overall composite ranking. Table 4 summarizes the countries that ranked highest and lowest in each WTP category.

Figure 2 also includes countries not listed in Table 4. In addition to highlighting significant differences between countries, the figure reveals a clear regional pattern: Central and Eastern European countries generally exhibit lower levels of willingness to pay, whereas Western European and Scandinavian countries tend to show much higher levels of willingness to pay for environmental protection.

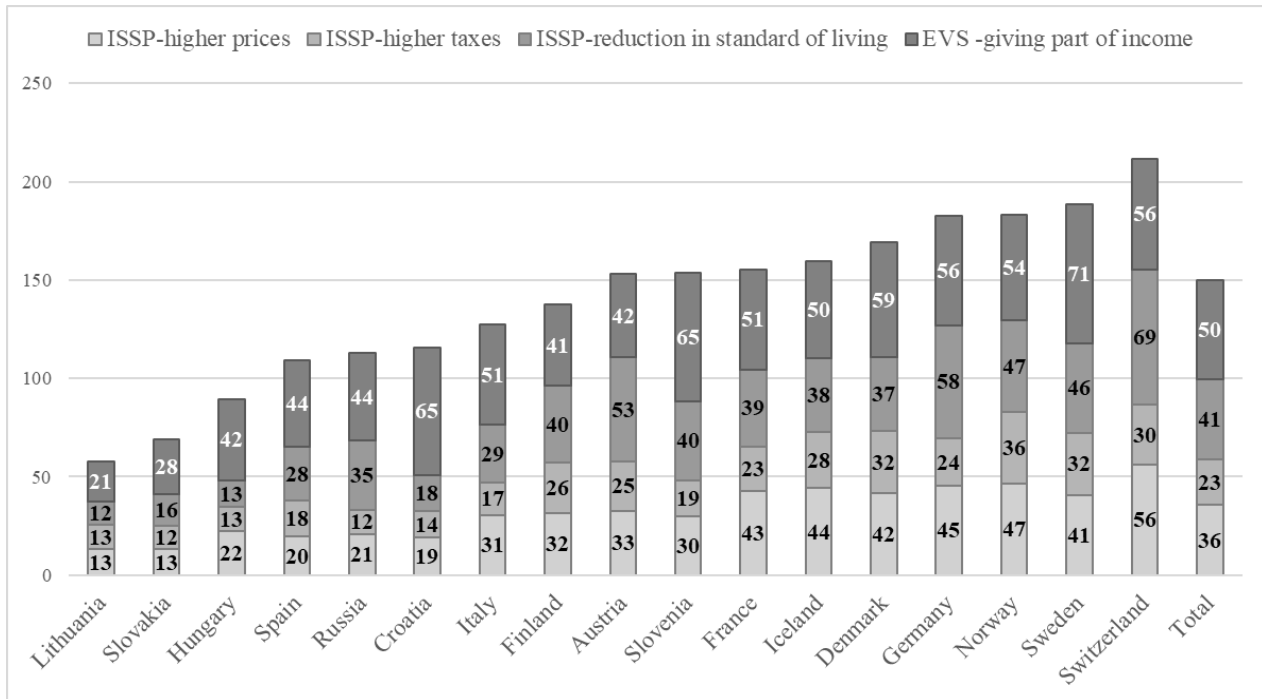


Figure 2. Environmental WTP – country level (%)
Source: computed by the authors.

Therefore, in the next step of our analysis, we divided the 17 countries into two groups: six Central and Eastern European (CEE) countries (Lithuania, Slovakia, Hungary, Russia, Croatia, and Slovenia) and 11 Western-European countries (Spain, Italy, Finland, Austria, France, Iceland, Denmark, Germany, Norway, Sweden, and Switzerland), and examined the differences in WTP. Figure 3 clearly shows significant differences between the country groups ($p < 0.001$; Pearson Chi-Square > 224.935). The most minor difference is the willingness to pay as a proportion of income between the two country groups. In the case of the other three WTPs, Western European countries show almost twice as much willingness to pay as Central and Eastern European countries. This is why we deemed it essential to include this regional grouping as an explanatory variable in the regression model.

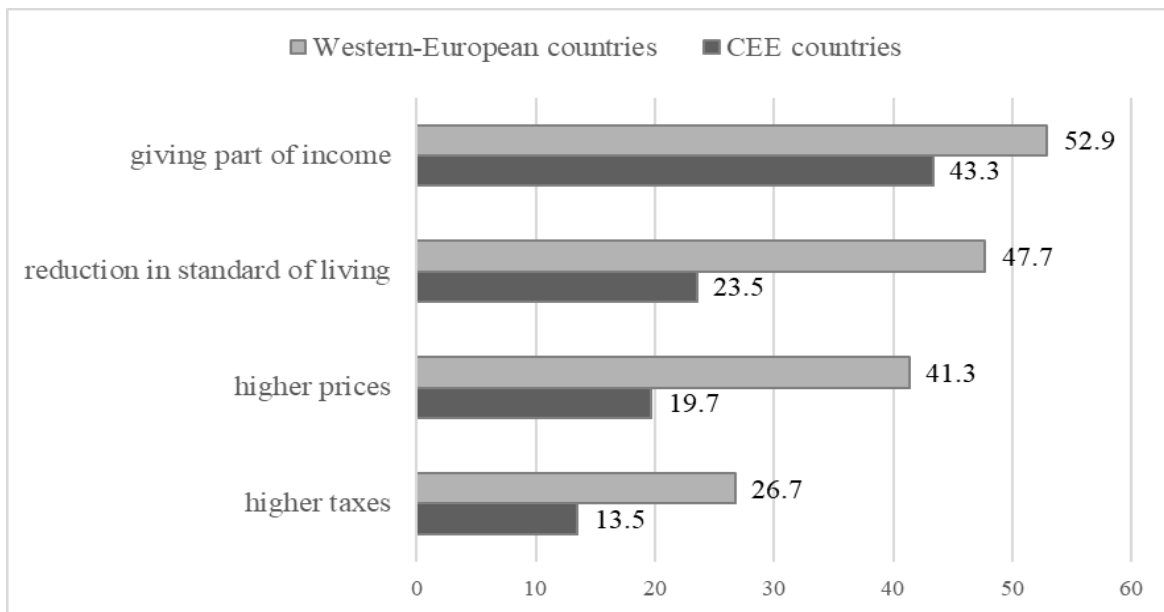


Figure 3. Environmental WTP across country groups (%)

Source: computed by the authors.

3.3. The social background factors associated with the WTP

In the final step of our analysis, we employed four binary logistic regression models to examine the factors influencing the probability of willingness to pay (WTP), as measured in four different ways. The dependent variables were the WTP indicators recoded into binary form (1 = willing to pay).

As detailed in the *Materials and Methods* section (Table 2), we included 11 explanatory variables—six socio-demographic characteristics and five social attitude measures—selected based on prior literature and available in both datasets.

Each of the four models covers approximately two-thirds of the total sample. The correlations among the explanatory variables were generally weak, with the highest observed Pearson correlation coefficient being $r = 0.361$. Multicollinearity diagnostics confirmed that collinearity was not a concern (maximum VIF = 1.243). All explanatory variables were entered simultaneously using the Enter method. According to the Omnibus and Wald statistics (Table 5), all four models are statistically significant. The improvement in classification accuracy over random assignment ranges from 1.6% to 11.9%, with the lowest gains observed in the ISSP models involving higher taxes and prices. The models explain between 18.7% and 23.5% of the variance in the dependent variables in the ISSP dataset, and slightly over 10% in the EVS. Among the four regression models, the final model—measuring willingness to pay for environmental protection in terms of a reduction in living standards—demonstrates the strongest explanatory power.

We relied on two indicators, odds ratios ($\text{Exp}(B)$) and unstandardized regression coefficients (B), to interpret the results.

Table 5. Logistic regression models of WTP

	<i>EVS 1997-2021</i>		<i>ISSP 2020</i>					
	<i>Giving part of income</i>		<i>Higher prices</i>		<i>Higher taxes</i>		<i>Reduction in living standards</i>	
	B	Exp(B)	B	Exp(B)	B	Exp(B)	B	Exp(B)
Age (SD1)	-0.004**	0.996	0.003**	1.003	-0.001	0.999	-0.004**	0.996
Male (SD2)	0.161**	1.175	0.089*	1.093	0.138**	1.148	-0.029	0.972
Education (SD3)	0.011**	1.011	0.042**	1.043	0.043**	1.044	0.016**	1.016
Higher income (SD4)	0.139**	1.149	0.383**	1.466	0.280**	1.324	0.208**	1.231
Bigger settlement (SD5)	0.032	1.033	-0.107**	0.899	0.080*	1.083	-0.229**	0.796
Western Europe (SD6)	-0.106**	0.899	0.569**	1.766	0.249**	1.283	0.834**	2.303
Trust in institutions (SA1)	-0.070**	0.932	0.234**	1.263	0.286**	1.331	0.060**	1.062
Interpersonal trust (SA2)	0.212**	1.236	0.286**	1.331	0.402**	1.495	0.305**	1.356
Voting (SA3)	0.269**	1.309	0.051	1.052	0.167**	1.182	-0.214**	0.808
Postmaterialist values (SA4)	0.452**	1.571	0.452**	1.572	0.549**	1.732	0.385**	1.470
Environmental attitudes (SA5)	0.477**	1.611	0.597**	1.817	0.594**	1.812	0.741**	2.097
Constant	-0.407**	0.666	-2.127**	0.119	-2.661**	0.070	-0.941	0.390
N	19 401 (65.5%)		17 375 (67.9%)		17 283 (67.5%)		17 401 (68%)	
Wald-statistics	38.363**		1263.476**		4327.584**		433.118**	
Omnibus test (χ^2)	1774.616**		2937.714**		2292.057**		3344.098**	
Nagelkerke R ²	0.117		0.213		0.187		0.235	
Model correction	10.5%		6.7%		1.6%		11.9%	

*= $p < 0.5$, **= $p < 0.01$.

Source: computed by the authors.

Overall, the results of the four regression models indicate that the social determinants of willingness to pay (WTP), as operationalized in different forms, are partly overlapping and partly distinct. Five explanatory variables—highlighted in *italics* in Table 5—consistently show significant effects across all four models. Among these, pro-environmental attitudes emerge as the strongest predictor, significantly increasing the probability of WTP in all models and more than doubling it in the case of willingness to reduce one's standard of living. This results is in line with previous data of the literature showing that WTP can be considered an environmental behavioral disposition which is rooted in environmental attitudes (Ivanova–Tranter 2008, Saari et al. 2021).

This is followed by a strongly post-materialist value orientation, which increases the likelihood of WTP by approximately 1.5 times across all models. This is, again a finding which confirms previous results obtained on previous waves of ISSP datasets (Ivanova–Tranter 2008, Franzen–Meyer 2010). Slightly lower effects are observed for interpersonal trust (see previous results obtained by Davidovic–Harring 2020) and belonging to the top three income deciles (see previous results obtained by Franzen and Vogl 2013), both of which raise the probability of WTP by about 1.3 times. Although the effect size is modest, educational attainment—measured by years of formal education—also shows a consistent and significant positive association with all four WTP measures, confirming previous literature findings (e.g., Ivanova–Tranter 2008, Franzen–Meyer 2010).

In addition to these common predictors, several differences in the social background characteristics emerge across the models. In the case of WTP measured by willingness to contribute a portion of income, a higher likelihood is associated with younger age, male gender, residence in Central and Eastern European (CEE) countries, lower trust in institutions (education, economy, politics, media), and political activism. Thus, in CEE countries, citizens would prefer to contribute voluntarily to environmental protection rather than by paying higher taxes.

For WTP, which is measured as willingness to pay higher prices, greater support is found among older individuals, residents of smaller settlements, those living in Western European countries, and

individuals with higher institutional trust. Willingness to pay higher taxes is more likely among men, Western Europeans, individuals with stronger institutional trust, and politically active respondents. Thus, environmental protection measures that imply a reduction in the standard of living or the acceptance of higher taxes are more common in Western countries and require rich social capital in terms of trust. Finally, beyond the five common predictors, willingness to reduce living standards for environmental protection is also positively associated with younger age, residence in smaller settlements, living in Western Europe, greater institutional trust, and political disengagement. These findings reassess the recent contributions of the literature, which highly emphasize the role of trust when approaching environmental dispositions expressed in terms of WTP (Marbuah 2019, Davidovic–Harring, 2020; Sjöstrand 2024).

4. CONCLUSIONS

The present research investigated whether different operationalizations of in-principle willingness to pay for the environment lead to varying results across 17 European countries. For this purpose, the EVS 2017 and ISSP 2020 datasets were used, and analysis was run on those countries included in both surveys. We have investigated the following research questions: Are there different degrees of WTP along different payment scenarios, i.e., different operationalizations of WTP for environment questions? Are there inter-country and inter-country-group differences in WTP? Do different WTP scenarios have different social backgrounds? To what extent do the key explanatory variables in the literature on WTP (higher income and education, post-material values, trust, interest in politics, environmental attitudes) influence willingness to pay?

The results in connection with these questions showed that the specificity of the payment scenarios leads to different results. Across the 17 countries studied, coercive propensity to pay (taxes) is generally the most unpopular, while giving (voluntary) part of income to support (EVS) environmental protection is the most popular willingness to pay measure. There are significant differences between countries' willingness to accept different payment scenarios. Western and Scandinavian countries “perform” significantly better than Central and Eastern European countries on all measures of willingness to pay (the latter typically “perform” better on the EVS-measured income offer). Switzerland, Sweden, Norway, Germany, and Denmark show the highest willingness to pay, while Lithuania, Slovakia, and Hungary show the lowest levels of WTP.

The different ways in which the willingness to pay is operationalised have partly the same and partly different social backgrounds: high income, interpersonal trust, post-material values and environmental attitudes significantly increase the willingness to pay for environmental protection in all dimensions measured differently. The willingness to pay, measured in four different ways, is also shaped by other variables. Willingness to pay as measured by EVS, i.e, by giving up part of income, shows a stronger correlation with gender and political participation. For all ISSP items, residence in a Western European country is a much more significant explanatory variable for paying higher prices and taxes, institutional trust is much more important for higher taxes, political participation and the role of men are also more significant for accepting cuts in living standards, and living in a smaller settlement also increases willingness to pay.

Our analysis provides a sociological view of the trends and determinants of the willingness to pay for environmental protection. However, it is only very marginally predictive of environmental policy support, especially since the variables under study describe theoretical, very generalised payment situations. The results clearly show that although all four questions measure environmental behavioral dispositions and assume a set of standard explanatory variables, different questioning leads to different results. Therefore, the research draws attention to the importance of specificity in formulating WTP questions and the caution about making environmental policy predictions based on WTP. Obviously, not only can the formulation of WTP items lead to different results, but the macro-social context in which a specific WTP question is investigated can also lead to different results. Thus, our research assesses the role of contextual factors as well. We know that this exploration can

be further continued by multi-level methods and more specific surveys in which WTP questions are more concretely formulated to get more precise data on environmental WTP.

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Authors' address

nistorlaura@uni.sapientia.ro, balintgyongyver@uni.sapientia.ro

Sapientia Hungarian University of Transylvania, Cluj-Napoca, Romania
Faculty of Economics, Socio-Human Sciences and Engineering
Department of Social Sciences
530104 Miercurea Ciuc
Piata Libertatii no. 1

ROMANIAN PUBLIC PROCUREMENT SYSTEM, BENEFITS AND PROBLEMS

KASSAY JÁNOS

Abstract: The public procurement system in Romania, in line with EU requirements, was launched in 2006 and, after several changes, a new law was adopted in 2016 to regulate public procurement. The public procurement system is complex but at the same time sufficiently transparent to ensure state control. Nevertheless, a number of problems have arisen, which the legislator has tried to address through specific provisions, mainly in the form of simplifications. The fundamental question is whether the digitalisation and professionalisation of the public procurement system helps or hinders the full application of the Public Procurement Act and whether local and institutional civil servants are prepared to apply it.

Introduction

Public procurement activities have a significant impact on the national economy, according to the OECD report the public procurement in Romania accounts for around 13% of GDP.

Public procurement basically means the purchase of goods, services and works by public authorities and state-owned enterprises. This is far from being merely an administrative task; it is a critical interface between the public and private sectors that has a profound impact on economic development, resource allocation and social welfare. Worldwide, government spending through public procurement accounts for a significant share of national GDP, estimated at between 10% and 15% in many countries and even higher in developing economies. This significant financial outlay underscores the strategic importance of public procurement and makes it an effective tool for achieving broad public policy objectives that go beyond the direct transactional goal of obtaining value for money.

Historically, the development of public procurement has been characterised by a gradual transition from informal, often protectionist systems to highly formalised and regulated frameworks. This development has been driven by a number of factors, including the fight against corruption, the promotion of fair competition, ensuring transparency and accountability in public spending, and, increasingly, the use of public procurement as a tool for achieving broader socio-economic and environmental objectives. The legal and institutional frameworks governing public procurement are therefore complex and multifaceted, based on principles of administrative law, economics and international trade law. Transparency, non-discrimination, equal treatment, proportionality and mutual recognition are principles enshrined in national and international regulations, which aim to create a level playing field for suppliers and optimise the use of public funds.

Contemporary research on public procurement goes beyond mere legal compliance and efficiency indicators to examine the multifaceted impacts and strategic potential of public procurement. Researchers, lawyers, legislators and practitioners are increasingly looking at how public procurement can be used as a catalyst for innovation, to promote sustainable development, to support small and medium-sized enterprises (SMEs) and to promote social inclusion. This requires a comprehensive understanding not only of the economic consequences of public procurement decisions, but also of their social, environmental and technological impacts. Therefore, the scientific study of public procurement requires an interdisciplinary approach that draws on knowledge from

economics, law, political science, public administration and management in order to address the complex challenges and opportunities inherent in this vital public task.

The main objectives of public procurement

Public procurement is not merely a means of spending public funds, but a versatile tool that serves the interrelated objectives outlined above. Obviously, the most important objective is to ensure competition and maximise value for money for taxpayers. This means that public procurement procedures must be conducted in such a way that the government receives the best possible quality goods or services at the most favourable price. This is facilitated by transparency and competition, as open and accessible procedures allow as many potential bidders as possible to participate, encouraging them to submit the best bids. This is somewhat contradicted, or more precisely nuanced, by the fact that the government sector is typically characterised by a lack of resources. (Law no. 98/2016 on public procurements, 2016).

In addition to ensuring competition, preventing corruption and maintaining integrity are also key objectives. Strict rules, accountability and transparency help to minimise potential abuse, conflicts of interest and unfair advantages. Ensuring equal opportunities is also essential, avoiding discrimination between bidders on the basis of their size, ownership background or geographical location (e.g. which country they come from, their ethnic background, etc.).

Main types of public procurement activities

Public procurement activities are diverse and involve different types of procedures depending on the subject matter, value and market characteristics of the procurement. Although the goal is always to use public funds as efficiently as possible, the organisation and implementation of the process may vary depending on the subject matter of the public procurement. The most common types of public procurement activities according to the Law no. 98/2016 on public procurements are presented below:

1. Procurement of goods

This is the most common and perhaps the simplest type of public procurement, which involves the purchase of tangible products. This includes almost everything that a government agency, institution or state-owned company may need for its operation, for example:

Office supplies and furniture: paper, pens, desks, chairs, etc.

Vehicles: cars, buses, ambulances, fire engines.

IT equipment: computers, software, servers.

In the case of healthcare institutions, medical equipment: medicines, medical instruments, protective equipment. Food: food purchased for school canteens and hospitals. The procurement of goods is generally relatively well defined, specifications can be precisely determined, and market competition is generally high.

2. Procurement of services

The second major group is the procurement of services, which refers to the purchase of intangible activities or expertise. This category is extremely broad and often more complex than the procurement of goods, as it is more difficult to objectively measure the quality of services in advance.

Examples of this include:

Consulting services: legal, financial, technical or strategic consulting.

Catering and cleaning services: cleaning or catering in schools, hospitals, office buildings.

IT services: software development, system operation, IT security.

Education and training services: training courses, professional development courses.

Marketing and communication services: campaign management, media buying.

Security services: security and protection.

When purchasing services, greater emphasis is often placed on expertise, previous professional experience, references and the methods used by the service provider.

3. Construction procurement

Construction projects involve the construction, renovation, maintenance or expansion of physical infrastructure. These procurements are generally more complex and often involve very high values (e.g. motorways) and significant financial and technical risks. We are talking here about the construction of public facilities that have a direct impact on the economy, e.g. road construction and maintenance: the construction or renovation of motorways and local roads. But this also includes other infrastructure projects such as the development of bridges, tunnels, railways, water and sewerage networks. Due to their significant social importance, the construction of public buildings such as schools, hospitals and government buildings is also of paramount importance.

Other public utility development projects are also subject to public procurement, e.g. the expansion or renovation of gas and electricity networks. Detailed plans, technical specifications and strict quality control are key to construction projects.

4. Concession contracts

This is a special type of contract under which the contracting authority transfers to an economic operator the right to provide a service or carry out a construction project, whereby the economic operator implements the project at its own risk and expense and then recovers its investment from the revenues generated by the operation. There are several examples of this in the EU and the US. Operation of toll motorways: the concession partner builds and operates the motorway, which is financed by tolls. Operation of car parks: the company builds or renovates the car park and then recovers its costs from the revenue generated by parking fees. Construction and transfer of public services (e.g. water supply) to a private company or municipal company: the concession partner is granted the right to provide the service. Concessions are long-term contracts in which risk sharing plays a key role. (Law no. 98/2016 on public procurements, 2016)

Other procurement mechanisms

In addition to the main types mentioned above, there are also more specialised procurement mechanisms, such as dynamic purchasing systems (accelerated and flexible procurement for recurring purchases), framework agreements (contracts with predefined conditions and a fixed term, on the basis of which further purchases can be made) or innovation partnerships (the development and subsequent procurement of innovative products, services or construction projects that do not yet exist on the market). The selection of procurement activities is always based on a thorough analysis of the specific needs and characteristics of the project in question, respecting the principles of efficiency, transparency and responsible management of public funds according to the Law no. 98/2016 on public procurements.

Procurements in Romania

In Romania, public procurement procedures operate in accordance with European Union rules, taking into account domestic legal and economic characteristics. The first Romanian public procurement system, which provided for and regulated comprehensive rules and even the operation of an electronic platform, was established in 2006 (Emergency Ordinance (GEO) No. 34/2006) . Currently, the basic legislation governing the Romanian public procurement system consists of three laws adopted in 2016, which form part of the Public Procurement Code:

Law No. 98/2016 on public procurement (Lege nr. 98/2016 privind achizițiile publice)

Law No. 99/2016 on sectoral public procurement (Lege nr. 99/2016 privind achizițiile sectoriale)

Law No. 100/2016 on the concession of works and services (Lege nr. 100/2016 privind concesionarea de lucrări și servicii)

Law No. 101/2016 on remedies and appeals in relation to the award of public procurement contracts, sectoral contracts and concession contracts for works and services, and on the organisation and functioning of the National Complaints Council (Lege nr. 101/2016 a közbeszerzési szerződések, ágazati szerződések és munkákra és szolgáltatásokra vonatkozó koncessziós szerződések odaítélésével kapcsolatos jogorvoslatokról és fellebbezésekről, valamint a Nemzeti Panaszügyi Tanács szervezetéről és működéséről)

These laws ensure the transposition of EU directives into Romanian law and contain fundamental principles such as non-discrimination, equal treatment, mutual recognition, transparency, proportionality and accountability. The main body responsible for public procurement in Romania is the National Agency for Public Procurement (ANAP – Agenția Națională pentru Achiziții Publice). ANAP is responsible for developing public procurement policies, monitoring compliance with legislation, supporting contracting authorities, operating the electronic public procurement system (SEAP – Sistemul Electronic de Achiziții Publice) and conducting ex ante checks on procedures.

Key information and resources in the romanian public procurement system

Electronic Public Procurement System (SEAP): In Romania, the vast majority of public procurement procedures are conducted through this platform (use of SEAP can only be avoided in exceptional

cases). This is where public procurement notices and tender documents are published, and where tenders can be submitted and evaluated. The platform is available at e-licitatie.ro.

The National authority for public achizitions (Autoritate Nationala pentru Achizitii Publice) which has central supervisory powers, and its website (anap.gov.ro) provide up-to-date information, legislation, guidelines and news on public procurement.

Local authorities and institutions: Many local authorities and public institutions also publish their public procurement notices and information on their own websites. For example, the Harghita County Council, Miercurea Ciuc City Hall and Târgu Secuiesc websites all have a public procurement section (www.harghitamegye.ro, www.szereda.ro, www.kezdi.ro).

European Commission: The European Commission's website also provides general information on public procurement in the EU, including Romania. Also implement policies for regional development and to increase the EU cohesion.

Legal guides: A bunch of law firms and consulting companies publish guides on Romanian public procurement law, which can be useful for foreign bidders. These are often available in English.

It is worth keeping an eye on changes in legislation, as public procurement laws may be amended from time to time, for example in response to changes in the euro-leu exchange rate or market developments, or when new EU directives are introduced.

Of course, local or central authorities, public utility companies and institutions that carry out public procurement are very important players. They carry out developments and public investments in line with their objectives, activities and budgets, in accordance with national and EU public policies. According to the SEAP in 2025 was 256,000 registered entities – economic operators and contracting authorities on the SEAP (www.e-licitatie.ro).

The EU's structural funds, cohesion funds and rural development funds are particularly important, as they finance a significant proportion of national investments.

Analyzing the Romanian Public Procurements

The specificities of public procurement procedures in Romania stem primarily from the full transposition of European Union legislation (*acquis communautaire*), the prominent role of digital systems, and the constantly evolving control and redress mechanisms.

One of the most characteristic features of the Romanian public procurement system is the electronic public procurement system (Sistemul Electronic de Achiziții Publice, SEAP), also known as SICAP, whose web address is www.e-licitatie.ro. This platform is the central place for public procurement procedures, which includes several functions, among which we can mention:

Publication of calls for tenders: All public procurement calls for tenders and tender documentation are published here.

Submission of tenders: Economic operators can submit their tenders electronically on this platform.

Real-time updates: Participants in the procedure receive up-to-date information from contracting authorities and can communicate continuously on the platform, which can be monitored by supervisory authorities.

Secure document sharing: The e-procurement system guarantees secure document management.

The use of SEAP is mandatory in most public procurement procedures and contributes to increasing transparency and reducing bureaucracy. However, it requires more and more digital competences from users.

Types and characteristics of procedures

In Romania, in accordance with EU rules, there are several types of public procurement procedures, the choice of which depends on the estimated value, complexity and other legal conditions of the procurement.

According to the Reports and statistics (ANAP, 2021,2024)The most significant is the open procedure: Any economic operator may submit a tender. This is the most commonly used procedure.

Restricted procedure: Anyone may request to participate, but only those invited by the contracting authority may submit a tender.

Negotiated procedure: Only economic operators invited by the contracting authority may submit a tender and negotiate with the contracting authority. This is used when the contract is unique or complex.

Competitive dialogue: This can be used when the contracting authority is looking for the most suitable solution.

Innovation partnership: This is used when a product or service is needed that is not yet available on the market.

Award criteria include the lowest price, the lowest cost or the best price-quality or cost-quality ratio. It should be noted that the lowest price or cost criterion is not applicable to all procedures, for example, not even in the case of creative intellectual services (e.g. technical design).

Risk management and integrity

According to the OECD report, public procurement in Romania accounts for around 13% of GDP, which is less than the EU average (14%) 2 trillion (European Court of Auditors, 2023) , but it is still a key activity affecting the economy. However, integrity deficiencies can undermine competition, increase costs and compromise the quality of goods, services and works procured. Romania is working to improve the integrity of public procurement through its National Anti-Corruption Strategy and its National Public Procurement Strategy. The database between integrity authorities and SEAP is interconnected, and all conflicts of interest are prevented, detected and sanctioned using all available tools.

Challenges and development directions

Frequent legislative reviews: While the continuous development of legislation has a positive impact, especially in terms of the introduction of digitalization and facilitations, frequent amendments (especially at the level of secondary legislation) can also cause uncertainty.

Lengthy procedures, appeals, and redress procedures cause delays in the use of EU funds, which can be critical, for example, for the withdrawal of PNRR funds but also for the absorption of structural funds. The use of EU funds is often slowed down by numerous complaints filed by applicants and the cancellation of procedures (a significant part of which is canceled due to lack of offers or inadequate offers).

Increasing transparency: recent changes have introduced stricter transparency rules, such as the online publication of contract performance deadlines and the sending of tender reports to all bidders.

Centralised procurement: The role of the National Public Procurement Agency (ANAP) in centralised procurement is also increasing for certain products (e.g. computers, office supplies, medicines).

The Romanian public procurement system is constantly evolving, with the aim of complying with EU directives and increasing transparency. The SEAP system, ANAP and NCCS (Consiliul National pentru Solutionarea Contestatiilor) institutions play a central role in this process.

Regional disparities under terms of number and value of the procurements

Although Romanian public procurement legislation is uniform throughout the country, as it is regulated by a single national law, in practice there are regional differences, mainly due to the following factors:

In more developed regions (e.g. Bucharest-Ilfov, Western region) and counties, procurement of larger and more complex infrastructure projects (road construction, hospital development, urban infrastructure) and services with higher added value is typically carried out. Competition is higher here, with more large companies and international players (ANAP, 2024).

Less developed regions (e.g. North-East, South-West regions): In these areas, public procurement generally focuses on the development of basic local infrastructure (water and sewage systems, local roads, schools, healthcare facilities). The volume of projects is typically smaller, and the role of local SMEs (small and medium-sized enterprises) may be more dominant.

Absorption of EU funds: Different regions have different levels of efficiency in absorbing EU funds, which directly affects the number and volume of public procurement. Where the absorption rate is higher, more public procurement projects will naturally be launched, we will show the correlation between the funds and procurements.

Romania's Recovery and Resilience Plan (PNRR) includes measures to improve the quality and efficiency of public administration by strengthening public procurement procedures. In particular, component 14 of the PNRR includes measures to improve public procurement procedures, including digitalisation and capacity building, as well as the adoption and implementation of the NAS (2021-2025). Under component 7, digital measures, such as the introduction of electronic forms, are expected to improve the transparency of public procurement administrative capacity and expertise (European Court of Auditors, 2023).

1. Differences between cities and counties: Larger cities and county-level cities generally have more developed administrative capacity and public procurement expertise, which can contribute to smoother procedures and more accurate documentation. In smaller settlements, local governments with weaker administrative capacity may have deficiencies in

documentation, or the tender conditions may be less clear, which can lead to more complaints or unsuccessful procedures.

2. Training and methodological support: ANAP strives to standardize practices through methodological guidelines and training, but regional differences may persist in the dissemination and application of information. It is very typical that the level of knowledge in rural areas lags behind that of county seats and large cities. The personnel of public administration institutions is aging, and the emigration of young people and those with professional competencies has a negative impact on the local government activities and public administration competencies of rural settlements.

Table 1: Counties with the 10 highest values vs. counties with the 10 lowest values of

County with the most contracting authorities 2025	Number of public procurements advertised - 2025	County with the fewest contracting authorities 2025	Number of public procurements advertised - 2025
Bukarest – Ilfov - 3015	3515	Giurgiu – 301	104
Iasi - 855	560	Covasna - 306	155
Dolj - 776	347	Mehedinti - 309	110
Cluj - 764	826	Salaj - 314	154
Constanta - 730	404	Tulcea - 326	98
Brasov - 689	433	Bistrita N. - 350	133
Prahova - 687	304	Ialomita - 355	102
Timis -670	432	Gorj - 373	346
Harghita - 640	175	Caras – Severin - 409	146
Suceava - 633	299	Vaslui - 418	203

Source: edited by author, data from www.e-licitatie.ro

It is clear that there is a correlation between the number of contracting authorities and the number of public procurements announced. But if we look behind the numbers, it is also clear that the most developed counties, Bucharest-Ilfov, Cluj, Timis, Constanta, Dolj, Brasov, carry out the most public procurements. These countries are the most powerful entities in the Romanian administration system.

These statements are reinforced by the indicators used by ANAP: more than half of the public procurement contracts concluded last year were executed in ten of the country's counties, with Bucharest Municipality in first place (30%), followed at a considerable distance by Cluj (7%), Iași and Sibiu (4% each), Constanța, Timiș and Dolj (with 3% each), and Brașov, Suceava and Gorj (with 2% each). (ANAP, 2023)

At the opposite end of the spectrum, the lowest number of contracts concluded in 2023 can be found in the following ten counties: Ialomița, Buzău, Teleorman, Sălaj, Brăila, Călărași, Caraș-Severin, Mehedinți, Covasna, and Giurgiu, which together account for less than 7% of the total number of contracts concluded during the period analysed.

If we looking for any other correlation between other factors and the public procurement value we find a correlation between the EU funds and number and value of public procurements. In 2024, according to data from the Ministry of Development, Public Works and Public Administration local governments Bihor county managed to draw the most money from the EU fund, 468.996 million lei, while Covasna drew the least. 12.896 million in Timiș county received 277.903 million lei in EU

funding, but Cluj (267.542 million lei), Braşov (195.57 million lei), Alba (183.834 million lei) and Sibiu (141.547 million lei) also performed well. With 107.618 million lei, Harghita was also among the counties that applied successfully, ahead of Maros (69.090 million lei) and Satu Mare (65.694 million lei), among others . Among the counties beyond the Carpathians, Galac took the lead with 237.068 million lei. Of course, Bucharest stands out among the cities, having drawn down 565.167 million lei. Among the provincial cities, only one managed to draw down more than 200 million lei in EU funds last year: Oradea. The county seat of Bihor County received 234.226 million lei from EU funds for its 2024 budget. The second most successful city is Timişoara 141.041 million lei, followed by Cluj-Napoca more than 132.328 million lei. (Ministry of Development, Public Works and Public Administration, 2025).

Unfortunately, the rule that the rich get richer still applies in the case of Romanian regions and counties.. So the powerfull countries are the main beneficiaries of the EU founds.

Corruption risks and transparency

Although anti-corruption measures are implemented at the national level, some analyses and reports (OECD, 2025) suggest that corruption risks may differ regionally. Where local political influence (un. baron locali) is stronger or control mechanisms are weaker, the incidence of public procurement irregularities may be higher.

There may also be differences in transparency: some local governments are more proactive in publishing detailed information about their public procurement, while others only comply with the legal minimum. This may be due to lack of knowledge of the law, a shortage of manpower, or simply laziness.(OECD, 2025).

Local economic operators and competitive environment

Although the public procurement system is one of the basic mechanisms for the functioning of the EU single market, it can have local implications. The structure of the local economy can have a significant impact on public procurement competition. If there are few qualified enterprises in a given area in a region, this can limit competition and lead to higher prices.

In some regions, SMEs participate more actively in public procurement procedures, while in others they have more difficulty accessing information or the necessary resources. A significant number of SMEs are not registered on the SEAP, and even do not want to access public contracts. This is due to fear of bureaucracy and lack of trust. According to ONRC data, in December 2024, there were 290,930 registered companies in Romania, while the number of bidders registered on the SEAP was 229,657. Of course, this includes not only small and medium-sized enterprises, but also other forms of entrepreneurship (individual entrepreneurs, authorized natural persons). The largest number of registered entrepreneurs was from Bucharest-Ilfov County with 47,839 bidders, followed by Cluj County with 10,744, Timis with 9,219, Iasi County with 8,719, Constanta County with 7,899, Bihor, Prahova Counties with over 7,000 registered bidders.

Overall, although Romania has a unified public procurement legal system, there are regional differences in practical implementation, type of projects, volume, administrative capacity and market competition, which can affect the efficiency and results of public procurement procedures.

It is also well known that certain public procurements, although their direct impact is in other counties or the entire country, are announced in Bucharest and the contracts are concluded here, e.g. procurements of ministries, public procurement procedures conducted by CFR (railways), CNAIR (highways).

The highest value public procurements in Romania

Based on the public procurements announced at the beginning of the year and the known major projects, the most significant and expensive public procurements and acquisitions in Romania are summarized in the table below.

Tabel 2.: The most valuable public procurements in Romania

Name of procurement	Estimated value	Observations
1. Transylvanian Motorway (Autostrada A3) - Poarta Sălajului – Zalău – Nuşfalău section (including the Meseş tunnel)	This contract was signed for 6.62 billion Romanian lei (excluding VAT), which is approximately 1.33 billion euros.	This 41-kilometer section of the A3 motorway includes the construction of the 2.89-kilometer Meseş tunnel, which will be the longest motorway tunnel in Romania. The project also includes 65 viaducts, bridges and viaducts, totaling 13 kilometers.
A8 Motorway Section 1C Sărăţeni-Joseni (Union Motorway)	This contract was awarded for approximately €1 billion	This 32.4-kilometer section involves complex terrain, including 39 bridges and overpasses, and three tunnels.
A1 Sibiu – Piteşti Motorway, Section 3: Cornetu – Tigveni	5.32 billion RON (excl. VAT).	Part of the challenging Sibiu-Piteşti route through the Carpathians, this section includes significant engineering works, including the largest ecoduct in Romania.
A1 Sibiu – Piteşti Motorway, Section 2: Boiţa – Cornetu	Around 860 million EUR (4.25 billion Lei excluding VAT)	This section is considered the most difficult part of the Sibiu-Piteşti motorway as it crosses the Olt Valley, a mountainous and complex area. It involves building 7 tunnels (totaling over 4.9 km), 27 viaducts, 22 bridges, and an ecoduct, along with numerous consolidation and stabilization works.

Source: Edited by author by data from www.130km.ro

Although the exact “most expensive” title may change depending on new contracts and project phases, the section of the Transylvanian Highway including the Meseş Tunnel (approximately €1.33 billion) currently holds the title as the most expensive single road infrastructure contract. (www.130km.ro).

Conclusions

In Romania, the public procurement system is well-developed, with a stable institutional background, and digital, technical and legal supervision are also solved. In terms of digitalization, the Romanian electronic public procurement platform is at the forefront compared to other institutional platforms (PNRR, Mysmis, AFIR, ANAF, ONRC), whether we examine its manageability or its functions.

Unfortunately, the sophistication and professionalism of the public procurement system is linked to the ability of counties and cities to draw down funds, and the drawing down of funds is also influenced by fear of public procurement obligations and the risks associated with them. Well-developed counties attract more resources and are much more likely to have well-trained workers and learning organizations than less developed counties. The personnel of public administration institutions is aging, and the emigration of young people and those with professional competencies has a negative impact on the local government activities and public administration competencies of rural settlements.

The public procurement system is becoming increasingly professionalized, this is actually a controlled process, which results from the EU legal harmonization on the one hand and from the fine-tuning of the public procurement system on the other. However, the downside of this is that it requires more and more knowledge and skills from users. However, this is an increasingly difficult requirement to meet, especially in institutions in rural settlements. External experts (lawyers, consultants) are charging increasingly high prices for this type of consulting activity, which is further exacerbated by rising inflation and the fact that more and more experts are being forced to take out professional insurance for their contracts. Knowledge must cover not only digital competencies, but also procedural, legal and technical ones. Training, further training, and even a wider network of consultants are needed. It would also be helpful if new automatic functions were built into the SEAP user interface to aid information processing and decision-making.

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MOTORWAYS CONSTRUCTION IN ROMANIA, A NEVER-ENDING STORY

KASSAY JÁNOS

Abstract

After the change of regime in Romania, the construction of motorways started in 2003 with the signing of a contract between the Romanian state and the American company Bechtel, but to this day the historical regions of Romania are still not connected. Common sense would expect that the capital has a vested interest in connecting the country's major cities, but with the exception of Constanța, this has not yet been achieved. The earliest motorway would have offered benefits to Cluj Napoca in particular, but the A3 motorway is now just a bypass that avoid Cluj Napoca. The aim of this study is to explore and illustrate this 24-year process and to analyse the economic and social impact of motorways.

Keywords: Highway, interconnection, express road, TEN-T, transportation, national interest, EU transportation policy, motorway density, local and economical impact.

Introduction

The history of freeways is a story of innovation driven by the need for efficient transportation in an increasingly mobile world. From the early parkways to the massive interstate systems, freeways have shaped our landscapes and our lives in profound ways. As we look to the future, the evolution of these vital arteries will likely focus on integrating them more seamlessly with other modes of transportation and mitigating their environmental and social impacts to create more sustainable and equitable mobility for all.

The history of motorway construction in Romania is a complex one, marked by periods of slow progress and recent accelerations. In the **the sixties began the** construction of the first motorway, this was began in 1967 between Bucharest and Pitesti. The reasons for this were partly political and ideological (to demonstrate the successes of communism) and partly economic. The car factory built in Pitesti made it necessary. The first segment, part of the A1 motorway connecting Pitești to Bucharest was opened in 1972.

After that the motorway construction progress remained limited under the communist regime, with focus shifting to existing road improvements. After the 90-s the transition to a market economy in the 1990s led to significant financial constraints, hindering infrastructure development. Motorway expansion remained slow for many years. Romania's accession to the European Union in 2007 brought increased access to EU funding, which spurred motorway construction, s ince then, there has been a noticeable increase in the pace of building. After the COVID in the last years, especially in 2023 and 2024, Romania has seen a significant increase in the amount of completed motorway kilometers.

2024¹² marked a record year for Romania's road infrastructure, with 195 km of highways and expressways inaugurated, bringing the total length of operational high-speed roads to approximately 1,270 km. "Through the National Road Infrastructure Administration Company (CNAIR), Romania is currently the leading developer of large road transportation infrastructure in the European Union. With 780 km under contract and in the design or execution phase, along with another 240 km currently in the tendering stage, Romania is employing the most modern technologies for the construction and design of high-speed roads," reads a post on the CNAIR's official Facebook page.

Company representatives remain optimistic about 2025, with plans to open more than 250 km of new roads this year, in addition to two high-speed road sections expected to be completed this spring. This would bring the total new motorway and expressway kilometres in 2025 to 280 km, nearly matching the combined total of 2023 and 2024. A key factor supporting these projections is the sustained pace of developer UMB, which delivered 100 km in 2024 and is expected to complete 180 km on the A7 highway alone, between Focsani and Pascani, this year.

2. MATERIAL AND METHODS

An analysis of relevant public policy documents, articles, studies and maps led us to conclude that the construction of motorways, at least in Romania, was based on a constantly changing set of criteria. Important factors include financial resources, political and even ideological considerations, and economic interests, but in my opinion, the cohesion objectives that appear in EU policies and Romanian planning documents have been pushed into the background. An important observation, when looking at the development of the public road network from a historical perspective, is that between 1990 and 2010, infrastructure development actually declined. A new impetus was provided by accession in 2007, when significant resources became available for this purpose and pressure from the EU increased, as the Romanian road network became an integral part of the Trans-European Network. This study analyses the pace of motorway construction, the construction of tracks and different track sections, as well as the factors that influenced changes in routes and the impact of tracks on the population and counties. The methods used include map analysis, statistical data processing, and the use of indicators.

3. RESULTS AND DISCUSSION

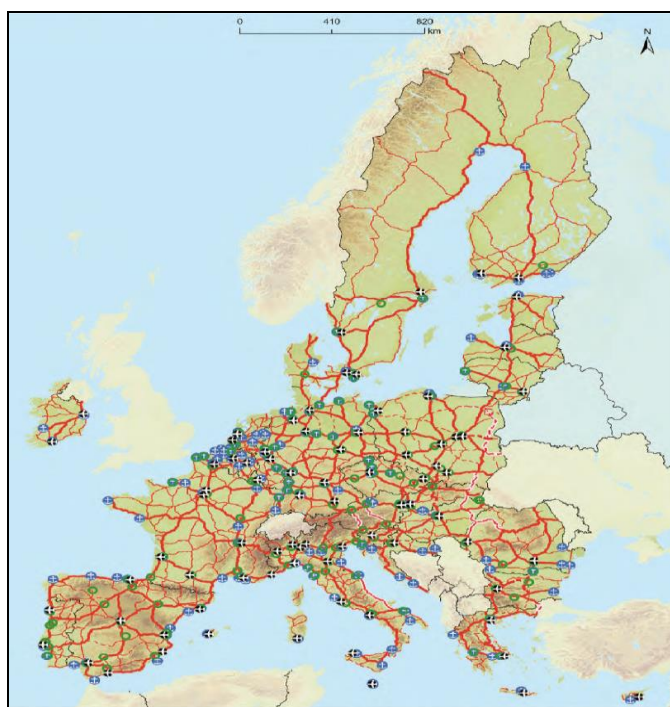
3.1. Ten-T as the European framework for transport development

The most important factor in the motorway construction is the TEN-T. The EU envisages the development of the trans-European network in line with the objectives of the Green Transition, with the important goals of reducing greenhouse gases, achieving zero emissions and creating sustainable, smart transport. The EU „ sets out milestones to show the European transport system's path towards **achieving** the objectives of a sustainable, smart and resilient mobility. It envisages that rail freight traffic should increase its market share by 50 % by 2030 and double by 2050; while transport by inland waterways and short-sea shipping should increase its market share by 25 % by 2030 and by 50

¹² "2024 was an unprecedented year for Romania's transport infrastructure. We inaugurated 197.77 km of high-speed roads, completed the connection between A7 and A3, and linked the Capital Ring Road A0 with A2. In 2025, we aim for even greater achievements. We need to open traffic on more than 200 km of high-speed road infrastructure. Additionally, drivers will be able to travel directly on high-speed roads from Craiova to Constanța and from Bacau to Bucharest," stated Transport and Infrastructure minister Sorin Grindeanu at the end of last year

% by 2050 and traffic on high-speed rail should double by 2030 and triple by 2050. Also, at least 30 million zero-emission cars and 80 000 zero-emission trucks should be in operation on Union roads by 2030, and nearly all cars, vans and buses and new heavy-duty vehicles should be zero-emission by 2050. Moreover, scheduled collective travel under 500 km should be carbon-neutral by 2030 within the Union and by 2030, there should be at least 100 climate-neutral cities in Europe” (REGULATION (EU) 2024/1679 of 13 June 2024). Very ambitious objectives. However, the development of TEN-T is not only important in terms of achieving green objectives, but also in terms of economic efficiency and global competitiveness. „The development of the trans-European transport network should also enable seamless, safe and sustainable mobility of goods and persons in all their diversity and should contribute to further economic growth and competitiveness in a global perspective, by establishing interconnections and interoperability between national transport networks in a resource-efficient and sustainable way”. Conform the regulation the development of the TEN-T will be realized graduatly in three steps „The trans-European transport network should be gradually developed in three steps with the overall aim to realise a multimodal and interoperable European wide network of high-quality standards, while respecting the overall Union climate neutrality and environmental objectives: the completion of a core network by 2030, of an extended core network by 2040 and of a comprehensive network by 2050, unless otherwise specified in this Regulation”.

Figure1.: Core, extended, comprehesiv network, all member states



Source: Source: Regulation (EU) 2024/1679 of the European Parliament and of the Council of 13 June 2024

From the point of view of Romania the core network mirroring the priorities of the country. Bucharest connects the eastern and western borders, and Romania's historical regions will finally be linked by 2030.

Figure 2.: The core network in Romania, bold red lines, other lines are the comprehensive and extended



Source: Regulation (EU) 2024/1679 of the European Parliament and of the Council of 13 June 2024

The newly created Baltic Sea – Black Sea – Aegean Sea (BBA) European Transport Corridor (ETC) links European Member States from the far north to the far south of Europe with the maritime interfaces of the Baltic Sea, Black Sea and Aegean Sea part of the Mediterranean Seas, through the countries of Ukraine and Moldova. It includes 13 countries, namely the 11 EU Member States Finland, Estonia, Latvia, Lithuania, Poland, Slovakia, Hungary, Romania, Bulgaria, Greece and Cyprus, as well as two neighbouring countries Ukraine and Moldova. It connects almost all capital cities of the BBA countries, except for Slovakia, where it connects the second largest city Košice, Hungary where it connects to the second largest city Debrecen, and Ukraine where it connects to Lviv.

Figure 3.: Analitical indicators of different countries related the motorway network

Country	KM 2014	Motorway density, km ap/1000 km ² 2014	Social indicator km/1 million inhabitants 2014	KM 2024	Motorway ensity, km ap/1000 km ² 2024	Social indicator km/1 million inhabitants 2024
Spain	16204	32.11	346.46	17228	32.8	300
Germany	12845	36	155.85	13183	38	158.29
France	11598	21.53	175	11671	20	175.37
Austria	1720	20.51	203.07	1743	21	190.30
Netherland	2758	66.42	164.26	2758	82	151.37
Poland	1389	4.30	36.55	5206	16.14	135.11

Hungary	1361	14.63	137.47	1880	20	196
Croatia	1270	22.44	298.87	1341	23.5	347.40
Romania	696	2.92	34.87	1276	4.9	66.94

Source: Edited by author, data from Facts and Figures Motorways, 2024

Numerous indicators can be used to compare motorway networks. These reflect the situation at a given point in time, but are suitable for measuring the state of infrastructure in a given country. Romania's situation changed significantly between 2014 and 2024, but it still ranks among the lowest in the EU near Bulgaria.

This corridor starts in the north in Finland from its capital Helsinki and in the south in Cyprus from its capital Nicosia. Heading south from Helsinki we find the Estonian capital Tallinn, continueing in two branches south to Latvian's capital Riga, branching out to the Baltic Sea ports in Latvia and Lithuania and on to Kaunas and Vilnius in Lithuania. In Poland the corridor enters from Lithuania to Elk and connects the ports of Gdansk and Gdynia going south via Warsaw and Lublin, it passes Krakov and near Rzeszow it branches out to Lviv (Ukraine) continueing from there towards Odessa at the Black Sea as well as via Romania south to Bucharest and east towards the Moldovan capital of Chisinau also connecting to Odessa. In the south of Poland two branches cross the border with Slovakia connecting north of Kosice before connecting into Hungary and Romania where it branches out in Oradea south east to Bucarest and on to the the port of Constanta and south west to Timisoara. From there there are two branches going south to Bulgaria, one western branch via Vidin to the capital Sofia and one eastern branch connecting to the Black Sea port of Burgas going south to the border with Turkey.

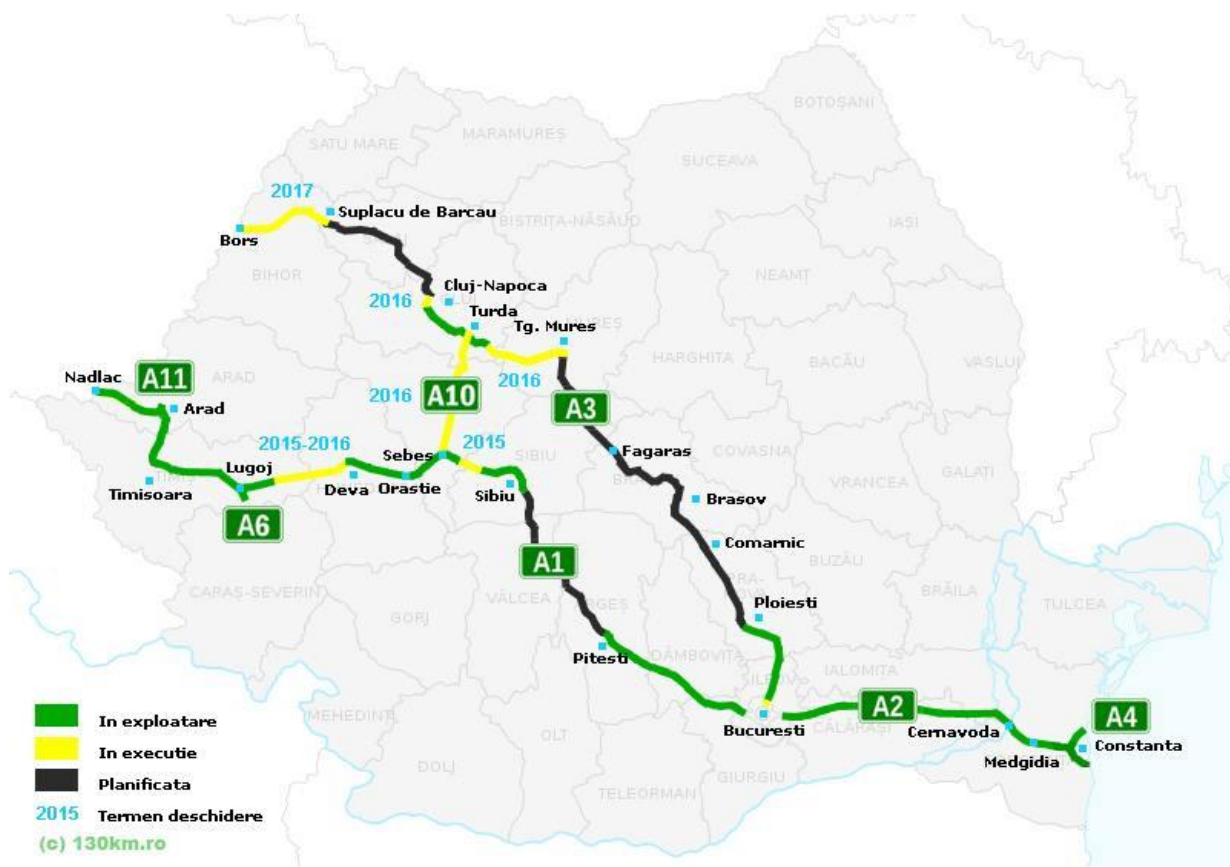
3.2. The national strategic instrument for planification - the transportation masterplan

Edited in 2015 the masterplan provides for the construction of 1,301 kilometres of motorway by 2030, double the level set before the public negotiations. Following public debate, the construction of 1,301 km of motorways was proposed, representing an increase of 645 km compared to the original version of the master plan. Other categories include 1,877 km of expressways, 147 km of Trans Regio and Euro Trans roads, and 67 bypasses, which are either independent or part of motorway and expressway projects, in addition to the Bucharest ring road, the 14 km long Bucharest-Ploiești motorway, the 14 km Bucharest-Câmpulung motorway, the 147 km Trans Regio and Euro Trans roads, and 67 bypasses, which are either independent or part of motorway or expressway projects, plus the motorway section of the Bucharest ring road. Investments in the road sector amounted to EUR 26.48 billion in 2015, more than half of which was invested in motorways (Masterplan, aug. 2016). The Master Plan envisages an increase in motorway length from 550 km in 2012 to 2074 km by 2030.

According to CEIC Data, the number of registered motor vehicles in Romania in December 2015 was **6,009,285** the total length of motorways in use in Romania was **726.6 km**. The number of vehicles on 1 km motorway was **8270.41**. In 2023 this proportion was **9450.80** As the number of registered vehicles has increased to **9,422,452** and the total lenghts of motorways was **997 km** 2023. So this indicator gotten worse. It is clear that, since the MP was adopted in 2016, further review and adjustment was and is necessary, primarily due to changes in economic and social conditions, the

country's development, and the emergence of new financing opportunities. For example according to the 2014 MP, the country needs approximately 656 kilometers of motorways and 2,200 kilometers of expressways. According to calculations at that time, by 2030, it will have to pay approximately €6.2 billion for motorways and €17.5 billion for expressways. In 2016 this was considerably changed. The masterplan provides the construction of over 6,800 kilometers of road, of which over 1,500 kilometers of highway and over 1,300 kilometers of express road,” according to the minister of transportation (Romanian Insider, 2016). The approval of the master plan was an important prerequisite for drawing down funds. The master plan identified the most important corridors within the country: No. 1 was the Bucharest-Braşov corridor (already under construction and planning at the time), and No. 2 was between Bucharest and the western border, which essentially connects the country to Western Europe via Hungary.

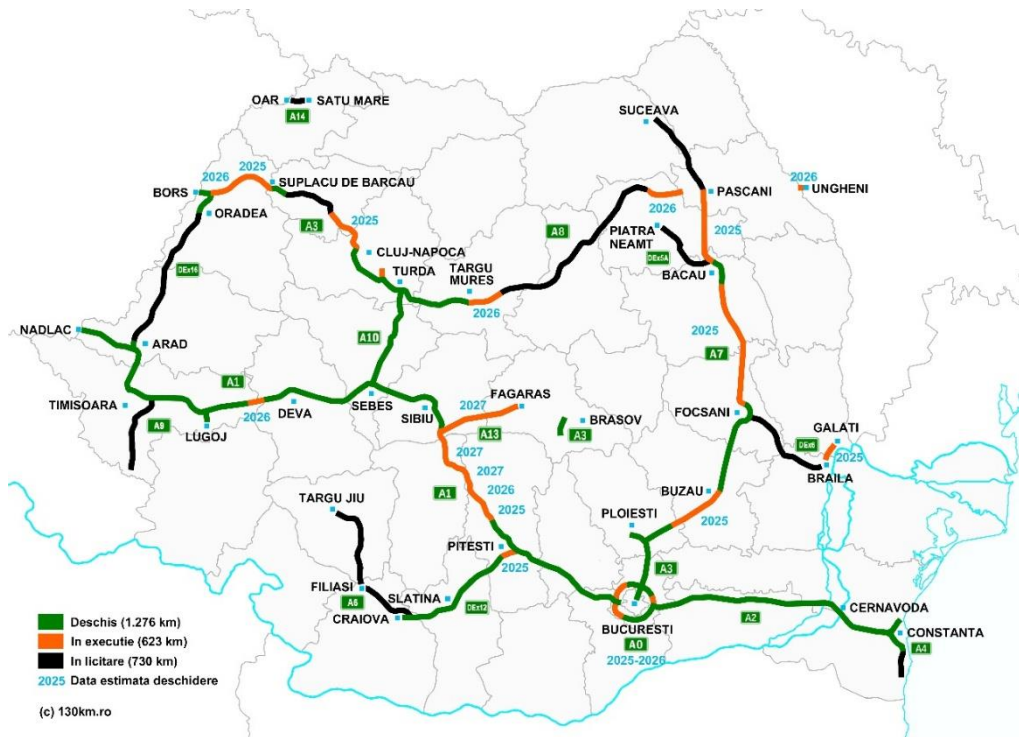
Figure 4: Status of planned and under construction motorways in 2014



Source: www.130km.ro

During this period, it is clear that the Brasov-Bucharest section (A3) was of paramount importance, forming the backbone of the motorway network alongside the A1. However, this will change later, and the route plan affecting Braşov will be pushed into the background, with the Iasi-Bucharest section (OR3-A7) and the Transylvania-Moldova motorway (A8) becoming the priority.

Figure 5: Status of planned and under construction motorways in 2024



Source: www.130km.ro

It is clear that by the end of 2024, the number of kilometers opened to traffic will have increased significantly, thus improving the vehicle-to-highway ratio. However, the sections opened will not be the ones that are difficult to build (A7, A6), while the A1 highway, which is perhaps the most important transport artery connecting the capital with other European countries, is still a long way from being completed in its entirety. The mountains hinder and complicate the construction of motorways (viaducts, tunnels), while rivers facilitate crossing, e.g. the Olt River valley between Pitesti and Sibiu. Unfortunately, this is not the case in the Prahova Valley, where the design of the motorway is still incomplete. In this way Brasov, an important industrial center located in the middle of the country, will remain without a highway for some time, whether we look to the south or the west.

3.2. The backbone of the motorway network

3.2.1 The A2 Highway, road to the Black Sea

The Bucharest-Constanța motorway, known as the A2 motorway (Autostrada A2), is a crucial transportation artery in Romania, connecting the capital city to the country's major Black Sea port. It is a very important road for economic activity, and tourism, due to its connection to the Black sea.

Construction began during Nicolae Ceaușescu's regime. The first completed section, from Fetești to Cernavodă, which included bridges over the Danube's branches, opened in 1987. Progress slowed significantly in the 1990s due to financial limitations. Construction resumed later, and the motorway

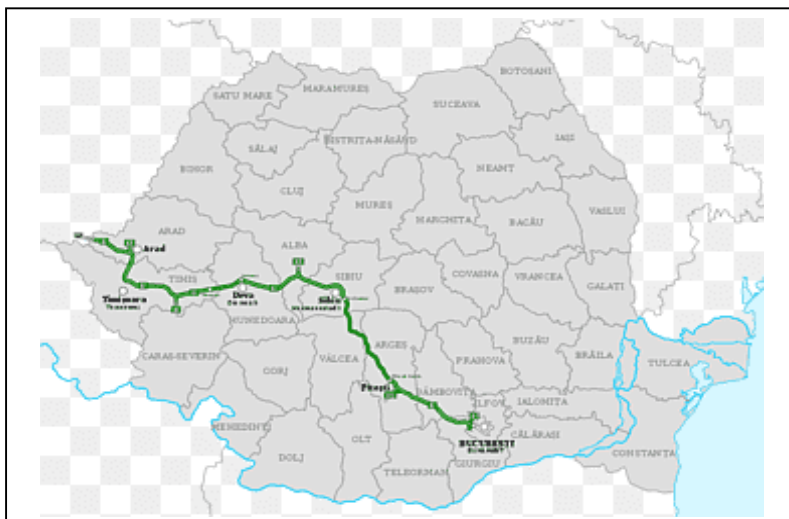
was completed in stages. One important note is that the original plans of the A2 were changed. The original plan had the road going north through Urziceni and Slobozia, but the finished road goes east in a straight line toward Fetesti. In this way Slobozia, county seat, the most important city in Ialomita county, and the nearest holiday resort Amara, has no contact with motorway. The entire A2 motorway was finalized in late 2012. The section from Cernavodă to Constanța received financial support from the European Union's Cohesion Fund and the European Investment Bank. Related Projects with this one and is also important to take into account the A0 motorway, the Bucharest Ring Motorway, that intersects with the A2. The A0 is currently under construction, and when finished, will greatly improve traffic flow around Bucharest.

In essence, the A2's development spanned several decades, marked by periods of both progress and stagnation. Its completion has significantly improved travel between Bucharest and the Black Sea coast.

3.2.2. The A1 motorway across mountains to the western border

According to Romanian public opinion, connecting the historical regions across the Carpathians is a national issue and a great dream. Over the past decades, this goal has not only failed to materialize, but has raised increasingly serious questions. The construction of the motorway is, of course, most expensive in these sections. Without EU support, the country would probably never be able to achieve this, or it would take a very long time. The construction of this motorway (A1), despite numerous changes to the route, now seems to be on track. The construction of the South Transylvanian motorway is important in several respects. If it ever reaches Brașov (via Fogaras on the A13), it will create a fast connection between major cities such as Brașov, Sibiu, Deva, Timișoara, Arad, and the western border. It will also make Pitesti and Bucharest accessible from Sibiu via the motorway. The constructions are not finished, while in 2010 was opened approximately 17.56 km, in the next years the annual progress where fluctuating. In the first years the accent where put on the transylvanian sections, in the last years to the connection between Sibiu and Pitesti. The A1 motorway is largely completed, with the most challenging remaining sections being part of the **Pitești - Sibiu** segment and the **Lugoj - Deva** missing link, tunnels, ecological corridors. Construction is ongoing on these remaining segments, with projected completion dates extending into 2025, 2027, and 2028 depending on the specific lot. The total length of the A1 motorway is approximately 578.48 km, with a significant portion (around 82%) currently open to traffic. These segments are the most expensive sections. For example the 69 kilometres between Boița and Tigveni, part of the Sibiu-Pitești motorway, cost over two billion euro. Road builders have to construct eight tunnels and numerous bridges and viaducts.

Figure 6: A1 Motorway Between Bucharest and Nadlac (HU border)



Source: <https://www.pngwing.com/es/free-png-vpkbr/download>

3.2.3 Motorway A3 across Transylvania

This motorway was the first project after the year 2000. It was built by Bechtel, an American company that did not finish the job. The project has a bad reputation. Essentially, it is an alternative route which starts and ends in the middle of nowhere and bypasses Cluj-Napoca. In 2004 the work begins on the Transylvania Motorway. In 2009-2010 the first kilometres of the Transylvania Motorway are opened to traffic, namely the Turda-Cluj-Napoca West (Gilău) and Turda-Câmpia Turzii (approximately 52 km) segments. In 2011 the contract with Bechtel is renegotiated, with the company remaining to complete only certain sections (2B Câmpia Turzii-Gilău and 3C Suplacu de Barcău-Borș). The other segments were to be put out to tender. At the other parts, in 2012 the Bucharest-Ploiești section (55.5 km), the first section of the Bucharest-Brașov motorway, part of the A3, is opened to traffic. At the final in may 2013 the contract with Bechtel for the Suplacu de Barcău-Borș section is terminated after years of slow progress and huge costs for the Romanian state.

After 2013 and up to the present the construction of the A3 continued in segments, with various contractors and completion dates. Many lots were subject to cancelled tenders, appeals, contract terminations and delays. In 2023 contracts were signed for new sections, such as Suplacu de Barcău – Chiribiș. Nowadays the A3 motorway is partially completed, with important segments still under construction or in the design/tender phase. The Bucharest-Ploiești section is complete. In Transylvania, sections such as Nădășelu-Târgu Mureș, and Râșnov – Cristian are open to traffic but this sections is very short. However, there are also ‘phantom kilometres’ or uncontracted segments, such as the mountainous section between Brașov and Târgu Mureș, where progress is very slow or non-existent.

This is the one of the most controversial infrastructure projects in Romania, with accusations of inefficiency, exorbitant costs and lack of progress. Unfortunately, the whole story is full of mysteries, unfortunate solutions and sudden changes, both in terms of the route and the allocated resources. The worst thing is that the Marosvásárhely-Brașov section has been completely removed from the agenda, and it seems that the Brașov-Ploiești section will no longer be a priority either. The government wants

to move towards the motorways of western Hungary by building short (and very expensive) sections here. For example the the 41-kilometre Meseş section between Poarta Sălajului and Nuşfalău on the Transylvania Motorway is the largest road infrastructure contract ever launched for procurement. This is the last uncontracted section of the Transylvania Motorway (A3). It was contracted by a turkish consortium for an offer of 6.62 billion lei (1,2 billion euro) this being the largest contract tendered to date.

Figure 7: The A3 motorway map, proposed to be finished in 2030-2040



Source: Masterplan for transport for Romania, 2016

3.2.4. Motorway A8, the unification of the country

A highly ideological highway the A8 motorway, also known as the Unification Motorway, is a major infrastructure project in Romania, designed to connect Transylvania (Târgu Mureş) with Moldova (Iaşi and Ungheni, on the border with the Republic of Moldova). It is a highly anticipated motorway and considered essential for the economic development of Moldova. xecution and design phases: The A8 project is divided into several sections, with different stages of implementation:

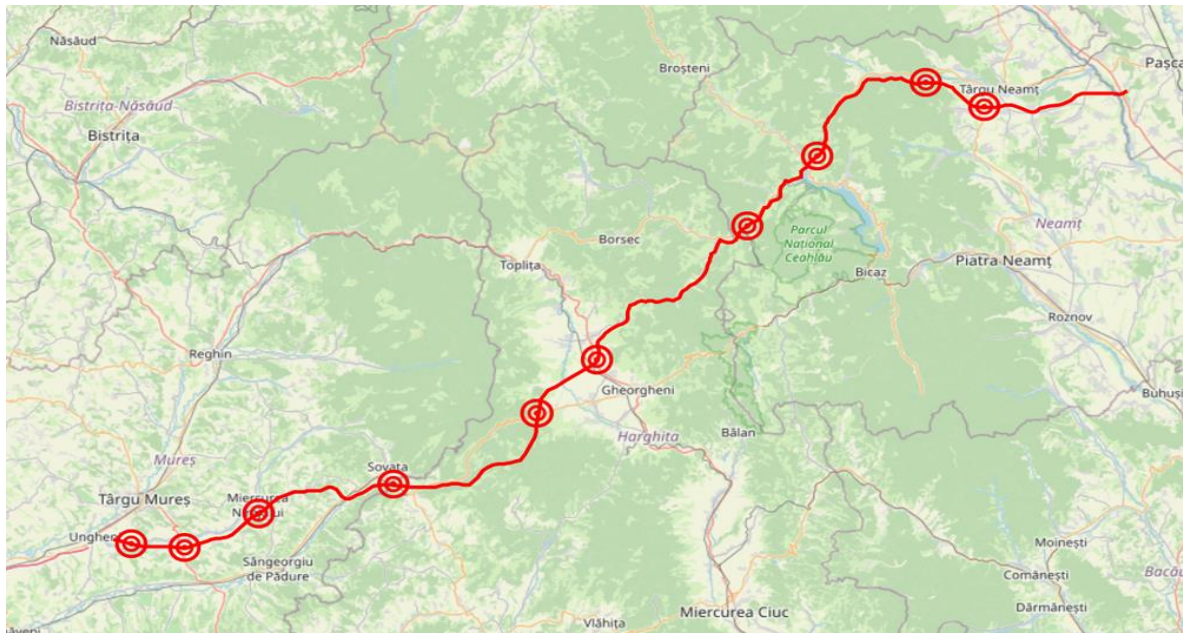
Târgu Mureş – Miercurea Nirajului (22 km): Contract signed with Turkish contractor NuroI. The design phase is underway, with an estimated completion date of 2026. Work has recently begun, but the pace is considered slow by some civic associations.

Miercurea Nirajului – Săraţeni (23.4 km): Contract signed with the consortium Özaltın Insaat Ticaret VE Sanayi AS and Infravis SRL. Includes two tunnels. Completion deadline: 30 months (6 months design, 24 months execution).

Săraţeni – Joseni (32.4 km): Contract awarded to UMB Spedition. It is in the design phase, but here also will be delay. This section will be financed offered from the PNRR. Joseni – Ditrău (14.4 km): Under tender. Ditrău – Grinţieş (37.9 km): Contract signed with UMB Spedition.

However, there are tensions, with UMB requesting at one point the termination of this contract and the one for Sărățeni-Joseni due to problems related to performance guarantees.

Figure 8: The A8 motorway map, proposed to be finished in 2026-2030



Source: <https://apix.ro/category/trafic/>

There are sections which are under tendering for ex. Grințieș – Pipirig (31.5 km), Moșca (Târgu Neamț) – Târgu Frumos and Târgu Frumos – Lețcani. Pipirig – Leghin (2.69 km): contract awarded to UMB Spedition. Leghin – Târgu Neamț / Moșca: The association “Moldova vrea autostradă” (Moldova wants a motorway) has raised serious concerns about the progress of work on this segment, financed through the PNRR, noting that the construction site appears to have been “abandoned by the contractor” in certain areas and there is a risk that it will not be completed on time (summer 2026). Moșca – Ungheni (93.27 km): The final route has been established, and the next step is to obtain the building permits. At the end of the A8, in Ungheni, a road bridge over the Prut River will be built, financed by European and state funds.

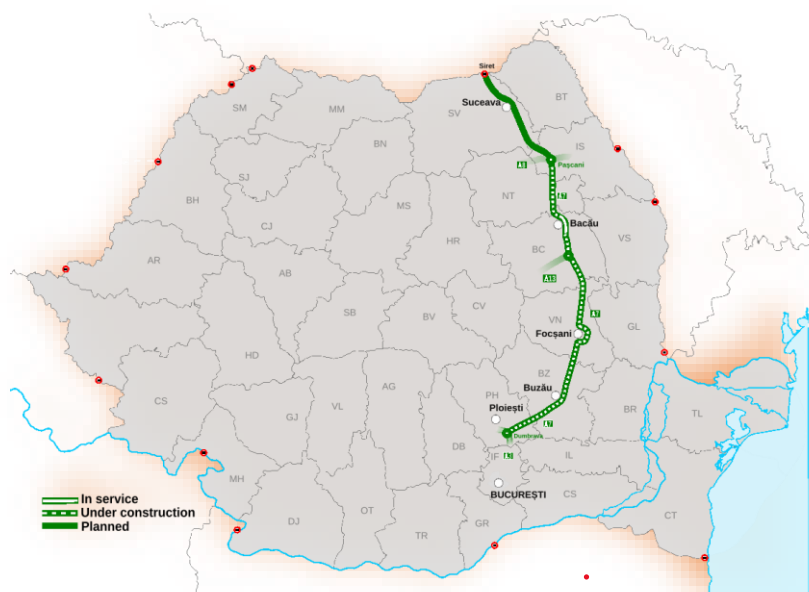
Deadlines: It is estimated that the first segments, especially those financed through the PNRR (Ploiești-Buzău on the A7 and Târgu Mureș-Sovata and Târgu Neamț-Pașcani on the A8), should be ready by 2026, the deadline set by the European Union. However, there are concerns about meeting these deadlines, especially for the sections in Moldova. A significant portion of the funding comes from European funds (PNRR, Transport Program).

In conclusion, the A8 motorway is an ongoing project, with progress on certain segments, but also with significant challenges that may affect completion deadlines, especially for achieving the goal of connecting Transylvania and Moldova by 2026.

3.2.5 Motorway A7, connect Bucharest and Moldova

This motorway is belong to Moldova. Another vital infrastructure project that will connect Ploiești and Bucharest to Siret (the border with Ukraine), crossing Moldova for approximately 440 km. This motorway runs on well-marked sections of easier terrain, with most of it being built by a single contractor. Most of the motorway was handed over in 2024, with further sections to be handed over by 2025. (CNAIR). Much of this highway is financed through the National Recovery and Resilience Plan (PNRR), with a completion deadline imposed by the EU for 2026. All segments from Ploiești to Pașcani must be completed by the end of 2026 in order to benefit from PNRR funding. CNAIR officials have stated that by the end of 2025, 268 km of the 319 km financed by PNRR should be ready.

Figure 9: The A7 motorway map, proposed to be finished in 2026-2030

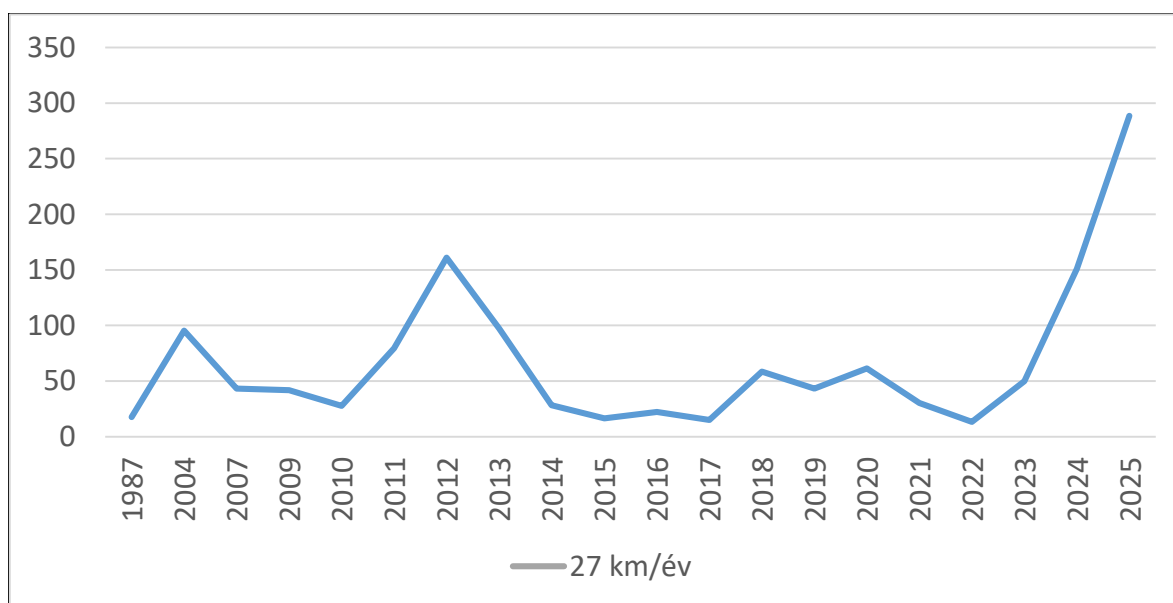


Source: CNAIR, 2024

3.3. Motorway handover between 2014-2024

Motorway completions between 2014 and 2024 were relatively slow, averaging 27 km per year. After 2023, the pace accelerated significantly, as shown in the figure below.

Figure 10: The handover of motorways between 2014 and 2024

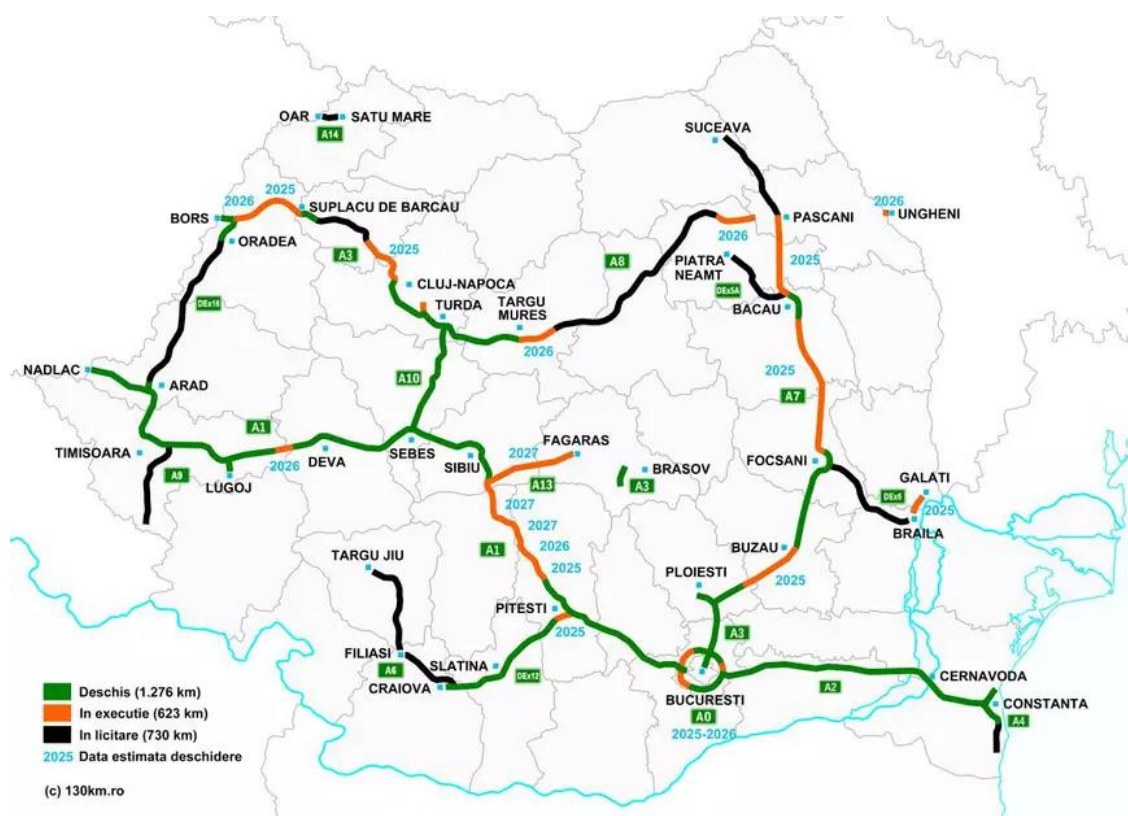


Source: Edited by author, data from www.130km.ro

Motorway and expressway network in 2025

In 2023 and 2024, the length of the tracks increased significantly, but the handover of certain track sections is constantly being delayed. The current situation is shown below, with the estimated date of commissioning in blue. Based on this, the final motorway network seems to be taking shape. In 2025, there will be 1,300 km of expressways, 1,150 km of which will be motorways.

Figure 11: Motorway and expressway network in 2025



Source: 130km.ro

The future situation of motorways and expressways in 2030

In 2030 2824 km of expressways and motorways are planned to be handed over. Given the current problems (deadlines, delayed public procurement, rising costs and prices, financing problems), this does not seem realistic.

In order for this to happen, the following must still be completed (2024):

Transylvanian Motorway (A3) – 138.5 km;

Bucharest Ring Road (A0) – 58.5 km;

Ploiești – Siret (Moldova) motorway – 437 km;

Sibiu – Pitești motorway – 112 km;

Margina – Holdea (part of A1) section – 9 km;

Craiova – Filiași motorway – 47.5 km;

Târgu Mureș – Ungheni (A8) – 320 km;

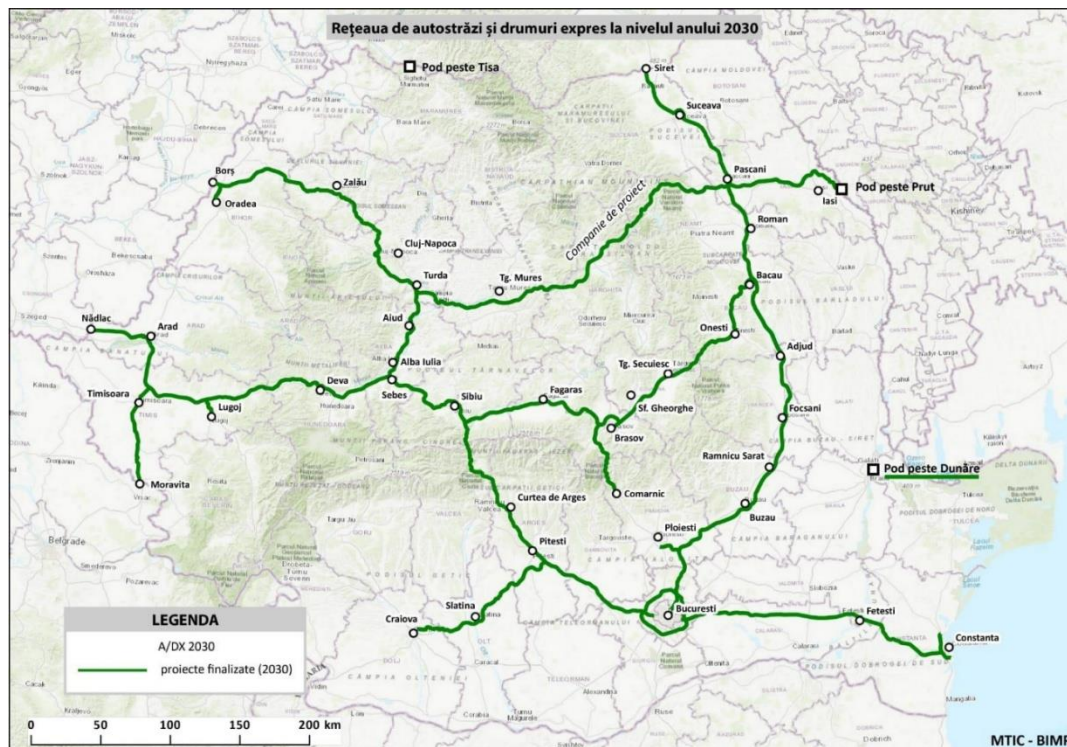
Sibiu – Făgăraș – 68 km;

Northern Motorway (A14) (Oar – Suceava) – 335 km.

Also 243 km DEX. e.g. Arad – Oradea expressway 120 km

It will definitely be completed by 2030: 1996.70 km, with a target of reaching 5000 km by 2032 (Ministry of Transportation).

Figure 12: Expressway and motorway network in 2030



Source: Transportation Master Plan, 2016

According to the Ministry of Transport, the following motorways will be completed by 2030: Braşov – Comarnic, Suceava – Siret, Braşov – Bacău (the pathway is under the planification), Paşcani – Ungheni (towards MD). Bacău – Pt. Neamt will not be completed, it is under public procurement, nor will the road leading from Constanţa to Bulgaria. The plan includes in 2016 the Satu Mare – Suceava section, but it does not even appear here.

The traffic situation in 2022

The traffic data is collected through general road traffic censuses, Origin-Destination traffic surveys and automatic traffic recordings, and the National Road Infrastructure Administration Company (CNAIR) provides an application for viewing this data through CESTRIN. Based on available data, the busiest road sections in Romania, according to the 2022 census conducted by CESTRIN, are:

Bucharest Ring Road: Ranked first, with an average daily traffic of 28,419 vehicles.

Braşov Ring Road: It ranks second, with a traffic of 26,895 vehicles.

Sibiu – Piteşti Motorway (A1): It completes the podium with a traffic of 23,240 vehicles.

DN6H (Mihăileşti Ring Road): It recorded a traffic of 23,111 vehicles.

Oradea Ring Road: With traffic of 20,499 vehicles.

DN5 (Bucharest-Giurgiu): Had traffic of 19,450 vehicles.

Bucharest-Constanţa Motorway (A2): With traffic of 18,332 vehicles.

A3 Transylvania Motorway: It was surveyed over 165 kilometres and had a traffic of 17,102 vehicles.

Cluj North East Bypass (VOCNE): On the Bulevardul Muncii-Apahida route, with a traffic of 16,745 vehicles.

DN1 (Prahova Valley): Although it is famous for its congestion, in the overall ranking based on average daily annual traffic, it ranks only tenth, with 16,452 vehicles. However, due to poor infrastructure, it becomes extremely congested on weekends and mini-holidays.

The teritorial impact of the motorways

It is general opinion that a well developed motorway system have a big impact on economy, can slash shipping costs, improve logistics, and attract foreign direct investment.

But it is still too early to talk about the regional economic impact of motorways in Romania, but it is apparent that new industrial and commercial units have appeared near certain economic centres and hubs. This is already apparent in Sibiu (A1), Torda (at the junction of the A3 and A10), and Sebeş, and is also evident in Arad and Timişoara. It is also true that even before the motorways were built, the two western cities, as well as Nagyvárad, were important targets for industrial investment. Oradea is closer to the Hungarian motorway sistem than to the Romanian expressway network, which is why the DEX16 road is being built to channel traffic towards Arad and to north at Satu Mare.

Figure 13: Operational motorways and the economic performance of counties along their routes

Name of county	Estimated length of motorway	GDP per capita 2014	GDP pe capita in 2024	% change	Average incom per capita 2024	Change between 2014-2024	No. SME 2015	No. SME in 2024	%-Change
Prahova	30	46858.10	93231.63	49.74	4719	274.04	26368	36685	39.13
Ilfov	91	40227.30	83872.85	52.03	5237	230.29	33538	66459	98.16
Cluj	79	42502.50	132858	68.01	6199	322.53	46470	70355	51.40
Sibiu	67	35047.20	94374.27	62.86	5412	303.19	15668	24822	58.42
Hunedoara	81	26929.00	72936.14	63.07	4062	267.06	15789	19750-	25.09
Alba	98	32821.00	87830.05	62.63	4665	300.00	13116	18519	41.19
Timis	106	43224.50	121743.3	64.49	5694	286.85	39473	57055	44.54
Calarasi	103	18133.70	47427.04	61.76	4615	349.62	7372	10459	41.87
Constanta	88	49874.30	101353.80	50.79	4690	290.40	36773	47860	30.15

Source: Calculated and edited by author, insse.ro, eurostat.ro, 130km.ro, observatorulph.ro

It is clear that there is no correlation between the presence and length of the track and economic performance; rather, it is influenced by the size of cities, industrialisation, and proximity to the capital and large cities. Metropolitan regions with industrial traditions and universities, such as Timisoara, Cluj-Napoca and Sibiu, attract investors, and the proximity of motorways will clearly have a ‘boosting’ effect here. Last but not least, these are all transport hubs, both in terms of road and rail. This is confirmed by the table below, which shows data for counties that do not have motorways.

We are seeing significant GDP growth in these counties as well, but the same is true for counties in the eastern and south-eastern parts of the country. This is much more the result of economic growth and effective (at least in terms of reducing income inequality in the country) state redistribution.

Figure 14: Performance of counties without motorways

Name of county	GDP per capita 2014 RON	GDP per capita 2024 RON	% change	Real income change - %	Change in number of SME - %
Vaslui	15590	40180.42	257.73	339.17	59.83
Botosani	16465	40403.01	245.39	321.42	28.95
Gorj	30297	82695.59	272.95	272.72	58.25
Suceava	19814,70	46942.29		317.91	62.66
Tulcea	25166.3	70136.42	236.91	290.29	28.46
Giurgiu	15740.40	43484.68	278.69	325.52	54.68
Caras- Severin	24382.20	74365.68		341.58	28.57
Bistrita - Nasaud	24172.30	56291.17	276.26	316.85	62.19
Valcea	28803	70215.57		282.34	36.22
Brasov	40386.40	106671.30	305.00	280.24	43.50

Source: Calculated and edited by author, insse.ro, eurostat.ro, 130km.ro, observatorulph.ro

It is clear that the tracks will have a positive short-term impact where they find an already functioning economy. This will significantly increase the role of Sibiu, for example, especially if the track is extended towards Brasov and Fagaras. If Braşov joins the motorway network (A13, A1) and then connects to Moldova via Bacău, the importance of the city and the metropolitan area will continue to grow.

Conclusions

In Romania, the odyssey of motorway construction is far from over. It will be a difficult and lengthy process, with the hardest part practically just beginning (the mountainous sections of the A8, the section of the A1 between Pitesti and Sibiu, and the sections of the A3 crossing the Meses Mountains). Considering that the A1 motorway has been under construction since 2007, following the revolution, we cannot be overly optimistic about the near future. To be fair, it should be noted that track construction has accelerated significantly, and a number of large companies (mostly) of Turkish origin are involved in modernising the country's infrastructure. However, we cannot ignore rising

prices, the situation on international markets and the country's macroeconomic situation, nor the fact that the use of EU funds is subject to time limits.

Putting the focus on infrastructure development would have been way more important than other ideological or nation-building stuff. The development of the busiest roads and the connection of large cities of economic significance would have had a more significant multiplier effect than constantly changing, politically driven and often questionable decisions.

In my opinion, it would be necessary to update the Master Plan, taking into account the current economic and geopolitical realities. Certain sections have been pushed into the background, e.g. motorways affecting Brassó (Ploiesti, Fagaras, Bacau), and will be built in a second phase, while others, which are even less unrealistic and less justified, e.g. Satu-Mare Suceava, will be implemented in the near future or within the same time frame.

Finally, it would be necessary to develop the infrastructure serving the motorways (which is completely lacking along the A3) and to make the motorway intelligent, with an intelligent camera system, proximity control systems, and built-in warning and accident prevention systems.

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THE UNIVERSITY KNOWLEDGE TRANSFER OFFICE (TTO) AS A SPECIFIC INTERMEDIARY FOR INNOVATION BETWEEN URBAN CENTRES AND PERIPHERIES

TIBOR JELEN

Universities are the urban side of the urban-periphery relationship. They can be seen as a source of knowledge, typically offering the results of their basic and applied research and their expertise to their local environment. The outflow of academic knowledge creates spill-over effects in the social and economic environment surrounding universities through various knowledge transfer mechanisms. This role of the university is being institutionalised: knowledge transfer offices are being set up in universities as key players in the transmission of innovation. What questions are worth answering in this context? For example: who has an interest in the effective functioning of TTOs and what are their interests? What direct or indirect impact can a TTO have on territorial development? Can these impacts be measured precisely? Are there methodological problems in measuring these impacts? These are the main issues addressed in this study.

Keywords:

university, knowledge transfer, technology transfer office, indicator, performance measurement

Dr. Tibor Jelen

Corvinus University of Budapest Fővám Square 8 H-1093 Budapest Hungary

tibor.jelen@uni-corvinus.hu

1. THE UNIVERSITIES

The processes that radically transformed higher education institutions took place more slowly at the end of the last century, and more rapidly in the 2000s, and are still taking place today. These institutions have been given new functions and have changed the quality of their role in society and the economy. Under the changed environmental conditions, "cooperation with economic actors became an inevitable requirement, complemented by the gradual industrialisation of research and the competitive tendering system, which now requires institutions to think in terms of actual management and entrepreneurship" (Hrubos 2012). These changes have generated new content and form in higher education institutions: they have broadened their scope of activities and defined new missions. Universities have recognised the societal expectation that they need to build meaningful cooperation with all stakeholders in their relations, in particular with local actors and communities.

In this process of transformation, successive eras can be identified, which the literature generally refers to as successive generations. At the same time, some authors refer to the same career stages as academic revolutions. The basis for this staggering is usually Etzkowitz's (2014) system, and his model is interpreted, adapted and extended by those who work on staggering. In his comprehensive theoretical article, Király (2019) summarises it as follows. This was not a simple extension of functions, as the two academic functions mutually supported and enriched each other. Today, a similar revolution is taking place, with the addition of social/economic engagement (service) as a priority (third) mission to the two existing academic functions" (Király 2019). The term "academic revolution", as used by Király, describes the major changes in the functions and, by convention, the missions of higher education institutions and universities.

If we simplify each stage of development (generation) down to its essence, we can most often do so with the university functions specific to that stage of development. Thus, in the first stage, which is the starting point of development, the higher education institution is traditionally an organisation concerned with training and education. In the second phase, the teaching function is complemented by research and development, and the university becomes a research-enterprise university. The third stage of development, the so-called third mission, is the emergence of the service university. The main features of the three generations, with particular reference to local influences, are summarised in Table 1, based on Wissema (2009). The third mission, briefly defined as the interdependent expansion of university functions, is nothing other than the teaching, research and development and public service activities of universities for the development of their local and regional environment. In their study on university functions, Imreh-Tóth and Lukovics (Imreh-Tóth et al. 2014) state that the third generation is the stage where knowledge exploitation is the decisive aspect, and it is at this stage that opportunities for the direct local use of the knowledge generated open up. As this third mission takes many different forms in practice, many authors have already identified a fourth generation of universities, based on an analysis of the different versions. Imreh-Tóth et al. do not refute this, but at the same time critically note that the fourth generation university cannot be seen as a further development, but rather as a more pronounced 'helix' role for the university. The 'helix' is a basic element of Etzkowitz's system description model (see below). The authors also stress that the most important distinguishing feature of this 'generational stage' is the proactive attitude of universities, whereby the stated aim of the university is to shape the local environment, positively influencing the socio-economic development of the local area.

Table 1 - Main content characteristics of the three generations of universities

	First generation universities	Second generation universities	Third generation universities
Their main objective is	Education (knowledge transfer)	Education and research	Education, research and knowledge exploitation
What do they create?	Professionals	Professionals and scientists	Professionals, scientists and entrepreneurs
Impact on the local environment	Indirect from	Indirect from	Direct from
Timeframe for the impact to be felt	Long	Long	Short

Source: own ed. based on Wissema (2009)

Nowadays, the focus is on third-generation universities all over the world, including Hungary. In Hungarian higher education, the priority is to operate these types of universities more efficiently, to optimise their operating mechanisms and to increase their role and effectiveness in society. To achieve these objectives, it is essential to model the university's operating mechanisms and to clearly demonstrate the interrelationship between the university and the other actors involved. The two most widely used models for the structural description of the third mission of universities are the so-called Triple Helix model of Etzkovitz (2014) and the Innovation University Ecosystem model.

2. THE TRIPLE HELIX MODEL

In its basic version (Etzkowitz & Leydesdorff, 1995), this model describes a knowledge-generating, innovation complex system with three actors and the interactions between them. The Triple Helix model is illustrated in Figure 1.

The creators of the model see value creation as taking place on the basis of the interactions between the three actors. These effects vary dynamically and, in favourable cases, form synergies with each other, amplifying each other's effects. There is no hierarchical relationship between the actors, who are, as the authors of the model put it, in a development-oriented partnership. The synergistic effects of cooperation can give rise to new institutional forms of knowledge creation and transfer (incubator and accelerator organisations, spin-off companies exploiting research results, etc.).

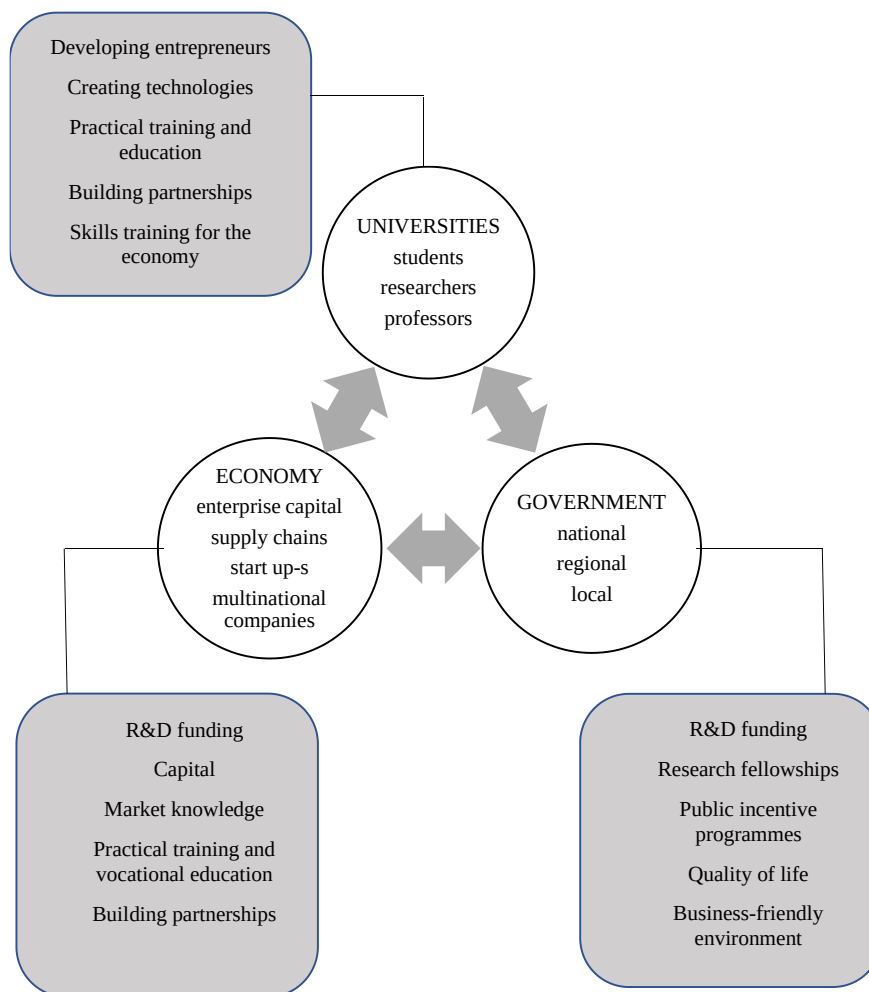


Figure 1 - The Triple Helix model

Source: own ed. based on Trott (2017) in (Deák 2021).

By adding new actors to the model, the Quadruple and Quintuple Helix models were created. In the Quadruple Helix model, the new actor (factor) is essentially the function of social empowerment, while in the Quintuple Helix model, sustainability and environmental factors have been incorporated. In his systematic work, Szakos (2022) describes the two models - drawing on literature sources - as follows. Here, too, interdependence and empowerment are reflected, as in the Triple Helix theory.

"Under the fourth helix, the creators of the model have also examined aspects such as culture, culture of innovation, values and lifestyles, multiculturalism, creativity, media, art and art universities. The diversity and heterogeneity of culture fosters creativity and becomes indispensable for the creation of new knowledge and innovation." (Carayannis & Campbell, 2009; Vas 2012, p. 204. in Horváth 2021) The Quintuple Helix model also takes into account the (natural) environment of society and the economy in addition to the four actors mentioned above. "These models already address sustainable and inclusive development and include the concepts of knowledge economy, knowledge society and knowledge democracy in the academic debate." (Carayannis et al., 2012)

3.THE UNIVERSITY INNOVATION ECOSYSTEM MODEL

We use the term ecosystem as a concept to interpret and study phenomena, states and things with a complex structure consisting of a large number of elements, as a kind of open system model. The concept of ecosystem, as originally understood in biology, can be applied with great certainty to innovation, i.e. it can be used to define the innovation ecosystem in an exact way. Based on the parallel, the innovation ecosystem is nothing else than a schema used to describe the large number and variety of actors and resources required for innovation, as well as the relationships and interactions between them (Szabó 2019).

The basic building blocks of the system model are two robust pillars. One pillar is the "structural capital" of innovation, while the other is "human capital". Structural capital includes innovation-related organisations (typically public agencies, companies, universities, research institutes), but also investors in innovation, those with control over the various resources, the tenders and programmes that provide the resources, and of course the wider and narrower environment of innovation, i.e. the innovation infrastructure. The other pillar of equal importance is human capital, i.e. the people who make innovation work (R&D workers, public and company managers and employees, staff of innovation organisations, experts), the formal and informal networks of people, the knowledge base accumulated in people and in organisations and companies. The comparison of the system model based on the two pillars is also useful because it draws attention to the fact that, however prestigious and solidly built the two pillars are, they can only fulfil their role if they are linked. The experience of recent times is that the essence of the model's operation lies in the relationships and interactions that are established. This means that the system of innovation can only work effectively if the main thrust of development is focused on intensified cooperation between actors. This requires innovation to be understood as an open innovation system, without legal and geographical barriers. The system should be dynamic and flexible enough to allow free entry and exit.

Because of its broader-based, open and dynamic structure, the ecosystem model is much better suited to describe the role and functioning of fourth generation universities in society and the economy. The ecosystem model also takes into account the context of the institutions that make it up, i.e. organisations - including universities - are not self-contained but are part of a system of relationships. And in this sense, for example, "the geographical location of the university and the other actors in its physical proximity matter a great deal" (Király 2019).

The reinforcement of the helix character of universities in the ecosystem model means that the scope of universities' tasks is substantially extended, mainly by tasks that are not found in their traditional tasks. The OECD (2004) has identified the main directions of this expansion of tasks, i.e. the university activities that can be carried out within the scope of the third mission, in the following main categories (in Inzelt-Bajmócy 2013):

- knowledge creation and technology transfer: marketing of university intellectual products
- selling training capacities: offering short programmes, specialised training and tailor-made courses in addition to traditional training
- selling university capacity: renting buildings, machinery, etc.
- resource generation: external research contracts.

4. KNOWLEDGE TRANSFER AND ITS INSTITUTIONALISATION

In the university innovation ecosystem model, knowledge transfer is the process by which knowledge is transferred from the source of knowledge to the actors receiving it, in a variety of forms. In the process of knowledge transfer, the elements of the system interact with each other. These interactions can be linked to the specific forms in which the knowledge transfer process takes place, depending on the actors and local conditions.

A general model of the knowledge transfer process is shown in Figure 2:

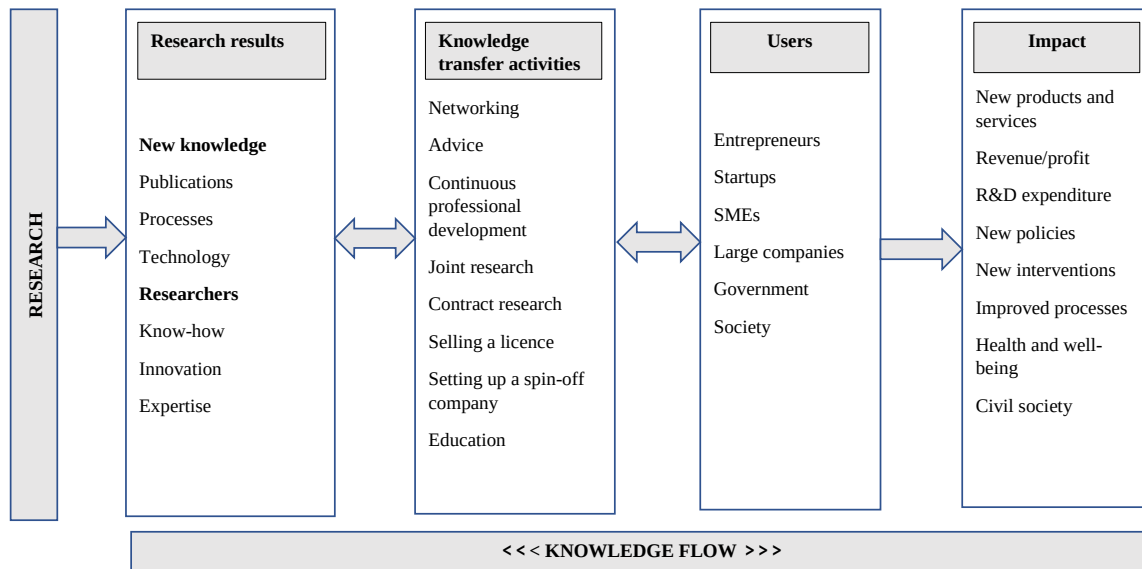


Figure 2 - Knowledge transfer from research to impact

Source: own ed. (University of Glasgow 2008, based on European Commission 2020). in: Buzási-Jelen (2023)

The growing importance of third mission activities in universities has led to the creation of university departments whose task is to implement this new type of activities in a planned and efficient way. These departments were most often called technology transfer offices (TTOs) or liaison offices. These departments have a wide variety of tasks, depending on local needs, and are therefore difficult to define.

The following interpretations bring us closer to defining their scope.

Technology Transfer Office

According to the OECD definition, the mission of such a unit is quite specific: its main task is to identify and exploit the knowledge (intellectual products) created at universities and to manage intellectual property professionally (including the profit-oriented sale of intellectual property to the business sector). In essence, the office is responsible for the management of intellectual products (quasi knowledge) within the university walls and in the university environment.

Liaison office

This term is less common in practice. As the name suggests, the emphasis is on the role of intermediary, although the specific tasks are essentially the same as those of a technology transfer office. The author of the specific definition of the organisational unit (Buzás 2007, p. 360) uses the

term "liaison office" and describes the definition as follows: "University liaison offices are organisational units (technology agencies) operating within universities that deal with the marketing and sale of knowledge and scientific results created within the university. They contribute to the practical exploitation of the accumulated knowledge base, look for business partners for the industrial application of results from basic research, carry out the licensing of new products and processes, and organise consultations. They also help to market the university's businesses, organise student placements, provide information to interested parties and seek direct support from businesses for university research teams."

5. MEASURABILITY OF THE KNOWLEDGE TRANSFER FUNCTION

Measuring the third mission of universities, knowledge transfer, is not an easy task. Concrete measurement is appropriately done using so-called indicators. However, this type of measurement raises a relatively large number of problems of principle and practice. These problems have been explored in a recent study using empirical data from Hungary (Buzási-Jelen, 2023).

The problems of principle are based on the practical usability of indicators. In many respects, measurement with indicators is still immature. Experience so far shows that it is difficult to reconcile the operational processes of universities with the intention to map them with indicators. Indicators are not simply statistical data that can be produced, but much more complex indicators. The statistician tries to explain this property in this way:

"An indicator is a parameter or value that points to, provides information about, or describes the state of some related phenomenon, environment or area.... Indicators are summary measures that can be used to show positive and negative changes in the phenomena related to key issues of the phenomenon under study." The author of the definition stresses that indicators have considerably more content than statistical data: "while statistical data are descriptive, indicators are interpretative indicators selected according to a specific perspective, a set of norms." (Havasi 2007, p. 680)

From this definition, it can be seen that the use of indicators must not only meet the requirements of statistics, but also, at least as strongly, the specific needs of the processes and impacts to be measured. There are no universally used indicators; they must always be "tailor-made". If this customisation is appropriate, it is ensured that continuous measurements can be used to monitor the functioning of the area in question, to assess its situation, either statically or dynamically: in terms of outputs, impacts, outcomes and performance. It is therefore clear that an indicator is not just data, but a "smart and intelligent" indicator. Their specific choice is appropriate if they are adapted as far as possible to the specificities of the application area to be studied.

The choice of indicators leads to practical problems. In each university, a wide variety of indicators are used to monitor and evaluate knowledge transfer processes. The choice of indicators may be based on either an internal management need (manageability, performance measurement) or on some external constraint. The external constraint may be explained by the fact that it is very common that indicators are used because they are required by the university (when applying for funding).

Under these conditions, it is not at all surprising that a rather large number of indicators can be identified in practice. In their study of this phenomenon, two German authors have attempted to collect them. In summary, they found more than 700 different indicators for the evaluation of knowledge transfer processes in universities (Falter 2023).

The same diversity can be seen in Hungarian practice. A study assessing the situation (Buzási-Jelen, 2023) identified 26 commonly used so-called core indicators. To illustrate the diversity, these are listed in Table 2.

Table 2: Most commonly used core indicators for the evaluation of knowledge transfer processes in Hungarian universities

Input indicators	Output indicators	Impact indicators	Outcome indicators
Institutional R&D expenditure (by source)	Number of domestic industrial property applications (by form of protection)	Revenue from research contracts size of	Number of contracts with external partners for R&D activities
Number of technology transfer personnel (FTE)	Number of international/European industrial property applications (by form of protection)	from R&D consultancy agreements the amount of income	Number of R&D consultancy agreements
Annual budget of the TTO (by objective)	Number of ghost reports	Value of research results brought to market, intellectual works sold or otherwise exploited	Number of marketed research results, intellectual works sold or otherwise exploited
Amount of external investment in spin-off companies	Number of priority patent applications	Income generated by established user enterprises	Number of spin-offs created
Providing business incubation	Number of patent applications from priority patent applications filed in other countries/regions	Amount of revenue from existing licence agreements	Number of joint publications between the private and public sectors
		Other non-royalty income from spin-off companies	Number of patents granted
		Number of jobs created in spin-off companies	Number of industrial property application/transfer of rights contracts
		Percentage of publications cited in patent applications	Number of products commercialised under licensing agreements

Source: own editing

Why were these 26 indicators chosen? The most plausible explanation is that the indicators used in Hungarian universities are very closely related to the expectations of tenders which helped to achieve the very goal of enabling universities to develop their missing knowledge transfer function and to create the organisational framework for this function. Of course, there were other strong influences. These include the proposed use of indicators linked to the industrial property protection requirements of a central institution (Hungarian Intellectual Property Office). Other strong influences were the publications of some EU institutions, but most notably the European Commission, which suggested specific measurement options and evaluation criteria based on the practice of European universities. perhaps the most interesting impact on indicator use is the use of indicators that correspond to different international university rankings, i.e. indicators that these rankings take into account for advancement in the rankings.

6. THE LINK BETWEEN KNOWLEDGE TRANSFER OFFICE AND TERRITORIAL DEVELOPMENT

Against the background outlined above, let us look at the answers to the questions posed in the abstract of this paper. The answers are by no means exhaustive, but are rather characterised by highlighting the most important features and posing problems.

Who has an interest in the effective functioning of university knowledge transfer offices and what is their interest?

Before giving a concrete answer, let's look in general at the impact of a university on a municipality and its immediate surroundings. The impacts mentioned are not ranked in order of importance. Some of them are direct, but there are also indirect impacts. Some impacts occur in the short term, others only after a longer period of time. What they have in common is that they are difficult to interpret individually, but rather in a complex, synergistic way. In a municipality where there is a university, the existence of a university has a stimulating effect on urban development and infrastructure provision (transport, housing, sports facilities, etc.). Educational opportunities are improved directly through the provision of university education, but the existence of a university also has an indirect effect on the quality of primary and secondary education. In a university city, a university is a centre of intellectual activity, which stimulates cultural and social life and generates a sense of social cohesion, and strengthens local identity. The economic impact is the most important for our topic. The university has a clear positive impact on the local economy. It is one of the largest employers and a major customer for the services of local businesses. But perhaps most importantly, the university's role as a knowledge hub makes it a source and driver of innovation.

It is through this latter role that the university knowledge transfer office comes to the fore. The operational objectives of such an organisation cover a very broad spectrum. These objectives are mainly in the interests of the university, but also take into account the interests of its immediate environment, precisely because of the mutual benefits. In concrete terms, the university has an interest in increasing its own revenues, but also in the market exploitation of its research results and intellectual products, which cannot be achieved without the involvement of local partners (industry, entrepreneurs). This back-and-forth effect clearly shows that both the university and its immediate economic environment have an interest in the efficient operation of university knowledge transfer offices. It has already been underlined in the previous presentation of the university innovation ecosystem model that the system (including the university knowledge transfer office) can be efficient if there is intensive cooperation between the actors. This relationship is also the starting point for the study that examines the third missionary activity and the so-called partnership management activity of universities (Vilmányi in: Kováts 2024):

"(1) the creation of value for local communities is included in one way or another in the areas of activity. It is also assumed that (2) this value creation is rooted in interactions and is shaped by interactions, so that relationship management is critical to the realisation of value creation." (Vilmányi in: Kováts p. 489)

The efficient operation of knowledge transfer offices is therefore in the interest of the university as well as its immediate economic environment and partners. If we are looking for further stakeholders besides the two direct actors, it is worth highlighting the findings of Shartinger et al. (Vilmányi in: Kováts 2024, p. 496):

"University partnerships, combinations of interactions, and the juxtaposition of them, can take a myriad of very different forms, which are far from homogeneous. It is essential to take account of these differences when formalising cooperation, since formalising the relationship helps to reduce uncertainty, increase trust, provide resources and forms of coordination to achieve objectives and avoid regulatory problems, thus creating the conditions for meeting the needs of the partners involved." (Shartinger 2002)

This theme calls attention to the need to find the most efficient forms of organisation and to create the right regulatory environment. Organisational forms, as we have seen earlier, in practice typically mean offices linking knowledge transfer offices (or less often). But whose responsibility is it to

regulate, or whose interest is it to create and facilitate the operation of this type of university activity? The answer is obvious: this stakeholder is the third actor in the Triple Helix model, the government.

What direct or indirect impact can a knowledge transfer office have on regional development? Can these effects be measured precisely? Are there methodological problems in measuring these impacts?

To answer these questions, let us return to the indicators presented in Table 2. The indicators, which can be used to assess the effectiveness of knowledge transfer processes, are not equally well suited to measure the impact on territorial development in a precise way. Simply because, as the grouping of indicators in the table shows, they have different content. According to the grouping used in the EU development policy (Cohesion Policy, 2017), there are four types of indicators, each with a different evaluation aspect. Input (input or resource) indicators measure the total resources available or used, quantified in monetary terms. These are simply financial indicators. Output (output or performance) indicators quantify the direct outputs of the processes being measured or monitored, typically in some natural unit of measurement. Outcome indicators are the indicators that the outputs of the process under study are intended to change. And finally, impact indicators, which are indicators that measure the measurable and meaningful effects of the processes under study over the longer term. If we look at the four types, we see that any of the indicators of any type can add useful information to an analysis. However, a complex picture can only be achieved by assessing them together, and their ability to provide a clear picture individually is limited. Of the four types, the impact indicators are perhaps the ones that are most suitable for assessing the effectiveness of our chosen area, spatial development.

But here we run into the problem of not being able to say exactly what we want to measure. This is because the effectiveness of spatial development can be interpreted in many different ways. The question arises: how can these different development processes be accurately and credibly monitored and evaluated using indicators? What is the methodological framework that can ensure a precise analysis of such complex phenomena? As the methodological recommendation (Kaiser 2017, p. 60) puts it: "The best way to measure complex domains....well is not by increasing the complexity of individual indicators, but rather by selecting a good set of indicators. More complex processes can be covered adequately by using several indicators, presenting several pages.....It is best to develop sets of indicators and use simple indicators and ratios as the individual indicators in the set."

The recommendation is obvious, but implementation is problematic. Impacts, which are difficult to quantify, should be measured in such a way that we can see how they change over time and compare results in different areas. In other words, they should meet basic statistical requirements. As we have seen, this need has not yet been met, not even in the area of measuring indicators in general, let alone in specific areas such as the effectiveness of technology transfer offices in universities.

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ENVIRONMENTAL WILLINGNESS TO PAY ACROSS EUROPE. COMPARING ISSP AND EVS SURVEY DATA

GYÖNGYVÉR BÁLINT – LAURA NISTOR

ABSTRACT

Willingness to pay for the environment constitutes one of the most popular measures of environmental concern. Our study compares the results of four questionnaire techniques measuring willingness to pay (WTP) in Europe in the 2017-2021 European Values Survey (EVS) and in the 2020 International Social Survey Programme (ISSP). Through our comparative analysis, we focus on answering the following research questions: Of the four components (paying higher price, paying higher taxes, reduction in standard of living, and giving part of income), which is the one that shows the highest WTP? Are there significant differences between countries in terms of WTP? What are the socio-demographic and attitudinal determinants of WTP's four components? The results show that the four types of measurement lead to different levels of willingness to pay. The most accepted sacrifices are giving away income and cutting back on living standards, while higher taxes are the most likely to reduce willingness to pay. Western and Scandinavian countries “perform” significantly better than Central and Eastern European countries in terms of willingness to pay measures. The different ways in which the willingness to pay is operationalised have partly the same and partly different social backgrounds: high income, interpersonal trust, post-material values, and environmental attitudes significantly increase the willingness to pay for environmental protection in all dimensions measured differently.

Keywords: willingness to pay, Europe, environmental concern, survey

2. INTRODUCTION

Willingness to pay (WTP) studies are part of the so-called contingent valuation (CV) method (Munro – Hanley 1999), which, by directly questioning people about the “economic value they place on a change in the quantity and quality of a specified resource” (Kotchen–Reiling 2000: 94), aims to appreciate the theoretical valuation of those kinds of goods which are not bought and sold on the market (Hanemann 1994), such as the clean environment. Thus, the contingent valuation method usually asks people if they would like to contribute financially to improve specific public goods, through the so-called willingness to pay questions.

The willingness-to-pay questions imply the formulation of a hypothetical market and payment scenario, which describes the environmental goods in question and the measures envisaged, and clarifies what we get in return for payment and acceptance (Ajzen–Driver 1992). Depending on how the question is asked, there are several subtypes of willingness-to-pay questions (Carson et al. 2011). In questions that examine willingness-to-pay at the conceptual level, the respondent is only asked to indicate whether or not he or she would be willing to pay for the environment or environmental protection. In more specific questions on payment and acceptance dispositions, the respondent is also asked to express the extent of the financial sacrifice or compensation accepted (Liebe et al. 2011).

In economic policy approaches, the willingness to make financial sacrifices is usually considered a precursor to actual action. Still, this direct causality only holds under strict requirements when formulating the questions (Monostori 2007). The predictive function of willingness-to-pay surveys on environmental policies thus requires exact questioning. In this context, several recommendations have been made. For example, the formulation of questions should create a conditional market that describes the environmental good as accurately and realistically as possible (Marjainé Szerényi et al.

2005). It is also a standard recommendation that questions should be closed questions; the results on WTP should be followed longitudinally, and comparing different questioning methods allows for better estimation of the actual WTP (Marjainé Szerényi 2001). According to Kotchen and Reiling (2000), we need to use the respondents' attitudes to help interpret CV survey responses. The underlying assumption is that a person with a solid pro-environmental attitude is more willing to pay for the environment, respectively, that a person who is more willing to pay will do so in a practical payment situation.

A problematic issue associated with contingent valuation and a source of potential response bias is the so-called 'warm glow' (Kahneman–Knetsch 1992), which refers to the respondents' satisfaction ensuing from expressing willingness to pay. A warm glow may be interpreted as impure altruism because respondents usually benefit from their desire to pay for good reasons, such as environmental protection. The warm glow is, in fact, very similar to environmentally desirable responding (cf. Ewert–Galloway 2009) since "respondents in a CV survey attempt to please an interviewer by agreeing (or not agreeing) to pay some amount when they would not do so otherwise, except for the utility gain associated with telling the interviewer" (Carson et al. 2001: 177). This response is also readily observable in comparisons between contingent valuation surveys and effective payments, the latter being usually lower than expected based on contingent valuation results (Diamond–Hausman 1994). According to Hanemann (1994), there are three significant ways to validate contingent valuation results: through replication, comparison with estimates from other sources, and comparison with actual behavior. Considering all the limitations and recommendations mentioned above, WTP is widely used to elicit consumers' valuation of non-market goods (Steigenberger et al. 2022).

Following the above recommendations, the present study compared the willingness to pay for the environment in European countries using two data collections: the European Values Survey (EVS) and the International Social Survey Programme (ISSP). In the EVS, willingness to pay for the environment was measured by a single question (I would give part of my income if I were certain that the money would be used to prevent pollution), while the ISSP approached the question with three variables (Would you be willing to... 1) pay higher prices to protect the environment, 2) pay higher taxes, 3) accept a reduction in the standard of living.

Through our comparative analysis, we focus on answering the following research questions: What is the difference in willingness to pay between the four measures? Which component is associated with the highest and lowest willingness to pay? Are there significant differences between countries in terms of willingness to sacrifice? What are the socio-demographic and attitudinal determinants of WTP's four components (price, tax, living standards and part of income)?

In the following sections, we will describe the two surveys and the questions through which these surveys targeted environmental willingness to pay. We will also present the methods of analysis. Then, the results will be presented and discussed. The paper ends with the conclusions.

2. MATERIAL AND METHODS

Two databases, the ISSP cumulative database (ISSP Research Group, 2023) and the EVS 2017-2021 integrated database (EVS, 2022), were used to analyse the willingness to pay for environmental protection. Both surveys included national representative samples for the participating countries, i.e., 36 countries in the case of the EVS and 28 countries in the case of the ISSP. For the present comparative analysis, we focused only on those 17 common countries that have been included in both surveys, such as Austria, Denmark, Finland, France, Germany, Croatia, Hungary, Iceland, Lithuania, Italy, Norway, Russia, Slovakia, Slovenia, Spain, Sweden and Switzerland.

As stated in the Introduction section, the two surveys measured environmental willingness to pay through different questions, as presented in Table 1 below.

Table 1. The wording of the WTP questions in the two surveys

Survey	Question(s) from the questionnaires		Response variants
ISSP 2000	Would you be willing to	1) pay higher prices to protect the environment	1. Very willing
		2) pay higher taxes to protect the environment	2. Fairly willing
		3) accept a reduction in the standard of living to protect the environment	3. Neither willing nor unwilling
EVS 2017-2021	I would give part of my income if I were certain that the money would be used to prevent pollution.		4. Fairly unwilling
			5. Very unwilling
			1. Agree strongly
			2. Agree
			3. Neither agree nor disagree
			4. Disagree
			5. Disagree strongly

Source: computed by the authors.

As mentioned elsewhere (Nistor–Bálint 2024), the literature on willingness to pay (Carson et al. 2011, Liebe et al. 2011) highlights the importance of dichotomous responses. In our analysis, we have followed this approach, converting the variables measuring willingness to pay into dichotomous variables. In all cases, 0 represents “not willing to pay” and 1 means “willing to pay”. In the bivalent dependent variables of both datasets analysed, the group declaring willingness to pay for the environment comprises those who agreed/were willing or strongly agreed/were very willing with the statements in Table 1. For neutral respondents, we assumed that those uncertain in a hypothetical situation would strengthen the group of non-payers in an actual situation. Although there are precedents in the literature for removing neutral, undecided respondents from the analysis to enhance the dichotomy (e.g., Israel–Levison 2004, Ivanova–Tranter 2008), due to the associated reduction in item counts, we have included them in the “unwilling to pay” group in the present analysis.

In the first part of the analysis, we relied on descriptive statistics to compare the popularity of the differently measured WTPs across the 17 countries. In the second part of the analysis, we used binary regression to investigate the socio-demographic, axiological, and attitudinal determinants of the different WTP questions. A total of 11 explanatory variables were included in the regression models to examine the factors that shape willingness to pay. Gender, age, and place of residence (3 additional variables) were considered control variables. As the research aims to compare the results of the two most recent surveys (ISSP 2020 and EVS 2017-2021), we also aimed to transform the variables (mainly socio-demographic characteristics) in both datasets to make them similar. Table 2 below lists the explanatory variables and their measurements:

Table 2. The explanatory variables of the regression models

Socio-demographic variables (SD) (6)	Datasets	Type	Variables of social attitudes (SA) (5)	Dataset	Type
Age (SD1) EVS: 82=82 years and older	ISSP, EVS	scale	Institutional trust (SA1) Factor score: 4 (ISSP) and 4 (EVS) institutions (education, parliament, news media, economic inst.)	ISSP, EVS	scale
Gender (SD2) Male=1, Female=0	ISSP, EVS	binary	Interpersonal trust (SA2)	ISSP, EVS	binary

<i>Education (SD3)</i> Years spent in full time education (ISSP). Age when ending formal education (EVS, 7=7 years or younger, 70=70 years or older)	ISSP, EVS	scale	<i>Political activity (SA3)</i> Taken part in the latest elections (ISSP, 1=have taken part, 0=Haven't). Frequency of participation in national elections (EVS, 1=always, 0=not always).	ISSP, EVS	binary
<i>Income level (SD4)</i> Total net income of household: 1=high (appr. 3 highest deciles), 0=not high	ISSP, EVS	binary	<i>Postmaterialist values (SA4)</i> 1=Postmaterialist, 0=Mixes and materialist	ISSP, EVS	binary
<i>Type of locality (SD5)</i> 1= bigger settlements: small and big cities (ISSP), over 20,000 inhabitants (EVS), 0=smaller settlements	ISSP, EVS	binary	<i>Environmental attitudes (SA5)</i> Factor score (4 types of attitudes towards the environment)	ISSP, EVS	scale
<i>Type of respondents' country (SD6)</i> 1=Western European, 0=East-Central European	ISSP, EVS	binary			

Source: computed by the authors.

When selecting these explanatory variables, we relied on previous literature results, which contend that higher educational attainment is most strongly associated with willingness to pay (Ivanova–Tranter 2008, Franzen–Meyer 2010, Franzen–Vogl 2012). Franzen and Vogl (2013) emphasized the role of higher income in influencing willingness to pay, highlighting that scarce financial resources can be an objective constraint that does not allow for the expression of willingness to pay even if the individual otherwise considers environmental protection important. However, the link between willingness to pay and material situation is somewhat nuanced by research that has found that the in-principle willingness to pay is less dependent on material situation than willingness to pay measured in concrete monetary terms (Liebe et al. 2011).

Inglehart's (1995) post-materialism thesis argues that prioritizing environmental protection is a higher-order demand, that the demand for environmental protection can be defined as a component of quality of life, and that it is linked to post-materialist values. In international comparative analyses based on the ISSP framework, Ivanova–Tranter (2008) and Franzen–Meyer (2010), among others, have demonstrated the association of post-materialist values with the willingness to pay for environmental protection. Research has shown that lower interpersonal and institutional trust reduces willingness to pay (Liebe et al. 2011, Davidovic–Harring 2020). Regarding political left-right orientation, the number of non-responses was quite high across the countries, so we included the variables measuring political activity, assuming that political proficiency is related to the payment disposition towards the environment. If willingness to pay is interpreted along the lines of Ajzen's (1985) intentional action model, it can be said that, in general, citizens with more intense environmental attachments are more willing to pay for the environment (Meyer–Liebe 2010, Liebe et al. 2011).

The research question of the analysis was to explore whether the differently measured willingness to pay variables share the same roots in terms of their socio-demographic and axiological determinants.

3. RESULTS AND DISCUSSION

3.1. The four environmental WTP rates

First, we used data from the two databases to examine the descriptive statistics of four differently measured willingness-to-pay variables across 17 European countries. Based on the relative frequencies of the original 5-point Likert scale responses (see Table 3), the highest level of willingness to pay is observed in the measure based on voluntary income contributions, as recorded in the European Values Study (EVS).

Table 3. Descriptive statistics of the environmental WTP in the 17 European countries

	<i>ISSP-higher prices</i>	<i>ISSP-higher taxes</i>	<i>ISSP-reduction in standard of living</i>	<i>EVS -giving part of income</i>
1. Very willing/Totally agree	5.7	3.6	7	13.8
2. Fairly willing/Agree	29.8	19.5	34.1	36.3
3. Neither willing nor unwilling/3. Neither agree nor disagree	25.6	23	24.4	24.2
4. Fairly unwilling/Disagree	21.8	26.6	18.9	16.2
5. Very unwilling/Totally disagree	17.1	27.3	15.6	9.5
<i>Total</i>	<i>100</i>	<i>100</i>	<i>100</i>	<i>100</i>
N	24818	24608	24839	28948
Mean	3.15	3.55	3.02	2.71
SD	1.186	1.183	1.197	1.172

Source: computed by the authors.

Over one-tenth of respondents across the surveyed countries fully agreed with this support for environmental initiatives. This is followed by willingness to pay measured as a willingness to accept a reduction in quality of life, and then by willingness to pay higher prices for environmental protection. The lowest level of willingness to pay is observed in the case of higher taxes: fewer than one-fifth of respondents expressed definite support for this measure, while more than one-quarter were strongly opposed. The results thus suggest that voluntary contributions are better accepted than constraints, such as paying higher taxes. This result is similar to our previous findings regarding Hungary (Nistor–Bálint 2024) and to the findings of Ivanonva and Tranter (2008) or Sjöstrand (2024). Approximately one-quarter of respondents chose neutral responses across the WTP items. The average values also indicate the same differences and order of willingness to pay, with standard deviations indicating slightly above-average variability in all four cases.

As outlined in the *Materials and Methods* section and following the literature's recommendations (e.g., Carson et al. 2011), we recoded the 5-point Likert scales measuring willingness to pay (WTP)—the central focus of our study—into binary variables. These four recoded dependent variables were then used in the subsequent analysis. Based on this categorization, aggregate willingness to pay (“very willing” and “fairly willing” responses) is highest when framed as a voluntary contribution of income, with half of the population across the 17 European countries expressing support for this option (Figure 1). The second most supported form of financial contribution is a reduction in living standards, followed by a slightly lower level of support for paying higher prices (35.5%). In contrast, fewer than

one-quarter of respondents indicated a willingness to support environmental efforts through higher taxes.

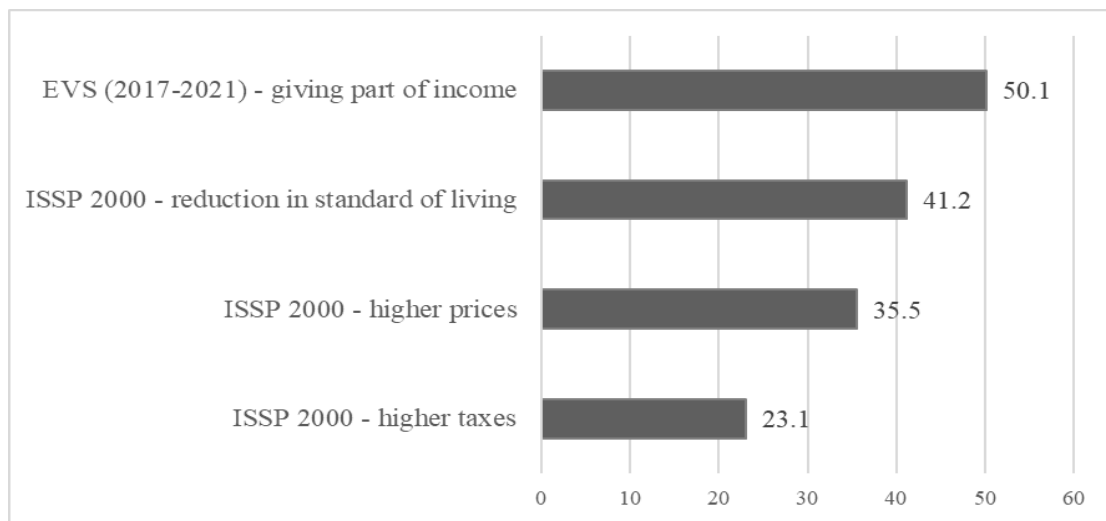


Figure 1. Environmental WTP in the 17 European countries (%)

Source: computed by the authors.

Finally, we examined the correlations among the three WTP measures included in the ISSP dataset. Our analysis revealed that there is a significant positive correlation ($p < 0.001$) among the three willingness-to-pay (WTP) variables, with all correlations exceeding a moderate strength: $r_1 = 0.715$ (paying higher prices – paying higher taxes), $r_2 = 0.598$ (paying higher prices – reducing living standards), and $r_3 = 0.559$ (paying higher taxes – reducing living standards). These results suggest that a higher willingness to pay in one form is also associated with an increased willingness to pay in the other forms.

3.2. Regional disparities in WTP

Next, we examined regional differences in aggregate willingness to pay across the 17 surveyed countries, focusing on the four types of WTP. As expected, significant differences emerged among countries for all four WTP measures ($p < 0.001$; Pearson Chi-Square > 790.528).

Table 4. Country rankings across the different dimensions of WTP (%)

<i>Dimension</i>	<i>1st place</i>	<i>2nd place</i>	<i>3rd place</i>	<i>HU</i>	<i>15th place</i>	<i>16th place</i>	<i>17th place</i>
Higher prices	Switzerland	Norway	Germany	12th place	Croatia	Slovakia	Lithuania
Higher taxes	Norway	Denmark	Sweden	14th place	Lithuania	Russia	Slovakia
Reduction in standard of living	Switzerland	Germany	Austria	16th place	Slovakia	Hungary	Lithuania
Giving part of income	Sweden	Slovenia	Croatia	14th place	Finland	Slovakia	Lithuania
<i>On all the 4 dimensions</i>	<i>Switzerland</i>	<i>Sweden</i>	<i>Norway</i>	<i>15th place</i>	<i>Hungary</i>	<i>Slovakia</i>	<i>Lithuania</i>

Source: computed by the authors.

Swiss respondents demonstrated the highest willingness to pay higher prices and to accept a lower quality of life for environmental protection. Norwegians showed the greatest willingness to pay higher taxes, while Swedes were the most willing to contribute a portion of their income. When considering all four WTP dimensions collectively, Switzerland ranked highest overall. In contrast, Lithuania ranked lowest in three of the four WTP categories and the overall composite ranking. Table 4 summarizes the countries that ranked highest and lowest in each WTP category.

Figure 2 also includes countries not listed in Table 4. In addition to highlighting significant differences between countries, the figure reveals a clear regional pattern: Central and Eastern European countries generally exhibit lower levels of willingness to pay, whereas Western European and Scandinavian countries tend to show much higher levels of willingness to pay for environmental protection.

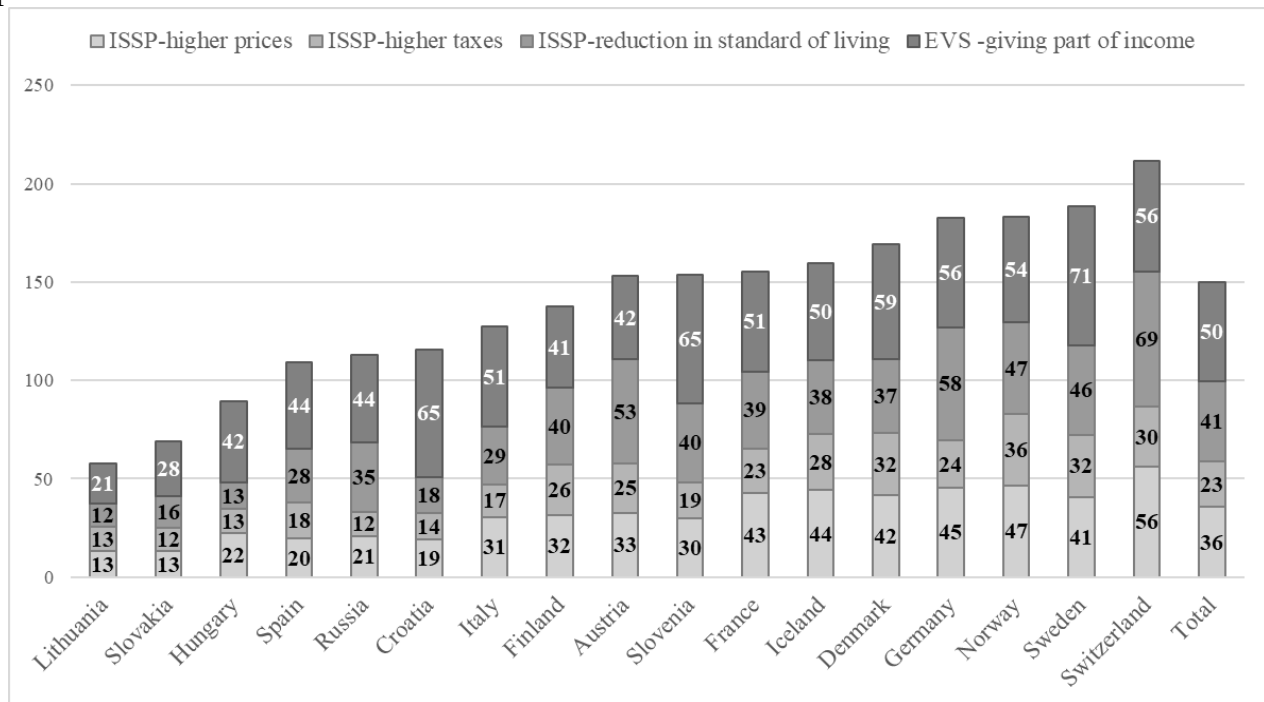


Figure 2. Environmental WTP – country level (%)

Source: computed by the authors.

Therefore, in the next step of our analysis, we divided the 17 countries into two groups: six Central and Eastern European (CEE) countries (Lithuania, Slovakia, Hungary, Russia, Croatia, and Slovenia) and 11 Western-European countries (Spain, Italy, Finland, Austria, France, Iceland, Denmark, Germany, Norway, Sweden, and Switzerland), and examined the differences in WTP. Figure 3 clearly shows significant differences between the country groups ($p < 0.001$; Pearson Chi-Square > 224.935). The most minor difference is the willingness to pay as a proportion of income between the two country groups. In the case of the other three WTPs, Western European countries show almost twice as much willingness to pay as Central and Eastern European countries. This is why we deemed it essential to include this regional grouping as an explanatory variable in the regression model.

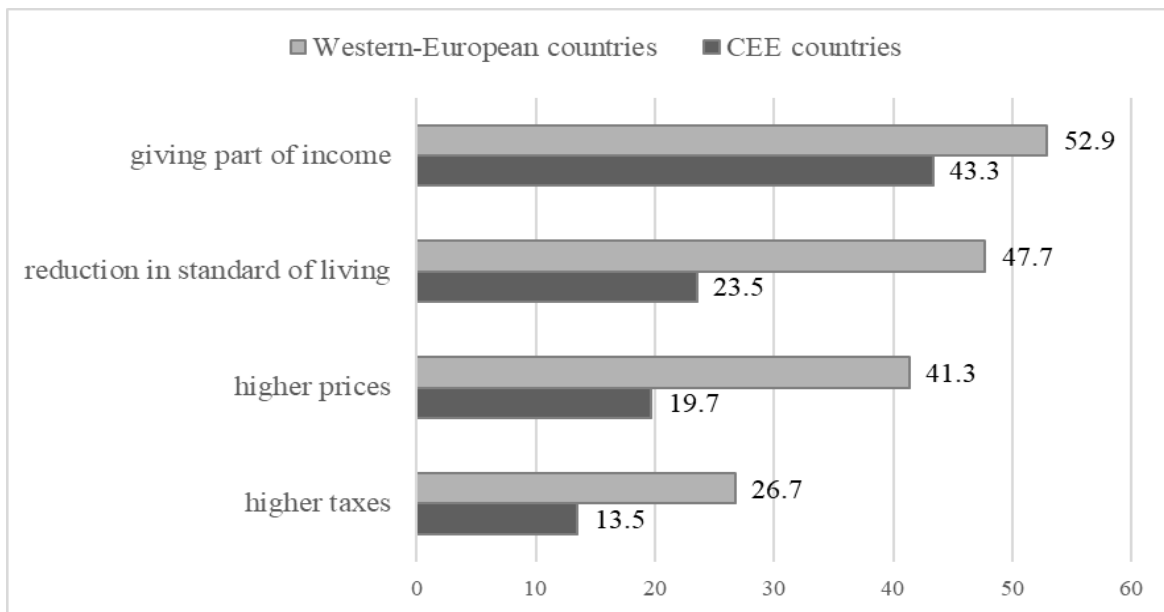


Figure 3. Environmental WTP across country groups (%)

Source: computed by the authors.

3.3. The social background factors associated with the WTP

In the final step of our analysis, we employed four binary logistic regression models to examine the factors influencing the probability of willingness to pay (WTP), as measured in four different ways. The dependent variables were the WTP indicators recoded into binary form (1 = willing to pay).

As detailed in the *Materials and Methods* section (Table 2), we included 11 explanatory variables—six socio-demographic characteristics and five social attitude measures—selected based on prior literature and available in both datasets.

Each of the four models covers approximately two-thirds of the total sample. The correlations among the explanatory variables were generally weak, with the highest observed Pearson correlation coefficient being $r = 0.361$. Multicollinearity diagnostics confirmed that collinearity was not a concern (maximum VIF = 1.243). All explanatory variables were entered simultaneously using the Enter method. According to the Omnibus and Wald statistics (Table 5), all four models are statistically significant. The improvement in classification accuracy over random assignment ranges from 1.6% to 11.9%, with the lowest gains observed in the ISSP models involving higher taxes and prices. The models explain between 18.7% and 23.5% of the variance in the dependent variables in the ISSP dataset, and slightly over 10% in the EVS. Among the four regression models, the final model—measuring willingness to pay for environmental protection in terms of a reduction in living standards—demonstrates the strongest explanatory power.

We relied on two indicators, odds ratios (Exp(B)) and unstandardized regression coefficients (B), to interpret the results.

Table 5. Logistic regression models of WTP

	<i>EVS 1997-2021</i>		<i>ISSP 2020</i>					
	<i>Giving part of income</i>		<i>Higher prices</i>		<i>Higher taxes</i>		<i>Reduction in living standards</i>	
	B	Exp(B)	B	Exp(B)	B	Exp(B)	B	Exp(B)
Age (SD1)	-0.004**	0.996	0.003**	1.003	- 0,001	0,999	-0,004**	0,996

Male (SD2)	0.161**	1.175	0.089*	1.093	0,138**	1,148	-0,029	0,972
<i>Education (SD3)</i>	0.011**	1.011	0.042**	1.043	0,043**	1,044	0,016**	1,016
<i>Higher income (SD4)</i>	0.139**	1.149	0.383**	1.466	0,280**	1,324	0,208**	1,231
Bigger settlement (SD5)	0.032	1.033	-0.107**	0.899	0,080*	1,083	-0,229**	0,796
Western Europe (SD6)	-0.106**	0.899	0.569**	1.766	0,249**	1,283	0,834**	2,303
Trust in intitutions (SA1)	-0.070**	0.932	0.234**	1.263	0,286**	1,331	0,060**	1,062
<i>Interpersonal trust (SA2)</i>	0.212**	1.236	0.286**	1.331	0,402**	1,495	0,305**	1,356
Voting (SA3)	0.269**	1.309	0.051	1.052	0,167**	1,182	-0,214**	0,808
<i>Postmaterialist values (SA4)</i>	0.452**	1.571	0.452**	1.572	0,549**	1,732	0,385**	1,470
<i>Environmental attitudes (SA5)</i>	0.477**	1.611	0.597**	1.817	0.594**	1.812	0.741**	2.097
<i>Constant</i>	-0.407**	0.666	-2.127**	0.119	-2.661**	0.070	-0.941	0.390
N	19 401 (65.5%)		17 375 (67.9%)		17 283 (67.5%)		17 401 (68%)	
Wald-statistics	38.363**		1263.476**		4327.584**		433.118**	
Omnibus test (χ^2)	1774.616**		2937.714**		2292.057**		3344.098**	
Nagelkerke R ²	0.117		0.213		0.187		0.235	
Model correction	10.5%		6.7%		1.6%		11.9%	

*=p<0.5, **=p<0.01.

Source: computed by the authors.

Overall, the results of the four regression models indicate that the social determinants of willingness to pay (WTP), as operationalized in different forms, are partly overlapping and partly distinct. Five explanatory variables—highlighted in italics in Table 5—consistently show significant effects across all four models. Among these, pro-environmental attitudes emerge as the strongest predictor, significantly increasing the probability of WTP in all models and more than doubling it in the case of willingness to reduce one's standard of living. This results is in line with previous data of the literature showing that WTP can be considered an environmental behavioral disposition which is rooted in environmental attitudes (Ivanova–Tranter 2008, Saari et al. 2021).

This is followed by a strongly post-materialist value orientation, which increases the likelihood of WTP by approximately 1.5 times across all models. This is, again a finding which confirms previous results obtained on previous waves of ISSP datasets (Ivanova–Tranter 2008, Franzen–Meyer 2010). Slightly lower effects are observed for interpersonal trust (see previous results obtained by Davidovic–Harring 2020) and belonging to the top three income deciles (see previous results obtained by Franzen and Vogl 2013), both of which raise the probability of WTP by about 1.3 times. Although the effect size is modest, educational attainment—measured by years of formal education—also shows a consistent and significant positive association with all four WTP measures, confirming previous literature findings (e.g., Ivanova–Tranter 2008, Franzen–Meyer 2010).

In addition to these common predictors, several differences in the social background characteristics emerge across the models. In the case of WTP measured by willingness to contribute a portion of income, a higher likelihood is associated with younger age, male gender, residence in Central and Eastern European (CEE) countries, lower trust in institutions (education, economy, politics, media), and political activism. Thus, in CEE countries, citizens would prefer to contribute voluntarily to environmental protection rather than by paying higher taxes.

For WTP, which is measured as willingness to pay higher prices, greater support is found among older individuals, residents of smaller settlements, those living in Western European countries, and individuals with higher institutional trust. Willingness to pay higher taxes is more likely among men, Western Europeans, individuals with stronger institutional trust, and politically active respondents. Thus, environmental protection measures that imply a reduction in the standard of living or the acceptance of higher taxes are more common in Western countries and require rich social capital in terms of trust. Finally, beyond the five common predictors, willingness to reduce living standards for environmental protection is also positively associated with younger age, residence in smaller

settlements, living in Western Europe, greater institutional trust, and political disengagement. These findings reassess the recent contributions of the literature, which highly emphasize the role of trust when approaching environmental dispositions expressed in terms of WTP (Marbuah 2019, Davidovic–Harring, 2020; Sjöstrand 2024).

4. CONCLUSIONS

The present research investigated whether different operationalizations of in-principle willingness to pay for the environment lead to varying results across 17 European countries. For this purpose, the EVS 2017 and ISSP 2020 datasets were used, and analysis was run on those countries included in both surveys. We have investigated the following research questions: Are there different degrees of WTP along different payment scenarios, i.e., different operationalizations of WTP for environment questions? Are there inter-country and inter-country-group differences in WTP? Do different WTP scenarios have different social backgrounds? To what extent do the key explanatory variables in the literature on WTP (higher income and education, post-material values, trust, interest in politics, environmental attitudes) influence willingness to pay?

The results in connection with these questions showed that the specificity of the payment scenarios leads to different results. Across the 17 countries studied, coercive propensity to pay (taxes) is generally the most unpopular, while giving (voluntary) part of income to support (EVS) environmental protection is the most popular willingness to pay measure. There are significant differences between countries' willingness to accept different payment scenarios. Western and Scandinavian countries “perform” significantly better than Central and Eastern European countries on all measures of willingness to pay (the latter typically “perform” better on the EVS-measured income offer). Switzerland, Sweden, Norway, Germany, and Denmark show the highest willingness to pay, while Lithuania, Slovakia, and Hungary show the lowest levels of WTP.

The different ways in which the willingness to pay is operationalised have partly the same and partly different social backgrounds: high income, interpersonal trust, post-material values and environmental attitudes significantly increase the willingness to pay for environmental protection in all dimensions measured differently. The willingness to pay, measured in four different ways, is also shaped by other variables. Willingness to pay as measured by EVS, i.e, by giving up part of income, shows a stronger correlation with gender and political participation. For all ISSP items, residence in a Western European country is a much more significant explanatory variable for paying higher prices and taxes, institutional trust is much more important for higher taxes, political participation and the role of men are also more significant for accepting cuts in living standards, and living in a smaller settlement also increases willingness to pay.

Our analysis provides a sociological view of the trends and determinants of the willingness to pay for environmental protection. However, it is only very marginally predictive of environmental policy support, especially since the variables under study describe theoretical, very generalised payment situations. The results clearly show that although all four questions measure environmental behavioral dispositions and assume a set of standard explanatory variables, different questioning leads to different results. Therefore, the research draws attention to the importance of specificity in formulating WTP questions and the caution about making environmental policy predictions based on WTP. Obviously, not only can the formulation of WTP items lead to different results, but the macro-social context in which a specific WTP question is investigated can also lead to different results. Thus, our research assesses the role of contextual factors as well. We know that this exploration can be further continued by multi-level methods and more specific surveys in which WTP questions are more concretely formulated to get more precise data on environmental WTP.

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Authors' address

nistorlaura@uni.sapientia.ro, balintgyongyver@uni.sapientia.ro

Sapientia Hungarian University of Transylvania, Cluj-Napoca, Romania
 Faculty of Economics, Socio-Human Sciences and Engineering
 Department of Social Sciences
 530104 Miercurea Ciuc
 Piata Libertatii no. 1

REGIONAL DISPARITIES IN ROMANIA AT NUTS 3 LEVEL: A MULTIVARIATE APPROACH WITH EMPHASIS ON HARGHITA COUNTY

VARGA ORSOLYA – RITTER KRISZTIÁN

Abstract. In the course of the territorial analysis of Romania at the NUTS 3 level, multivariate statistical methods are applied to examine economic, social, and infrastructural disparities across counties, with a particular focus on Harghita County. Through factor and cluster analysis, the study identifies the main structural characteristics, including economic development, employment, industrial activity, demographic dynamics, education, and tourism potential. Based on the results, Romania's counties can be grouped into five distinct clusters, with Harghita County classified within the "moderately developing" category. The research highlights the specific challenges and opportunities facing Harghita County and proposes policy recommendations aimed at enhancing economic diversification, improving educational outcomes, and developing tourism infrastructure. These measures are intended to contribute to reducing regional disparities and promoting sustainable development.

Keywords: Multivariate Statistical Methods, Regional Disparities, County-Level Analysis, Socio-Economic Indicators, Sustainable Regional Development

1. Introduction

In recent decades, the analysis of territorial disparities has become a central topic within regional science and spatial planning, particularly in countries undergoing economic transition and regional restructuring, such as Romania. The present study aims to investigate county-level differences at the NUTS 3 level by applying multivariate statistical methods to explore the economic, social, and infrastructural heterogeneity that characterizes the Romanian territory. By focusing on key structural indicators – including economic development, employment, industrial activity, demographic dynamics, education, and tourism potential – the research seeks to provide a comprehensive understanding of regional disparities and the spatial configuration of development across the country. A particular emphasis is placed on Harghita County, located in the Central Development Region, which is analyzed both as a distinct territorial unit and in relation to broader regional patterns. Through the application of factor analysis and cluster analysis, the study identifies the main dimensions shaping regional disparities and groups the 41 counties of Romania into five statistically distinct clusters. This classification helps reveal internal hierarchies and structural similarities among counties, offering a more nuanced view of regional development beyond traditional administrative categorizations.

The results indicate that Harghita County belongs to the category of "moderately developing" regions, characterized by average performance across several socio-economic indicators. Despite not belonging to the country's most advanced territorial units, Harghita shows a complex and balanced profile, combining moderate levels of industrial activity and employment with significant potential in tourism and education. At the same time, the county faces specific structural challenges, such as limited economic diversification and demographic vulnerabilities, which constrain its development trajectory.

This paper highlights these challenges and opportunities in the context of Romania's evolving regional landscape and formulates policy-oriented recommendations to support more balanced development. These include proposals for improving educational infrastructure, enhancing the quality and accessibility of tourism services, and encouraging investment in underdeveloped sectors. By addressing these issues, the study contributes to the academic and policy dialogue on how to reduce territorial inequalities and promote sustainable regional development within Romania and beyond.

2. Material and Methods

In the framework of our extended regional development research, this study applies a multivariate statistical approach to explore socio-economic disparities across Romania's 41 counties at the NUTS 3 level. The capital, Bucharest, was intentionally excluded due to its disproportionately high concentration of economic, infrastructural, and administrative functions, which tend to skew comparative regional analyses – a methodological choice supported by both national and international best practices. This exclusion enables a more balanced and meaningful evaluation of county-level disparities (see: Goschin 2014, Cismas et al., 2020). The empirical foundation of the analysis rests on a comprehensive dataset compiled from the most recent available indicators for the years 2021 and 2022, published by the Romanian National Institute of Statistics. These data were initially structured and preprocessed using Excel, followed by standardization procedures to ensure comparability across variables. Variable selection was grounded in both a critical review of the existing literature and insights derived from our prior research, with a strong emphasis on capturing the multidimensional nature of regional development, including economic activity, demographic patterns, infrastructural endowments, and tourism capacity.

The statistical analyses were conducted using the SPSS (Statistical Package for Social Sciences) software, which is widely accepted in regional studies for its reliability and flexibility. Among the techniques applied, factor analysis was employed to identify latent dimensions that capture the underlying structure of socio-economic variation across counties. Originating from the work of Karl Pearson (1901, cited in Cohen 1988), factor analysis reduces the dimensionality of large datasets by grouping correlated variables into orthogonal factors that retain the majority of the explanatory variance (Szelényi 2004). This approach provides a more manageable and interpretable representation of complex regional realities and facilitates subsequent multivariate techniques. Building on the results of factor analysis, cluster analysis was utilized to classify the counties into homogenous groups based on their development profiles. Unlike factor analysis, which focuses on variables, clustering aggregates individual units – here, counties – into categories that exhibit internal coherence and external differentiation. Hierarchical and non-hierarchical methods were explored, with particular attention to the K-means algorithm derived from MacQueen's approach (Székelyi – Barna 2002). Given the often-ambiguous nature of clustering outcomes, we applied multiple methods to validate the robustness of the results, in line with recommendations from Sajtos and Mitev (2007). Factors such as the number of clusters, distance metrics, and variable configuration were carefully adjusted to enhance interpretive accuracy.

A central focus of the study is Harghita County, which is examined both independently and in its comparative position within the identified cluster structure. Harghita presents a unique case within the Romanian regional landscape: while it does not belong to the most dynamically developing counties, it exhibits a balanced development pattern with moderate performance in key indicators, such as employment, industrial activity, and education, alongside significant tourism potential. However, structural challenges – most notably limited economic diversification and demographic constraints – continue to hinder its development trajectory. These issues are evaluated within the broader context of national disparities and provide a basis for policy recommendations aimed at fostering more inclusive and territorially balanced growth.

The credibility and validity of our findings are closely tied to the integrity of the data and the appropriateness of the selected methodological tools. By applying rigorous statistical procedures and drawing on robust empirical evidence, this study contributes to the ongoing scientific discourse on spatial inequalities and regional policy in post-transition economies (Lengyel 2012, Cismas et al. 2020). Through its focus on Harghita County, the research also offers actionable insights for sub-national policy design tailored to the distinct characteristics and needs of less dynamic but structurally balanced territories.

3. Results and Discussion

To gain a clearer understanding of regional disparities across Romania's counties (NUTS 3 level), we applied factor analysis – a statistical technique designed to reduce data complexity by uncovering latent variables that underpin observable indicators. This approach allows for the transformation of a large and fragmented dataset into a more manageable set of composite factors, making it easier to interpret and compare territorial inequalities. These factors serve as a foundation for subsequent classification techniques, such as cluster analysis, which can group counties based on shared characteristics. Additionally, this analytical step lays the groundwork for evaluating how Harghita County, our central area of interest, aligns with broader regional patterns. The analysis began by standardizing all variables to ensure comparability. A key part of the methodology involved refining the dataset: we eliminated redundant indicators with high intercorrelations, those with negligible factor loadings, and variables with limited explanatory potential. This refinement process was aimed at maximizing the clarity and interpretive power of the resulting factors. Ultimately, out of an initial pool of 61 indicators, we retained 36 variables deemed most relevant for the comparative assessment of regional development conditions.

These 36 indicators were categorized into five thematic dimensions – demographics, economy, infrastructure, agriculture, and tourism – each representing a core domain of regional development.

Demographic indicators:

1. Crude rate of natural increase (‰), 2022
2. Population density (inhabitants/km²), 2022
3. Enrollment in pre-university education (per 1000 inhabitants), 2022
4. Share of population with only primary education (per 1000 inhabitants), 2021
5. Number of secondary school graduates with diploma (per 1000 inhabitants), 2021

Economic indicators:

1. GDP per capita (RON), 2021
2. Employment rate (%), 2022
3. Unemployment rate (%), 2022
4. Number of active enterprises (per 1000 inhabitants), 2022
5. Number of private entrepreneurs (per 1000 inhabitants), 2022
6. Recipients of general social assistance (per 1000 inhabitants), 2022
7. Number of beneficiaries of child-rearing benefits (per 1000 inhabitants), 2022
8. Family allowance beneficiaries (per 1000 inhabitants), 2022
9. Employed persons (per 1000 inhabitants), 2022
10. Employed persons in the industrial sector (per 1000 inhabitants), 2022
11. Average monthly pension (RON), 2022
12. Pensioner population (per 1000 inhabitants), 2022
13. Average gross nominal wage (RON), 2022
14. R&D staff (per 1000 inhabitants), 2022
15. R&D expenditure (RON per 1000 inhabitants), 2022
16. Building permits issued (per 100 inhabitants), 2022

Infrastructure indicators:

1. Medical institutions (per 1000 inhabitants), 2022
2. Hospitals (per 1000 inhabitants), 2022
3. Sewerage network length (km per 1000 inhabitants), 2022
4. Gas distribution network length (km per 1000 inhabitants), 2022
5. Population connected to wastewater treatment systems (%), 2022
6. Volume of gas consumed (m³ per 1000 inhabitants), 2022
7. Number of educational institutions (per 1000 inhabitants), 2022

Agricultural indicators:

1. Agricultural employment (per 1000 inhabitants), 2022

2. Value of crop output (RON per 1000 inhabitants), 2022
3. Value of livestock production (RON per 1000 inhabitants), 2022
4. Cultivated land area for key crops (ha per 1000 inhabitants), 2022

Tourism indicators:

1. Tourist accommodation units (per 1000 inhabitants), 2022
2. Tourist arrivals (per 1000 inhabitants), 2022
3. Guest nights spent (per 1000 inhabitants), 2022
4. Net accommodation occupancy rate (%), 2022

By structuring the data in this way, we created a coherent framework to examine not only macro-regional trends but also the distinctive developmental trajectories of counties such as Harghita. The streamlined indicator set not only enhanced the statistical robustness of the factor model but also provided an integrated view of the multiple dimensions influencing regional performance. Utilizing the standardized indicators described earlier, we performed a factor analysis that yielded an optimal solution comprising six distinct factors. Together, these components account for 79,073% of the total variance in the dataset, as shown in Table 1. This level of explained variance is considered sufficient for analytical purposes. As noted by Székelyi and Barna (2002), a cumulative variance explanation above 33% is generally regarded as an acceptable threshold for factor-based models.

Table 1. The information content of the factors obtained during the analysis

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings*		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1.	13,97	37,76	37,76	13,97	37,76	37,76	6,42	17,37	17,37
2.	6,03	16,31	54,08	6,03	16,31	54,08	6,33	17,11	34,48
3.	3,18	8,61	62,69	3,18	8,61	62,69	4,52	12,23	46,72
4.	2,34	6,34	69,03	2,34	6,34	69,03	4,06	10,99	57,72
5.	2,08	5,62	74,66	2,08	5,62	74,66	3,98	10,76	68,48
6.	1,63	4,40	79,07	1,63	4,40	79,07	3,91	10,58	79,07

Source: Own research and representation.

Note (): with Varimax rotation.*

To determine whether the dataset was suitable for conducting factor analysis, two key diagnostic tools were utilized: the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity. The KMO index, which evaluates the proportion of shared variance among variables, yielded a value of 0,700. This suggests that, although the degree of partial correlations among variables is moderate, it falls within the acceptable range for factor analysis. According to Dodge (2008), values above 0,5 are considered the minimum threshold for suitability, with 1,0 indicating ideal conditions. Therefore, the result of 0,700 confirms that the sample data are sufficiently interrelated for the extraction of latent factors. In addition, Bartlett's test of sphericity further validated the use of factor analysis. The test produced a chi-square statistic of 1839,511 with 666 degrees of freedom and a significance level well below 0,001. This highly significant result indicates that the correlation matrix differs significantly from an identity matrix, which implies that the variables are not independent of one another. In other words, the presence of meaningful correlations among the variables confirms the appropriateness of applying factor analysis to this dataset. Drawing on the interpretations of Sajtos and Mitev (2007),

these results collectively affirm the methodological soundness of the analysis. The moderate KMO score reflects an acceptable structure of inter-variable relationships, while the significance of Bartlett's test strongly supports the existence of latent factors within the data. Together, these indicators validate the adequacy of the data for factor extraction. Moreover, the explanatory capacity of the retained factors – how well the original variables are represented in the new factor structure – can be assessed through the communalities (h_j^2). As per Székelyi and Barna (2002), variables with communalities of at least 0,25 are considered sufficiently well represented. In this study, the six extracted factors together account for approximately 79,1% of the total variance in the dataset, a value that reflects a high level of information retention and indicates the robustness and interpretability of the model.

Factor Analysis Results

Although the distribution of explained variance across the extracted components varied (Székelyi – Barna 2002), a deeper examination of each factor provides essential insight into the spatial dynamics of socio-economic disparities. The naming of the factors was based on the dominant variables contributing to each, with factor loadings serving as the primary guide for interpretation. These loadings reveal the intensity and direction of the relationship between each variable and the corresponding latent construct, offering a meaningful way to understand regional patterns and differentiation.

Factor 1 – Socioeconomic performance

The first factor identified through rotated factor analysis captures the broad concept of socioeconomic performance and has therefore been labeled accordingly. It has an eigenvalue of 6,42 and accounts for 17,37% of the total variance in the dataset. Counties with higher positive scores on this factor are characterized by strong socioeconomic conditions, whereas those with negative scores tend to demonstrate weaker economic and social structures. This factor integrates a variety of indicators that together provide a comprehensive picture of a region's socioeconomic status. These include wage levels, research and development (R&D) employment, healthcare infrastructure, gross domestic product (GDP), and overall infrastructural development. The combination of these variables reflects not only economic strength but also the quality of life and institutional capacities present in the counties. Counties such as Cluj (2,50), Sibiu (2,16), Timiș (2,27), Dolj (2,03), and Iași (1,39) display high positive factor scores, indicating advanced socioeconomic environments. These areas benefit from competitive income levels, vibrant innovation sectors, extensive healthcare services, and developed infrastructure that support sustained growth and social well-being.

In contrast, Harghita County (-1,02) is distinctly marked by a negative factor score, positioning it among the counties with relatively lower socioeconomic performance. The indicators reveal that Harghita faces challenges including below-average GDP, limited R&D activities, and less developed healthcare and infrastructural systems when compared to the national mean. These factors suggest structural limitations that hinder its capacity for economic expansion and social progress. Harghita's position on this factor highlights the critical need for focused development strategies aimed at improving its socioeconomic standing. Enhancing innovation potential, upgrading healthcare infrastructure, and fostering economic diversification are essential measures to help close the gap between Harghita and the more prosperous Romanian counties. Addressing these issues is key to supporting balanced regional development and promoting long-term resilience.

Factor 2 – Employment structure and industrial activity

The second factor extracted through the rotated component matrix reflects regional disparities in employment conditions and industrial dynamics. Accounting for 17,11% of the total variance and characterized by an eigenvalue of 6,33, this factor encompasses indicators such as employment rates, the extent of industrial presence, the density of private enterprises, and the availability of educational infrastructure that supports labor market participation. High positive scores on this factor are associated with territories demonstrating vibrant economic activity, relatively low unemployment,

and a strong institutional framework. Such conditions are evident in counties like Alba (1,85), Sălaj (1,80), Sibiu (1,71), and Arad (1,67), where industrial performance and workforce integration are notably strong. On the opposite end of the spectrum, counties such as Constanța (-1,37) and Dolj (-1,52) exhibit low factor scores, suggesting structural weaknesses in employment and production capacity. These are typically areas marked by labor market stagnation, limited industrial activity, and insufficient institutional support.

Harghita County distinguishes itself with a factor score of 1,32, placing it among the highest-performing counties in terms of employment structure. Despite its economic underperformance in other dimensions, Harghita's labor market indicators signal a well-functioning employment ecosystem. The county benefits from a visible industrial presence and a relatively dense network of educational institutions and social support mechanisms – factors that promote active labor force participation. These structural advantages contribute to the county's resilience and reveal important opportunities for targeted regional development policies. Taken together, this factor reveals significant territorial differences in Romania's employment landscape. It underscores the role of industrial and educational infrastructure in shaping local labor market performance and highlights counties – particularly Harghita – that exhibit notable potential for further economic consolidation through employment-led strategies.

Factor 3 – Rural-urban balance

The third extracted factor captures the nuanced dynamics between rural and urban characteristics across Romanian counties, and has therefore been labeled as "Rural-Urban Balance." This dimension is primarily defined by variables that reflect the intensity of agricultural activity, population density, access to public utilities, and the share of pension income. With an eigenvalue of 4,52, this factor accounts for 12,23% of the total variance in the dataset. Positive factor scores are associated with counties exhibiting stronger urban profiles – marked by higher pension incomes, greater population density, and broader access to natural gas networks – indicating better-developed service and industrial sectors. Counties such as Hunedoara (1,46), Gorj (1,34), Dâmbovița (1,33), Bacău (1,16), and Galați (0,97) fall into this category, illustrating a socio-economic structure that is less reliant on agriculture and more diversified in terms of economic activity. In contrast, counties with strongly negative factor scores, such as Ialomița (-2,30) and Călărași (-2,03), are predominantly rural. These regions are characterized by lower levels of infrastructural development and a high dependence on agriculture, both in terms of employment and economic output.

Within this context, Harghita County occupies an intermediate position, with a factor score of approximately -0,02. This near-neutral value reflects a county where rural characteristics still dominate, but not to an extreme degree. Agricultural activity remains a fundamental economic pillar, yet it coexists with a modest but emerging presence of non-agricultural sectors. The level of infrastructure development and public services suggests a balanced, albeit still rural-oriented, economic landscape. The county's moderate integration into more urbanized systems signals a gradual transition in its territorial and socio-economic profile. While Harghita does not align with the most urbanized counties, its relative stability and the coexistence of traditional and modern sectors may provide a platform for sustainable rural development and policy-driven diversification.

Factor 4 – Demographic vitality

The fourth identified factor encapsulates the demographic vitality of Romanian counties, reflecting the interplay between population growth, housing development, and tourism dynamics. With an eigenvalue of 4,06, this factor accounts for approximately 11% of the total variance, highlighting its relevance in capturing territorial differences in population-related processes. Counties with high positive factor scores exhibit characteristics of demographic dynamism – marked by expanding housing stock, positive natural population change, and an active tourism sector. These features not only influence the demographic structure but also stimulate related sectors of the economy. Ilfov (3,22), Suceava (1,83), Iași (1,63), Bistrița-Năsăud (1,16), and Timiș (1,03) are prominent examples of such territories, where favorable demographic trends align with broader socio-economic growth.

On the opposite end of the spectrum, counties such as Hunedoara (-2,72) and Teleorman (-1,40) register markedly negative scores, which indicate declining populations, stagnating or shrinking housing development, and limited tourism activity – factors that may exacerbate economic vulnerability and constrain future development prospects.

Within this framework, Harghita County presents a moderately positive factor score (0,30), suggesting a relatively favorable demographic outlook compared to many other regions. The data point to a stable or slightly growing population base, supported by moderate levels of residential construction and localized tourism activity. Although Harghita may not experience the rapid growth observed in counties like Ilfov or Suceava, its demographic conditions are conducive to long-term social and economic resilience. The county's youthful population profile and ongoing investment in housing and tourism infrastructure reflect an environment where moderate but steady development is possible – one that can form the basis for sustainable regional growth if complemented by coherent policy initiatives.

Factor 5 – Dynamics of youth and secondary education participation

The fifth extracted factor centers around demographic and educational patterns tied to the youth population and secondary education participation across Romanian counties. With an eigenvalue of 3,98, this factor accounts for 10,76% of the total variance, reflecting notable inter-county differences in the structure of school-age cohorts and associated social support mechanisms. This dimension is shaped by variables such as the proportion of students enrolled in primary and secondary education, the demographic weight of younger age groups, and the prevalence of family support benefits that are typically linked to child-rearing and educational needs. Higher positive factor scores characterize counties with a stronger presence of school-aged populations, more robust participation in lower levels of education, and a corresponding increase in the need for social transfers related to children and education. Counties such as Suceava (2,27), Iași (1,53), Vaslui (1,70), Botoșani, and Sălaj (1,08) exemplify these traits, displaying sustained educational engagement and significant shares of the population with primary or secondary education qualifications. At the other end of the spectrum, counties like Ilfov (-3,54) and Hunedoara (-1,08) record substantially negative scores, reflecting demographic profiles with fewer school-age children, likely higher shares of residents with tertiary education, and a diminished reliance on family-oriented social assistance.

Harghita County registers a distinctly positive factor score (0,91), underscoring its relatively youthful demographic structure and active engagement in primary and secondary education. The data suggest that Harghita sustains a higher-than-average share of students in the school system and benefits from state support instruments aimed at families with children. These dynamics indicate not only a demographic environment conducive to long-term educational investment but also a socio-economic landscape in which family policy plays a vital role. The elevated score further implies that the region maintains a broad base of lower and medium-level educational attainment, which, while signaling potential for continued education system engagement, also points to the need for strategies that foster higher education access and long-term skill development.

Factor 6 – Tourism-driven economic engagement

The sixth latent dimension identified in the factor analysis is closely aligned with the intensity and structure of tourism-related activity at the county level. Explaining 10,59% of the total variance and with an eigenvalue of 3,91, this factor captures disparities in tourism infrastructure and visitor flow, along with associated social welfare characteristics. The factor is defined by indicators such as the volume of overnight stays, the number of incoming tourists, and the density of tourist accommodation facilities. A key inverse relationship is also observed with the proportion of the population dependent on social assistance, suggesting that counties with a well-functioning tourism economy tend to exhibit stronger economic resilience and reduced reliance on state support. Counties such as Constanța (3,74), Brașov (2,33), Bihor (1,21), Tulcea (1,18), and Covasna (1,14) register the highest positive scores, reflecting dynamic tourism sectors characterized by significant visitor numbers and robust accommodation infrastructure. These regions benefit from tourism not merely as a source of revenue

but as a cornerstone of broader economic vitality. In contrast, counties like Teleorman (-1,40) and Sălaj (-1,27), which display highly negative scores, suffer from underdeveloped tourism sectors and heightened social vulnerability, pointing to structural challenges in local economic activity.

Harghita County exhibits a moderately high positive factor score (0,50), underscoring the region's growing engagement with the tourism economy. The county's performance suggests a tourism infrastructure that surpasses the national average, with a healthy volume of visitors and accommodation options contributing positively to local economic output. At the same time, the relatively low proportion of individuals reliant on social assistance points to tourism's role as a stabilizing force in the region's labor market and household income levels. While Harghita may not yet rival the top-tier tourism destinations in Romania, the data indicate a strong upward trajectory and a sector that plays an increasingly strategic role in regional development.

Cluster Analysis Results

Following the factor analysis of Romania's NUTS 3 counties, a cluster analysis was undertaken to group counties exhibiting similar socio-economic characteristics based on the extracted factor scores. This methodological approach enables the identification of both common regional patterns and significant disparities, offering valuable insights for the formulation of more precise and regionally sensitive development policies. A particular emphasis was placed on situating Harghita County within this regional classification framework, given its distinctive socio-economic profile in the context of Central Transylvania. The positioning of Harghita is critical to understanding its current developmental status and to guiding policy measures tailored to its specific needs and potentials.

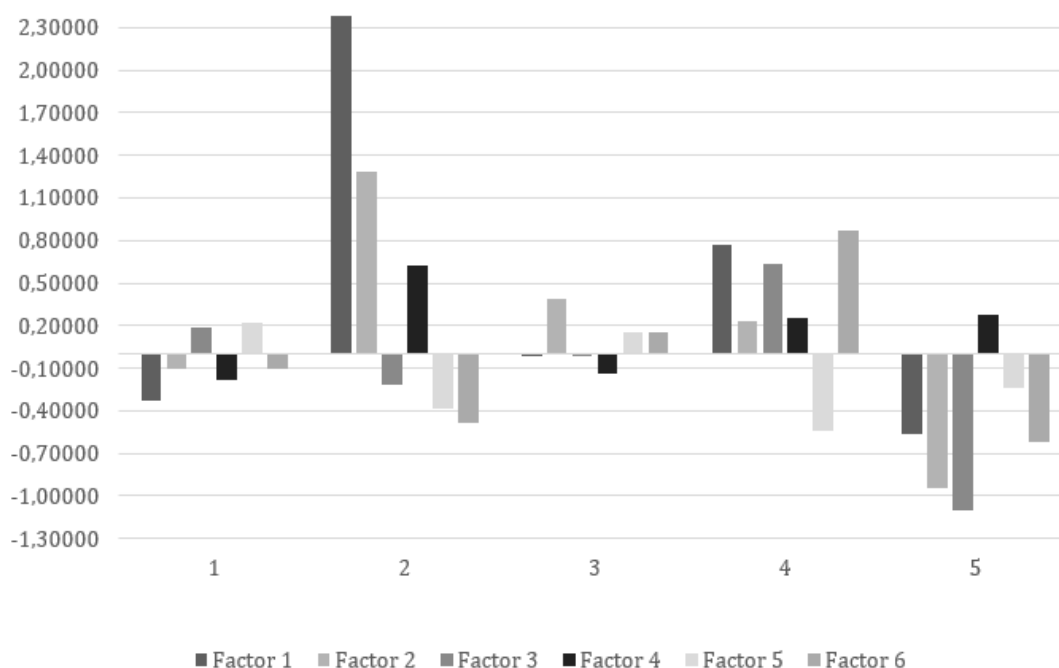
Among several clustering algorithms tested – including various hierarchical approaches and the k-means algorithm - Ward's method was selected due to its robustness and superior performance in minimizing within-cluster variance while producing clearly defined and stable clusters. The dendrogram analysis supported an optimal solution of five clusters, balancing cluster size, interpretability, and meaningful differentiation between groups. Harghita County was classified into the cluster characterized by moderate development needs. This cluster groups counties that occupy an intermediate socio-economic position, neither among the most advanced nor the most disadvantaged regions. Such positioning underscores Harghita's unique territorial identity, marked by both strengths and development challenges. This calls for nuanced, context-sensitive strategies to effectively harness the county's potential and address its specific obstacles.

Given the focus on Harghita County, the subsequent analysis will concentrate exclusively on the first cluster, offering a detailed examination of counties with moderate development needs, which most accurately reflect Harghita's current developmental dynamics.

The five clusters identified through this analysis, derived from the six principal factors, are summarized in Figure 1:

- Cluster 1 – Counties with moderate development needs
- Cluster 2 – Counties exhibiting strong economic performance
- Cluster 3 – Counties with mixed development profiles
- Cluster 4 – Counties with economies centered on tourism
- Cluster 5 – Rural counties confronting developmental constraints

Figure 1. Profile of the identified cluster structure based on mean factor scores



Source: Own research and representation.

The first cluster comprises the counties of Bihor, Bistrița-Năsăud, Maramureș, Satu Mare, Covasna, Harghita, Bacău, Neamț, Suceava, Brăila, Buzău, Galați, Vrancea, Dâmbovița, Dolj, Mehedinți, Olt, and Hunedoara. Since Harghita County is part of this cluster, the subsequent analysis will concentrate on its characteristics as representative of the cluster's overall profile. This focus allows for a detailed understanding of the challenges and opportunities faced by counties with similar socio-economic profiles. Counties in this cluster are characterized by moderate levels of economic development and social conditions that do not show extreme disparities but suggest a need for strategic development efforts. The average economic development score for the cluster is negative (approximately -0,33), indicating below-average economic performance relative to national standards. However, these average masks internal heterogeneity, as some counties, such as Dolj and Galați, demonstrate relatively more favorable economic outcomes, highlighting uneven regional growth within the cluster. Labor market conditions across these counties reflect a generally weak employment situation, with an average employment factor slightly below zero (-0,10) and a high variance among counties. This indicates substantial differences in labor market vitality, where some areas may struggle with higher unemployment or underemployment while others perform comparatively better. Harghita County aligns with the cluster trend, facing challenges in sustaining robust employment levels, which necessitates targeted economic interventions to improve job creation and workforce participation. Demographic trends within the cluster point to population aging and decline, as evidenced by a negative average score in population dynamics (-0,18). This demographic pressure compounds economic challenges by reducing the active labor force and increasing dependency ratios. Nevertheless, the secondary education dynamics factor shows a positive average (0,23), suggesting that younger cohorts remain engaged in educational activities at higher rates, and there is an increased uptake of family support programs. This may provide some long-term potential for human capital development, although the cluster's overall educational attainment is mixed. For instance, counties like Bihor and Dolj show stronger performance in higher education completion, while others lag behind. In this regard, Harghita County's educational indicators are reflective of the cluster's moderate profile, with efforts needed to enhance educational outcomes and better link them to regional economic needs. Tourism activity within this cluster is generally subdued, with a slightly negative average factor score (-0,11) and moderate variability. Tourism's limited role contributes to the social

vulnerability observed in many counties here, where economic diversification remains a critical goal. Harghita County stands out within the cluster for having notable tourism potential, owing to its natural and cultural assets, yet this sector remains underexploited relative to its capacity. Thus, bolstering tourism could serve as a key lever for regional development and social stability in Harghita.

In summary, the counties grouped in Cluster 1 share a profile marked by moderate economic development, demographic challenges, and mixed educational attainment, alongside an underdeveloped tourism sector. Harghita County, as a member of this cluster, encapsulates these trends and highlights the necessity for integrated regional policies. These should aim at strengthening the economic base, enhancing workforce participation, addressing demographic decline, improving educational outcomes, and unlocking the latent potential of tourism. The focus on this cluster is justified given Harghita's inclusion, providing insights relevant for formulating balanced, place-based development strategies tailored to counties facing comparable socio-economic realities.

4. Conclusion

The present study has demonstrated that regional disparities within Romania's NUTS3-level counties are deeply rooted in a complex interplay of economic, social, demographic, and infrastructural dimensions. These disparities are neither uniform nor random, but are structurally embedded in the historical trajectories, sectoral compositions, and policy environments of individual counties. Using a multivariate analytical framework, our research employed both factor and cluster analysis to distill the most salient patterns of territorial inequality and to identify groupings of counties with shared developmental characteristics. Factor analysis uncovered several underlying dimensions that structure the socio-economic landscape of Romania. These include, most notably, levels of economic performance (as proxied by GDP per capita, wage levels, and innovation metrics), labor market vitality, social wellbeing, educational participation, and tourism capacity. Counties such as Cluj and Sibiu emerged as advanced economic poles, while others occupy more peripheral positions, characterized by lower economic dynamism and reduced diversification. However, such a classification masks important internal variation.

Harghita County stands out as a distinctive case. Despite its modest overall economic indicators, it shows signs of relative balance in several areas. Employment rates are above average in regional comparison, and indicators related to secondary education suggest a favorable demographic structure, with relatively high youth participation and educational engagement. Furthermore, Harghita's robust tourism sector – rooted in its natural and cultural endowments – presents a tangible opportunity for sustainable development, even in the absence of major industrial capacity. Nevertheless, the county continues to grapple with structural limitations, especially those linked to its reliance on agriculture and limited infrastructural integration, which hamper its capacity to attract investment and retain a skilled workforce. Cluster analysis further refined our understanding of Romania's territorial heterogeneity, revealing five major county clusters with distinct socio-economic configurations. Harghita belongs to a cluster typified by moderate development needs and relative internal balance. While lagging behind the national leaders in terms of economic indicators, it exhibits strengths in demographic renewal and tourism, pointing toward latent development potential if appropriately leveraged.

These findings underline the inadequacy of universal policy prescriptions for addressing Romania's territorial disparities. The diversity in development pathways and structural conditions demands a place-based policy logic, where strategies are specifically tailored to the local realities of each county or development cluster. In the case of Harghita County, targeted interventions aimed at enhancing economic diversification, improving connectivity, and further developing human capital – particularly among the younger population – are essential. Simultaneously, tourism could serve as a strategic pillar for balanced territorial growth, provided it is embedded in broader, sustainability-oriented frameworks.

Ultimately, narrowing inter-county inequalities in Romania requires a differentiated, region-sensitive development paradigm. Future research will focus on the formulation of such locally attuned

development models, with Harghita County serving as a primary case study for evaluating how territorially adaptive policies can catalyze inclusive and resilient growth.

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Author's address

Varga Orsolya PhD student, Hungarian University of Agriculture and Life Sciences, Doctoral School of Economics and Regional Sciences, Gödöllő, Hungary, MATE 2100 Gödöllő, Páter Károly str. 1. Hungary, vvorsika@gmail.com

Dr. habil Ritter Krisztián PhD, Hungarian University of Agriculture and Life Sciences, Institute of Rural Development and Sustainable Economy, Department of Rural- and Regional Development, Gödöllő, Hungary, MATE 2100 Gödöllő, Páter Károly str. 1. Hungary, Ritter.Krisztian@uni-mate.hu

COMPARATIVE ANALYSIS AND FUTURE REFORM PROPOSALS FOR THE HUNGARIAN AND ROMANIAN LOCAL GOVERNMENT AND ADMINISTRATIVE SYSTEMS

MAROSI GYÖRGY CSONGOR

Abstract

This study provides a comparative assessment of the Hungarian and Romanian local government systems, focusing on structural features, decentralization trajectories, and reform initiatives. It aims to propose contextually relevant recommendations to improve efficiency, responsiveness, and autonomy through fiscal decentralization, regionalization, capacity building, and citizen engagement.

Keywords: local government, decentralization, Hungary, Romania, public administration

1. INTRODUCTION

After the political transition of 1989, both Hungary and Romania underwent sweeping administrative reforms centred on reorganising local government. Establishing elected local authorities was a cornerstone of democratization, in line with the principles of the Council of Europe (Council of Europe 1985)'s European Charter of Local Self-Government, which requires guaranteeing the political, administrative, and financial autonomy of local bodies. The present analysis aims to provide a doctoral-level comparative examination of the historical development, institutional structure, and reform opportunities of the Hungarian and Romanian local government systems. In doing so, we trace how the two countries' contemporary local governance structures took shape in the post-communist period, identify their institutional characteristics, and assess the challenges they face along with proposed reforms intended to improve efficiency and strengthen local autonomy.

Our scholarly comparative approach draws on legal and institutional frameworks, academic literature, and case studies to ensure both theoretical depth and practical relevance. The significance of this topic is underscored by the fact that effective and inclusive local governance is indispensable for the delivery of quality public services and for enabling democratic participation at the community level. (BALOGH Zoltán – NAGY István 2020). By comparing the two countries' local government systems, we highlight both similarities and differences, shedding light on how historical and social context influences the outcomes of decentralization. This approach also allows us to identify broader patterns, offering general insights for public administration reforms across the post-socialist region.

2. MATERIAL AND METHODS

The research methodology is defined by a comparative analysis. Through this approach, the local government systems of Hungary and Romania are examined side by side across multiple dimensions: these include the governance structure and division of functions, political and administrative processes, fiscal autonomy, and mechanisms for local participation. The analysis is grounded in an examination of the legal and institutional frameworks of both countries, supplemented by case studies and a comprehensive literature review, ensuring that the assessment is well-founded and multifaceted. This comparative approach makes it possible to identify similarities and differences, as well as to uncover causal linkages between different institutional choices and their outcomes. We endeavor to

integrate qualitative methods (e.g. institutional analysis, case studies) with quantitative insights (e.g. key statistical indicators) to provide a nuanced understanding. The methodology also encompasses an examination of historical processes to contextualize the present arrangements. Overall, the research design ensures that our conclusions are well-grounded and reflect both theoretical frameworks and practical experiences.

3. RESULTS AND DISCUSSION

3.1. HISTORICAL BACKGROUND

In Hungary, the modern foundations of local self-government were laid by the Local Government Act of 1990, which dismantled the communist council system and established autonomous municipal and county authorities. The previously centrally managed local councils were replaced by directly elected bodies and mayors, and the role of the 19 counties was dramatically scaled back. In the first years after the regime change, more than 3,000 local governments were formed as many settlements regained independence - this proliferation of municipalities led to significant fragmentation from the outset. Throughout the 1990s, Hungary's decentralization reforms aimed to strengthen local autonomy, but the extreme local fragmentation and limited resources became apparent early on. By the 2000s the local government system had stabilized, yet new challenges emerged, especially in terms of financial sustainability.

In Romania, the first major step after 1989 was the adoption of the 1991 Constitution, which enshrined the principles of decentralization and local autonomy in public administration. Reforms in the early 1990s introduced a system of local taxation (between 1991 and 1994) and established the legal framework for local government operations. In the period 1998-2000, administrative and fiscal decentralization accelerated: the share of resources managed at the local level increased, and the central government gradually devolved more responsibilities to lower tiers.

In the 2000s, a new wave of reform followed: for example, a comprehensive decentralization framework law was passed in 2006, reinforcing the principles of subsidiarity and local autonomy. In 2010, another important step was the transfer of responsibility for managing public hospitals to local governments, which significantly increased subnational spending in the health sector. Nevertheless, Romania's decentralization process remained gradual and partial: analysts point out that many powers and financial resources have yet to be fully transferred, and state supervision through the prefect system has remained strong.

In Hungary, a turning point came after 2010. Following a new Fundamental Law and the Local Government Act of 2011, a number of functions and institutions were taken back under central control, partially reversing earlier decentralization. In 2013, the government introduced district offices (*járások*) which took over many administrative tasks from municipalities and reinforced central legal oversight. The historical evolution of the two local government systems thus took different paths: whereas Hungary saw an initially strong decentralization followed by a later recentralizing correction, Romania underwent a slower, incremental decentralization with robust central oversight throughout.

3.2. Structural Framework

Hungary is a unitary state with a two-tier system of local government: a municipal (local) level and a county level. There are currently 19 county self-governments, and the capital city Budapest has a special status with 23 districts. The local (municipal) level comprises approximately 3,150 local governments: about 2,800 villages (communes), over 300 towns, including 23 cities with county rights (large urban municipalities). There is no hierarchical authority between the two levels of local government: counties are mainly responsible for territorial functions that smaller municipalities cannot perform on their own, while municipalities possess extensive powers over local matters.

It is noteworthy that after 2010, the role of the county level in Hungary became more limited due to recentralization reforms. Many functions - for instance, secondary education and numerous administrative services - were transferred from county and municipal authorities to the state's newly created district offices, leaving county governments with reduced competencies. Hungary also does not have an elected regional level: although there are statistical planning regions (for example, seven NUTS-2 regions for EU development purposes), these entities have no autonomous government or elected councils.

Romania's administrative system is also formally two-tier (local and county), but it is often described as "three-tier" in reference to the distinct categories of local units. At the local level, a distinction is made between communes (rural municipalities) and cities (urban municipalities). Among the cities, 103 have the status of municipalities (*municipii*, typically larger cities) and 217 are other towns, alongside 2,861 communes in the rural areas. However, all of these are fundamentally first-tier local government units with legally equal status and powers - the municipality designation confers prestige but no additional authority. The second tier consists of 41 county councils (*județe*), and the Municipality of Bucharest, which has a special status and is subdivided into six sectors - effectively boroughs with their own elected mayors and councils.

A defining feature of the Romanian system is the strong supervisory role of the central government. In each county, the central government appoints a prefect as its representative, who oversees the legality of local government decisions and coordinates the deconcentrated state services. County councils in Romania primarily have a coordinating role (e.g. synchronizing the activities of communes and cities) and their legislative and financial autonomy is more limited than that of their Hungarian counterparts. Overall, Romania's local government structure is more centralized: local authorities rely heavily on state funding and approval, reinforced by the prefects' oversight and relatively limited local revenue-raising powers. Despite this centralization, Romania, like Hungary, has not established elected regional governments; although eight development regions were created in 1998 for EU funding purposes, they function only as planning zones without autonomous authority.

3.3. Functional Competencies

In Hungary, the responsibilities of local governments have traditionally been broad in the sphere of public services. They have included operating preschools and local schools, providing basic social welfare services (e.g. care for the elderly, child welfare), primary healthcare (such as family doctor services and clinics), maintaining local roads and public utilities (water supply, sewage), managing waste collection and public lighting, as well as running local cultural institutions and sports facilities. Municipal governments had the power to issue local decrees to regulate these matters. However, a significant shift occurred in the early 2010s: from 2013, the maintenance of primary and secondary schools was taken over by the central government, marking a major recentralization in the field of education. Similarly, most hospitals in Hungary were transferred from municipal or county control to state administration earlier in the decade, representing a reverse trend compared to Romania's approach.

In Romania, local government functions cover similar domains, although the allocation of responsibilities differs somewhat. Under Romanian law, the exclusive competences of commune and city authorities include the management of local road infrastructure, the operation of local cultural institutions, the provision of preschool and primary education (including school facility upkeep and, in part, payment of teachers' salaries), the operation of local public health units (such as community health centres), urban planning and zoning, water supply and sewerage services, waste management, local public transport, and social welfare and elderly care services. County governments, for their part, are responsible for services of county significance - for example, they oversee certain hospitals (county hospitals) and some cultural institutions of regional importance. In 2010, the Romanian government significantly decentralized healthcare by transferring the administration of most public hospitals to county and municipal authorities, after which local health expenditures increased dramatically. (WORLD BANK 2020). In the education sector, by contrast, Romania has retained a

decentralized model: local governments continue to manage schools, although the state exerts substantial influence through normative funding and national curriculum standards.

Overall, in both countries local governments are tasked with providing the basic services needed for citizens' daily life, but the degree of centralisation and the funding model differ. In today's Hungary, the scope of local authority is narrower (focusing mainly on preschools, basic social services, primary healthcare, and local infrastructure), whereas in Romania, local governments still play a major role in a wider range of services (for example, they remain heavily involved in managing schools and hospitals).

3.4. CHALLENGES

In Hungary, major challenges for local governments include financial difficulties and the sustainability of very small municipalities. Out of more than 3,100 municipalities, the vast majority serve very small communities - approximately three-quarters of local governments serve populations under 2,000. This highly fragmented structure leads to a lack of economies of scale and weak administrative capacity in many places. Small municipalities often struggle to provide adequate services and to retain skilled personnel, and they are heavily reliant on fiscal transfers from the central government. By the late 2000s, local financial problems had escalated: the municipal sector's debt had grown significantly, prompting the central government to step in between 2011 and 2014 and assume over HUF 600 billion (around \$2.8 billion) of local debt. In parallel, stricter central oversight was imposed on local finances - for example, since 2012 local governments in Hungary cannot take on new debt without central approval.

To address the viability of small villages, the government has mandated inter-municipal cooperation. Since 2013, villages below a certain population threshold have been required to form joint municipal offices to share administrative personnel. By 2021 there were 738 joint offices operating across Hungary, involving 82.6% of municipalities in some form of service- sharing arrangement.

In Romania, the challenges are characterised by a fragmented municipal landscape and limited local autonomy. The country has nearly 3,200 local governments, many of which are small, resource-poor rural communes. These very small units often face low efficiency and difficulties in delivering quality services, leading to discussions about the need for amalgamation or more robust inter-municipal cooperation. However, political and practical obstacles have so far impeded any major territorial consolidation, so fragmentation persists.

The constraints on local autonomy in Romania are evident in the fact that local authorities cannot make many significant decisions without central approval (VINCZE Enikő 2021). Government-appointed prefects review the legality of local council acts and can suspend them if they violate laws; key local tax rates and bases are set by central legislation; and the bulk of local revenues comes from central transfers and earmarked funds. Because of centralized decision-making and often unpredictable funding allocations, the room for independent local policymaking is limited: analysts note that the decentralization process remains unfinished, and local government capacity and discretion are still restricted in many areas. To cope with these challenges,

Romanian local governments also engage in inter-municipal associations and regional development partnerships, though the effectiveness of these collaborations varies.

4. REFORM PROPOSALS

Comprehensive reform proposals have been put forward to strengthen local governance in both countries, focusing on several key areas.

Regionalization: Creating new, larger administrative regions or strengthening the intermediate level of government to improve efficiency and economies of scale. This has been a prominent proposal especially in Romania (e.g. elevating its 8 development regions into official administrative units), but

so far it has faced constitutional and political hurdles. In Hungary, regionalization was also debated in the past, but the county system has remained predominant.

Fiscal Decentralization: Enhancing the financial autonomy of local governments by increasing their own-source revenues and establishing a fairer system of intergovernmental fiscal transfers. The goal is to provide a greater share of resources for local functions and reduce dependence on central funding. Measures could include introducing new local taxes or fees, raising the local share of shared taxes, and reforming grant allocation and equalization schemes.

Capacity Building: Developing the institutional and human capacity of local administrations (MATEI Ani 2017). This involves training programs for local officials and staff, sharing best practices, and further incentivizing small municipalities to cooperate or merge services (MATEI Ani 2017). The aim is to ensure that even the smallest local governments have the professional expertise and organizational strength to fulfill their tasks effectively.

Citizen Engagement: Increasing public participation in local decision-making and strengthening accountability (UNDP 2018). Tools for this include public hearings, participatory budgeting, local referendums, and online consultation platforms. Greater citizen involvement can bolster democratic legitimacy and community trust by giving residents a direct role in shaping local policies.

Digitalization: implementing e-government solutions and smart technologies in local administration to improve efficiency and service delivery. This includes moving administrative procedures online, using data-driven decision-making tools, and investing in digital infrastructure (such as broadband internet) at the local level.

4.1. REGIONALIZATION

Regionalization has been a prominent topic of debate in both Hungary and Romania. The core idea is to reform territorial administration by creating larger and stronger regions that can coordinate development policies and infrastructure more effectively. **Theoretical framework:** Proponents argue that larger administrative units can achieve better economies of scale and more coherent regional planning, potentially improving competitiveness and efficiency, especially in accessing and utilizing EU funds. Critics, however, caution that regionalization might introduce an additional layer of bureaucracy and could dilute local identities and accountability.

Practical context: In Hungary, discussions in the 2000s considered merging the 19 counties into a few large regions, but in the absence of political consensus this was not implemented (TÖRÖK Gábor 2019). Instead, Hungary uses NUTS-2 statistical regions for EU planning purposes, without elected regional governments. In Romania, regionalization remains on the agenda: in 2013 a concrete plan was proposed to transform the 8 development regions into formal administrative regions, but it was struck down by the Constitutional Court. The debate continues, as many believe the current 41 counties are too fragmented and that creating a regional tier is the next step in decentralization.

Implications and debates: Successfully implementing regionalization requires both structural and cultural change. Examples from other countries (such as Slovakia or Poland) show that establishing a regional tier can improve the management of territorial disparities, but only if the new regions are endowed with appropriate powers and resources. In both Hungary and Romania, a key question is whether citizens would identify with and support the new regional bodies - ensuring legitimacy and democratic accountability is crucial. In sum, regionalization is one of the most complex reform options, requiring long-term commitment from central governments, but it has the potential to significantly impact the efficiency of local governance and the countries' overall competitiveness.

4.2. FISCAL DECENTRALIZATION

Fiscal decentralization aims to strengthen the financial autonomy of local governments so they can sustainably fund their responsibilities. **Theoretical background:** According to fiscal federalism theory,

local governance works best when local authorities have adequate resources to meet local needs. Increasing local revenue sources and better aligning expenditure responsibilities with revenues can reduce dependence on the center and improve accountability. At the same time, one must consider regional inequalities: wealthier municipalities can raise much more revenue than poorer ones, so robust equalization mechanisms are necessary to ensure fairness.

Current challenges: In Hungary, a large share of municipal revenues is centrally determined (for instance, the business tax is virtually the only significant local tax), and during the 2010s the central government redirected portions of certain local revenues (e.g. vehicle taxes) to itself. Similarly, in Romania local governments rely heavily on central funds; their own taxes (such as property and vehicle taxes) contribute a relatively low percentage of GDP. This lack of fiscal independence limits local innovation and planning; when municipalities face uncertainty in funding, it is difficult for them to carry out long-term investments and development projects.

Reform options: Reforms to promote fiscal decentralisation can take several forms. One approach is to broaden the local tax base - for example, introducing new local taxes or fees, or giving municipalities more leeway to set tax rates. Another is to overhaul the system of central transfers: replacing ad-hoc or politically driven grants with more transparent, formula-based and performance-oriented funding that municipalities can count on. In addition, greater local fiscal autonomy must be accompanied by greater local financial discipline and oversight to avoid excessive debt accumulation - in this regard, Hungary's experience with debt consolidation provides a cautionary example (HOFFMAN István 2022). Overall, fiscal decentralization can empower local governments, but only if proper safeguards and equalization measures are in place to maintain balance in the system.

4.3. CAPACITY BUILDING

Capacity building refers to strengthening the institutional and human resources of local governments. Theoretical basis: Principles of good governance hold that the quality of local administration depends greatly on the skills of its personnel and the efficiency of its organization. When local governments have adequate administrative capacity, they can implement innovative solutions and respond to challenges more effectively; without it, decentralization may become merely nominal.

Current issues: In both Hungary and Romania, many small municipalities suffer from a limited staff and shortages of expertise. In numerous local governments there is no full-time chief architect, financial officer, or legal counsel, which hampers professional decision-making. Turnover is high and public sector salaries are often not competitive with the private sector, making it difficult to retain talented young professionals. Moreover, risks of political patronage and nepotism can undermine administrative efficiency. Another concern in both countries is that few local and county offices have dedicated units for strategic planning, and there are gaps in digital skills within the local bureaucracy.

Proposed solutions: A cornerstone of capacity building is continuous training and knowledge sharing. Training programs for mayors, city managers, and municipal staff are vital - potentially supplemented by international exchanges of best practices. Incentives are needed for small municipalities to form further partnerships or shared service arrangements (building on initiatives like joint municipal offices) to pool specialists and reduce administrative burdens. It is also important to introduce career programs to make local public service more attractive (e. Incorporating modern technology is another aspect of capacity development: e-learning courses, online knowledge hubs, and expanding digital administration tools can all contribute to greater efficiency. Investments in capacity building yield returns in the long run by improving governmental performance and the quality of public services at the local level.

4.4. CITIZEN ENGAGEMENT

Citizen engagement is crucial for enhancing the democratic legitimacy and transparency of local decision-making. Theoretical perspective: Participatory democracy theory suggests that involving

citizens leads to better-quality and more legitimate decisions, as local knowledge and preferences are directly reflected in policy. Arnstein's "ladder of participation" framework highlights that citizen involvement can range from mere consultation to genuine decision-making power - and the higher the level of participation, the more it empowers the community.

Current situation: In Hungary and Romania, legal provisions exist for certain participatory mechanisms (such as public hearings, petition rights, and the possibility of local referendums), but in practice public participation is often low. In addition to factors like distrust or apathy, a problem is the relative scarcity of structured participatory programmes. There are, however, promising examples: in Romania, the city of Cluj-Napoca was the first to implement a city-wide participatory budgeting initiative, successfully involving residents in allocating development funds. In Hungary, some larger cities - including several districts of Budapest and the capital city itself - have begun experimenting with participatory budgeting in recent years.

Directions for improvement: To boost citizen engagement, local governments need to take proactive steps. These include using online platforms (mobile apps, web forums) to gather resident input, holding regular town hall meetings on important issues, and partnering with civil society organizations. Increasing transparency is also vital: communicating local decisions and budgets in an accessible way builds trust and encourages citizens to take a more active role. Strengthening participation improves the effectiveness of policy decisions and aligns public services more closely with real needs, while also fostering local community cohesion and a sense of shared responsibility.

4.5. DIGITALIZATION

Digitalization is a main avenue for modernizing local governments by leveraging technology to improve efficiency and access to services. Theoretical framework: The concept of e-government posits that digital administration can reduce red tape, increase transparency, and speed up service delivery, thereby strengthening citizens' trust in public institutions. The smart city approach, similarly, involves using integrated IT solutions in urban management and decision support.

Current situation: Both Hungary and Romania have taken important steps in recent years towards administrative digitalisation, but they still lag behind European frontrunners. In Romania, challenges include insufficient internet coverage in some rural areas and gaps in the population's digital skills; the uptake of e-government services is among the lowest in the EU. In Hungary, the infrastructure for electronic administration (e.g. the "Ügyfélkapu" client gateway and "e-Papír" system) is in place, but the degree of adoption at the local government level varies. The COVID-19 pandemic accelerated digital transition: many councils moved meetings online and launched virtual customer services.

Reform suggestions: Further advancing digitalization requires investing in infrastructure (broadband internet, public Wi-Fi in communities) as well as improving the digital skills of officials and citizens. It is advisable to introduce uniform national standards and platforms so that municipal systems are interoperable. Solutions such as publishing open data can enable civic tech initiatives and innovation while increasing transparency. In addition, digital participation tools - for instance, mobile apps for reporting local problems or online voting on community issues - can bring local governments closer to the people. Successful digitalization is not only a technological matter but also one of mindset: it demands leadership commitment and change management. In the long run, digital transformation contributes to more efficient, citizen-friendly governance and can help bridge urban-rural divides, provided that access to internet connectivity and digital services is ensured for all communities.

4.6. COMPARATIVE EVALUATION

The comparative evaluation highlights both parallels and contrasts between the Hungarian and Romanian local government systems. Similarities: Both countries established their modern local government systems around 1990 during the post-socialist transition, making local self-government a cornerstone of democratization. In each case, elected local councils were given broad powers and

county-level authorities were instituted with more limited roles. Both Hungary and Romania face challenges of a highly fragmented municipal landscape and resource constraints: out of thousands of local governments, many are very small, leading to efficiency problems. Dependence on central funding and underdeveloped local revenues are common issues, as are gaps in training and administrative capacity. The two countries have also committed to similar international standards (e.g. adhering to the Council of Europe (Council of Europe 1985)'s Charter of Local Self-Government) and, as EU members, they operate under comparable expectations regarding decentralization and good governance (EU COM 2021).

Differences: At the same time, there are notable differences. In the 2010s, Hungary underwent a pronounced recentralization, with several functions (education, healthcare) taken back under state control, whereas Romania continued on a path of decentralization in certain areas (e.g. transferring hospitals, keeping schools under local management). Romania's system retains a stronger formal oversight by central government via prefects, whereas in Hungary a similar legal supervision was reinforced through government offices somewhat later. The degree of fragmentation also differs: municipalities are on average smaller in Hungary, so the effects of fragmentation may be more acute there. In terms of financing, Hungary relies heavily on a single major local tax (the business tax), while Romania has a mix of smaller local taxes - but in both cases local tax revenue is a relatively low share of GDP. There are political culture differences as well: in Hungary local politics is highly polarized along national party lines, while in Romania the influence of county "barons" and local patronage networks gives decentralization a distinctive character.

Summary: In evaluating their local governance, it is apparent that both countries still have work to do to achieve truly empowered and efficient local self-government. In Hungary, the increase in centralization has brought some stability (e.g. debt consolidation, more uniform service standards) but raises questions about the curtailment of local autonomy. In Romania, decentralization is more advanced in some respects, but financial and institutional constraints still narrow the practical autonomy of local authorities (WORLD BANK 2020). The similarities suggest that the legacy of the centralized state in the post-socialist region persists in both countries, while the differences show how political choices and reform pace can diverge. By learning from each other's experiences, each country can refine its local government reforms moving forward.

6. CONCLUSIONS

Concluding thoughts: in both Hungary and Romania, the success of local government reforms requires progress in several dimensions - structural, financial and cultural. Historical experience shows that mere institutional changes (e.g. reorganisation of administrative levels) alone will not bring the desired results unless they are accompanied by an appropriate reallocation of resources and a change of mindset. Local governments can only function effectively and contribute to the development of the country if they have a stable funding base, well-developed capacities and transparent participatory decision-making mechanisms.

The complexity of the reforms makes gradualism and broad social dialogue essential. Involving local actors in the reform process increases acceptance and ensures that changes take account of real needs. Furthermore, adapting good international practices (whether decentralisation models or digital tools) can accelerate progress. Ultimately, strengthening local governance in both countries will benefit democratic stability and the quality of life of citizens. This requires not only government commitment but also the support and active participation of local communities, which are at the heart of local governance, which gives them the power to shape their own affairs.

Concluding remarks: In both Hungary and Romania, the success of local government reforms requires progress on multiple fronts - structurally, financially, and culturally. Historical experience suggests that purely institutional changes (such as redrawing administrative tiers) will not yield the desired outcomes unless accompanied by proper reallocation of resources and a shift in governance culture.

Local governments can function effectively and contribute to national development only if they have a stable financial base, built-up capacity, and transparent, participatory decision-making processes. Given the complexity of these reforms, gradual implementation and broad social dialogue are essential. Involving local stakeholders in the reform process increases acceptance and ensures that changes reflect real needs on the ground. Moreover, adapting best international practices - whether in models of decentralization or in the use of digital tools - can accelerate progress. Ultimately, strengthening the local government system in both countries serves democratic stability and improves citizens' quality of life. Achieving this outcome requires not only commitment from central authorities but also the support and active involvement of local communities - after all, the essence of self-government is to empower communities to shape their own affairs.

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Institution: Ludovika University of Public Service Doctoral School in Public Administration
Country of origin: Hungary
E-mail: marosi.gyorgy.csongor@gmail.com

SUSTAINABILITY APPROACH OF LOCAL GOVERNMENT LEADERS IN HUNGARIAN UNIVERSITY CITIES

ANDRÁS NÁHLIK– ANDRÁS POLGÁR– LAURA BERTALAN

ABSTRACT

One of the key issues in contemporary science is the process of sustainability transition. The 17 Sustainable Development Goals (SDGs) set by the United Nations define the directions of this transition. Achieving these sustainability goals is equally crucial for cities. The changing environmental, social, and economic conditions affect them more intensively, requiring both well-developed strategies and operational decisions. Cities with universities may have an advantage, as the knowledge generated there can facilitate the transition. Therefore, it is crucial for city leaders to be knowledgeable and committed to this topic. To examine their commitment to sustainability, we are conducting structured in-depth interviews with the mayors of 9 Hungarian university cities. During these interviews, we have focused on the sustainability measures implemented by the cities so far, their future plans and strategies, and the measurement of sustainability performance. Another key question is how they envision the path to achieving their goals, what partnerships they establish, and what role higher education institutions play in their cities. The sampling and evaluation of the results took place between March and April 2025. Our findings may help understand the attitudes of city leaders and contribute to facilitating the sustainability transition of cities.

Key words: in-depth interviews, sustainable engagement, mayoral behaviour, partnerships, sustainability rankings

1. INTRODUCTION

Sustainability is among the most pressing challenges of the 21st century, representing a paradigm that permeates all spheres of life. Its environmental, social, and economic dimensions are equally significant for both contemporary and future well-being. As such, it constitutes a global issue with numerous critical local and regional implications. This has also been acknowledged by political decision-makers. In recent years, the pivotal role of cities in achieving global sustainable development has become increasingly evident.

The European Union has articulated its aspirations and recommendations concerning the development of sustainable cities, most notably in the Leipzig Charter on Sustainable European Cities (2007). This document outlines key recommendations, including: the enhanced utilization of urban development policy, the creation and activation of high-quality public spaces, the promotion of infrastructural development, the enhancement of energy efficiency, the implementation of proactive policy approaches, and the strengthening of labor markets.

In order to systematize and clarify their objectives, cities have increasingly adopted strategic planning tools—such as Integrated Urban Development Strategies, Sustainable Urban Development Strategies, and climate-neutrality strategies—which also serve as prerequisites for accessing European Union funding. These documents assess the prevailing conditions at the time of their formulation, define

and structure development goals, and establish detailed action plans. They also identify key stakeholders and partners required for the implementation of these objectives. The emphasis on partnership-based implementation aligns closely with the core messages of the United Nations' 17 Sustainable Development Goals (SDGs).

However, the successful realization of sustainability objectives in urban contexts requires more than strategic recommendations and well-formulated plans. It is essential that cities are led by competent, action-oriented leaders—mayors and municipal decision-makers—who are capable of adopting both strategic and operational approaches to urban development. For this reason, it is crucial to examine city leaders' attitudes, their prior sustainability efforts, the quality of partnerships formed, and their long-term visions.

Our research aims to explore these dimensions through primary qualitative research methods. Specifically, we employ structured in-depth interviews, which enable mayors, deputy mayors, and key decision-makers to articulate their perspectives. The anticipated outcomes are expected to provide a comprehensive understanding of how urban leaders relate to sustainability and how they envision its implementation in their respective cities.

2. THEORETICAL BACKGROUND

Efforts toward sustainability have increasingly come to the forefront over the past decades. The United Nations' landmark 1987 report, *Our Common Future*, brought significant attention to the sustainability of urban environments. According to the report, one of the most pressing challenges facing cities is population growth, which necessitates extensive infrastructure development. It is essential to provide urban populations with adequate infrastructure and services to ensure a decent standard of living, which in turn requires a strategic and holistic approach.

Numerous policies, initiatives, and shared objectives have since emerged. Among the most significant is the Local Agenda 21 (LA21), adopted in 1992, which emphasized the responsibility of cities in ensuring economic, social, and environmental sustainability. In 2007, ministers responsible for urban affairs in the European Union convened in Leipzig and formulated key principles and recommendations regarding the sustainability transition of cities. This document became known as the Leipzig Charter. Key recommendations included: precise assessment of local contexts, identifying strengths and weaknesses; defining development goals and long-term visions; creating integrated sectoral and technical plans for urban districts to promote development. Ensuring coordinated use of public and private funding; and harmonizing policy actions across all levels of governance while taking into account all pillars of sustainability.

Cities have also emerged as key actors in the European Green Deal. Urban climate neutrality objectives have gained increasing prominence in development policies, and cities themselves have become more aware of the importance of sustainability across all three dimensions. Multiple funding sources are available to EU member states to support cities in achieving their sustainability goals through partnership-based implementation. New interdisciplinary approaches such as smart cities, resilient cities, adaptive cities, liveable cities, and inclusive cities have been introduced. These frameworks help cities navigate toward sustainability and respond to various economic, environmental, and social challenges (Szabó 2015; Pirisi 2017; Hegedüs 2020).

To evaluate progress, a variety of indicator systems and rankings—such as smart city indexes and liveability rankings—have been developed. These tools quantify development outcomes and highlight existing gaps. In addition, the United Nations Sustainable Development Goals (SDGs)

provide a widely accepted framework, with Goal 11 specifically focusing on sustainable cities and communities. Key challenges under this goal include affordable housing, sustainable transportation systems, provision of green spaces, rational resource management, and reduction of urban emissions. The need to address social issues under the umbrella of urban sustainability is also becoming increasingly prominent.

In Hungary, urban-level sustainability has likewise gained significant attention (Simon, 2024b). Achieving sustainability efforts necessitates the development of strategic plans. To this end, both the Hungarian State (e.g., *Methodological Handbook for Sustainable Urban Development Strategies*, 2021–2027) and the European Union (Fioretti et al., 2020) have published guidelines. Cities are required to develop Sustainable Urban Strategies (SUS) to ensure that their goals are transparent and accessible to residents and other stakeholders. Several domestic studies have analyzed the emergence, methodology, and objectives of these strategies (Buskó 2024; Simon 2024a).

Compared to previous urban strategies (e.g., Integrated Urban Development Strategies), SUSs represent a novel approach in requiring the coordinated cooperation of existing stakeholders and professional sectors. This integrated approach allows for the activation of urban linkages and untapped potentials (Simon 2024b). The European Commission's guidelines (Fioretti et al., 2020) place particular emphasis on partnership, encouraging strong and broad-based local collaboration between citizens, civil society, industry, and municipal governments to realize shared sustainability objectives.

Universities can serve as key partners for cities in achieving these goals. In addition to their research capacities, aligning academic and urban goals enables coordinated efforts (Gál, 2005; Rechnitzer, 2009; Lengyel, 2021; Caughman et.al,2023). Cooperation is also essential in activating urban communities and implementing social innovations, which can enhance the liveability of urban spaces for a broad spectrum of society. There is a growing need for a new model of urban governance, one that gives greater agency to local residents and communities, fostering meaningful and participatory collaboration (Veresné S.M. & Sikos T.T. 2023).

3. METHODOLOGY

This article presents primary research conducted among municipal leaders and decision-makers in cities with populations ranging from 15,000 to 170,000. The aim was to explore the attitudes of urban leaders and the outcomes achieved so far, identify gaps and development potentials, and assess possibilities for cooperation—with particular attention to university partnerships.

The research employed opinion-based open-ended questions, as this format allows respondents to elaborate on their perceptions and contributions. The questionnaire was structured into six thematic groups: "Basic Concepts", "Challenges and Measures", "Development Directions", "Partnerships", "Civic Commitment to Sustainability", and "Measuring Sustainability." This structure was intended to capture both the current state and future development directions.

A key component of the research was the exploration of sustainability partnerships, based on the premise that urban societies and economies are complex. Therefore, sustainability effort can only be achieved through collaboration with relevant stakeholders. The partnership section placed special emphasis on higher education institutions, as the knowledge and research accumulated there can significantly support the sustainability transition of cities.

We also sought to investigate whether municipalities monitor the achievement of sustainability goals and whether they receive internal or external feedback on their progress.

The in-depth interviews were conducted in March and April 2025, both in-person and online. Participants included mayors, deputy mayors, chief cabinet officers, and regional development officers from nine university towns, as well as one city councillor who was interviewed jointly with the mayor of their municipality. Four respondents were from Western Transdanubia, two from Northern Hungary, one from Southern Transdanubia, one from the Southern Great Plain, and one from Transylvania, representing a Hungarian-led city.

All interviews were audio recorded, except for one case in which the interviewee preferred to respond in writing. The audio recordings were transcribed using transcription software. Notes were drafted based on the responses, and the information was entered into a matrix format, where columns represented interviewees and rows represented questions. This tabular structure allowed for the identification of recurring responses and emerging patterns, thereby enabling deeper insights into common themes and perspectives.

4. FINDINGS

Our first question aimed to explore how interviewees define urban sustainability. Although responses varied, a common theme emerged: most participants primarily associated the concept with environmental factors and acknowledged the necessity of proactive actions to ensure the social well-being of both present and future generations. Climate change was frequently cited as a major urban challenge, with several interviewees highlighting the urban heat island effect as a particularly pressing issue. The severity of this phenomenon was said to depend largely on a city's geographical location, the quality of building stock, and the urban layout.

In addition to climate change, cities are facing numerous other environmental sustainability challenges, such as energy management, water governance, waste management, light and noise pollution, and transportation. Interviewees emphasized the need for nature-based solutions to address these issues in ways that also contribute to the broader well-being of society.

One respondent emphasized that such complex challenges require a comprehensive approach, which must be embedded within formal strategic frameworks. Only a few respondents addressed social dimensions of sustainability: one mentioned outmigration and the aging population as major concerns. In terms of economic sustainability, the issue of maintaining liquidity emerged as a key challenge, particularly in the face of chronic underfunding.

Our second question focused on the concept of urban resilience. This was intended to assess the diversity of interpretations among respondents. Most defined the concept as a city's adaptive capacity—its ability to maintain well-being despite changes in the environmental, social, or economic context. Several interviewees referred to heatwaves as a growing threat to urban systems, stressing the importance of responsive actions to ensure the continuity of city functions.

Resilience was also discussed from an economic perspective, particularly regarding the need for municipalities to maintain financial liquidity and diversify their economic portfolios. However, efforts toward urban resilience are increasingly hindered by the frequency and duration of crisis management periods, such as the COVID-19 pandemic, inflationary pressures, and geopolitical conflicts.

We also asked interviewees to identify what they perceived as the most significant sustainability challenges in their cities. Responses reflected the difficulties of managing new and emerging problems under prolonged crisis conditions. Two recurring themes stood out: the energy sector was identified as a critical issue by all respondents, though each city approached it from a different perspective. Outdated heating technologies during the winter months were said to contribute significantly to air pollution and smog formation.

The second major issue cited was urban expansion and the spatial planning of cities. Respondents raised concerns about urban sprawl, particularly the environmental consequences of low-density suburban development, which complicates the implementation of the 15-minute city model. The other major challenge was economic sustainability, especially in terms of liquidity and competitiveness, including the need for portfolio diversification. A key question for the future will be how to secure financial resources for the development projects necessary for the sustainability transition.

Our next question asked interviewees to reflect on the most significant measures implemented to date. Responses fell into several categories: strategy development, energy-related investments, transportation improvements, waste management, and water governance. The most commonly cited were strategy development and energy investments. One interviewee noted that developing strategic documents is essential for accessing EU funding, which helps compensate for budget shortfalls.

Many cities had already made improvements in transportation, focusing on public transit and micromobility. Respondents mentioned the introduction of bike- and scooter-sharing systems, as well as infrastructure upgrades to support cycling. The establishment of waste collection islands, selective waste collection systems, and public education campaigns were also reported as key achievements.

Efforts toward energy efficiency and energy investments were evident in every city surveyed, aligning with the finding that energy issues were universally perceived as major sustainability challenges. One city representative highlighted project to implement environmentally friendly public lighting, while another mentioned the energy-efficient design of sports facilities.

In a subsequent question, interviewees were asked to describe their future plans—with a focus on new practices and deeper partnerships. Unsurprisingly, energy and climate-related issues remained prominent. Some cities mentioned plans to introduce new renewable energy sources, including geothermal and hydrogen-based energy systems. Two cities indicated an intention to establish workshops and communication forums to facilitate community-level dialogue on energy transition challenges. One city reported plans to equip public buildings with solar panels.

On the topic of partnerships, most respondents expressed a high degree of openness. International partnerships were mentioned in three cases, with two specifically referring to twin city relationships. These partnerships often involve cities of similar size and character (e.g., geographic location, economic profile) and can support the exchange of best practices and collaborative sustainability efforts. One respondent, however, noted that personal relationships and interpersonal conflicts sometimes hinder the effectiveness of these collaborations.

The next question addressed how cities consider residents' needs in the development of sustainability policies. Based on the responses, it can be stated that all participating cities engage in some form of public consultation. One interviewee noted that social media platforms also serve as valuable channels for feedback—comments and interactions on posts provide decision-makers with insights into public opinions and preferred development directions.

In one case, it was emphasized that the large volume of public input must be reviewed and prioritized. Most respondents agreed that the opinions expressed in these forums are taken seriously and

significantly influence the creation of sustainability strategies. Some also mentioned targeted stakeholder engagements, including interviews with professionals and consultations involving schools—parents, students, and teachers.

A separate section of the questionnaire dealt with the city's sustainability-related partnerships. As highlighted earlier in this article, forming partnerships is crucial for achieving sustainability objectives. This aligns with the 17th goal of the United Nations Sustainable Development Goals (SDGs)—"Partnerships for the Goals"—which underscores the importance of collaborative efforts.

The aggregated responses revealed that businesses were the most frequently mentioned partners, appearing in seven out of nine interviews. These included local public service providers, waste management companies, water management and transportation firms, as well as for-profit enterprises with a significant role in the city's socio-economic fabric.

In four interviews, residents themselves were explicitly mentioned as partners whose needs are essential for creating liveable and sustainable urban environments. Civil society organizations were cited less frequently appearing in only three cases. One interviewee specified the types of NGOs involved: environmental and educational organizations.

In two cities, neighbouring municipalities were identified as sustainability partners, particularly for topic-specific, recurring collaborations. One respondent noted that joint applications for funding with surrounding villages can create win-win scenarios, as infrastructural development in the broader region also benefits the city.

Two respondents again emphasized the importance of partnering with similar-sized European cities, where mutual learning and knowledge exchange can support the sustainability transition. A dedicated question addressed the role of higher education institutions, aimed at mapping city-university collaborations. All interviewees considered multidimensional cooperation between cities and universities to be important, though only seven reported active partnerships. These partnerships varied in scope and covered multiple domains of university activity.

Several respondents highlighted educational collaborations, noting that cities depend on having qualified and motivated professionals, trained in both the public and private sectors. These partnerships are mutually beneficial: universities can increase employment rates among graduates, students gain financial stability, and cities benefit from a skilled, up-to-date workforce.

In two cities, research collaborations were also active, aiming to produce city-specific analyses and impact assessments. These partnerships allow for a joint investigation into local energy challenges and facilitate the co-creation of suitable solutions. In one case, a university suggested an optimal energy mix for the city, tailored to local conditions. Two other cities reported collaborations in transportation: in one, universities helped install traffic sensors, and in the other, they were involved in establishing a bike-sharing system.

When asked about additional best practices, respondents provided a variety of examples. Half of them mentioned the creation of communication platforms for sharing best practices. These platforms help social and economic stakeholders understand that preserving the natural environment is as important as profit maximization. A notable example is the climate workshop, a forum for collective reflection on climate challenges by government, corporate, and household stakeholders. Another respondent emphasized the importance of raising public awareness through local media.

Most interviewees also mentioned municipal and environmental service providers as key players in operationalizing sustainability. Encouragingly, two cities reported plans to establish active energy communities, which would further enhance civic engagement in energy management.

The subsequent question focused on corporate activities in relation to sustainability. A fundamental tension emerged between environmental/public interests and the business imperatives of maintaining liquidity and maximizing profit. Nevertheless, it was noted that sustainability is gaining prominence in the corporate sphere as well, forming part of companies' corporate social responsibility (CSR)—now an expected standard and even a differentiating strategy for many firms.

Examples were provided of cities and businesses aligning their goals. For instance, wellness hotels have agreed to recycle used water, and one company co-founded an urban beekeeping initiative. It also became apparent that in some cities, corporations actively encourage sustainability efforts. One notable practice involved coordinating public transport services with workplace shifts near large industrial sites, reducing road congestion and ensuring uninterrupted production cycles.

The next set of questions focused on how residents are informed about sustainability-related issues. It is important to note that in all participating cities, public awareness-raising activities are actively carried out. Similar to opinion-gathering methods, information dissemination occurs through both online and offline channels. In many cities, sustainability forums are also organized; however, these are usually project-specific and linked to particular developments, rather than general information sessions.

One respondent emphasized that these forums are only truly effective when they are tied to concrete cases or investments, providing citizens with targeted information and education on specific matters. When asked about future plans for public engagement, all but one respondent affirmed continued efforts, highlighting that municipal awareness campaigns are ongoing. Most of these campaigns are tied to specific projects or focus areas, such as smart heating systems, climate change, thermal insulation, and transport-related awareness.

Only one interviewee specifically noted that the city leadership is receptive to public criticism. In the city where the answer was negative, the lack of capacity was cited—stating that municipal staff simply do not have the time to organize public briefings on sustainability topics.

When it comes to goal-setting, it is essential that the cities define SMART goals, one key dimension of which is measurability. Cities must ensure that their efforts are not only quantified but also effectively evaluated. To assess whether cities are open to monitoring their sustainability performance, we explored their willingness to participate in sustainability rankings.

Among the cities surveyed, only one regularly and actively participates in such rankings. However, many interviewees reported that their efforts had been recognized through occasional awards, including those for energy efficiency, sustainability, tourism, cycling infrastructure, and the EU Green Leaf Award. Often, it is external funding applications that prompt cities to measure their sustainability performance, as such metrics are often a prerequisite for securing financial support.

From this, the idea of a formal sustainability ranking emerges as a potentially useful mechanism. Half of the cities surveyed expressed openness to such a system. Among the supporting arguments was the notion that comparing cities in similar situations could be helpful. Rankings, in turn, would encourage a systematic data collection process, producing a more accurate picture of the quantity and quality of municipal efforts.

Nevertheless, some critical views were also expressed. One concern was that ranking-based indicator systems may distort priorities, as cities could start focusing disproportionately on indicators rather than broader sustainability goals. It was also argued that ranking evaluations should not be conducted by the cities themselves, and that participation alone does not inherently improve sustainability, meaning the resources invested may not yield direct results.

5. CONCLUSION

This study examined urban sustainability efforts through the lens of municipal actors, especially mayors and deputy mayors, using primary qualitative methodology. We conducted structured in-depth interviews with officials from nine cities, producing a data set suitable for analysis and interpretation of municipalities' commitment to sustainability.

Overall, the findings suggest that city leaders are well aware of the significance of sustainability and are actively working toward these goals. In all cases, participants demonstrated awareness of the key challenges, which include maintaining financial liquidity, preparing for the impacts of climate change, engaging profit-oriented companies in environmental responsibility, and transitioning to sustainable transport systems. These challenges have also helped define their intended actions, which are often supported or accelerated through targeted funding calls and grant programs.

Accordingly, municipal leaders are currently prioritizing energy, climate, and transport-related measures. They favour renewable energy sources, often developing green energy infrastructure that is suited to regional characteristics. Across the sample, cities reported utilizing solar, geothermal, and even hydrogen-based energy solutions. However, the availability of financial resources is crucial for these transitions, making energy-related funding schemes particularly important for greening the urban energy mix.

Cities have also recognized the importance of forming sustainability partnerships, most commonly with local companies. While collaboration with municipal service providers remains fundamental, partnerships with private-sector actors are also frequently established. On the corporate side, mandatory ESG and sustainability reporting has become a motivating factor.

Increasingly, cities are adopting a more complex partnership model by including higher education institutions, recognizing their need for qualified, young professionals and scientific input. University partnerships are facilitated by mutual interests, as universities also rely on municipal infrastructure and services, reinforcing the value of strong local collaboration.

A key element of the research was assessing the demand for and openness to sustainability rankings. As the results show, opinions were mixed. On one hand, rankings offer feedback mechanisms and comparability with other municipalities in similar circumstances. On the other hand, scepticism remains: some view rankings as an added administrative burden with limited practical impact, and others expressed concern over the distorting effects of indicator-driven assessment frameworks.

6. RECOMMENDATIONS

In order to support cities in achieving their sustainable development goals, we propose the following recommendations based on the findings of our study.

First, we suggest the establishment of a national sustainability platform for cities. Such a platform would facilitate knowledge exchange, joint awareness-raising programs, and collaborative strategy

development. One of its key benefits would be enabling municipalities to apply for and access funding more efficiently through joint applications.

Within this organizational framework, a sustainability assessment and ranking system could be developed. This system would allow cities to track and benchmark each other's sustainability efforts, fostering idea-sharing and mutual inspiration. Such comparative evaluations could stimulate continuous improvement, leading to positive outcomes for the urban environment, local society, and economy.

As discussed throughout this study, higher education institutions can play a crucial role in advancing urban sustainability. We therefore recommend that each city formalize partnerships with universities, develop joint action plans, and define shared goals across multiple areas, including waste management, water management, energy efficiency, and transportation. These partnerships should also incorporate joint awareness-raising initiatives, aligning with universities' third mission activities—community engagement beyond teaching and research.

Another key recommendation is to adopt a regional systems-based approach to sustainability. Cities should seek to establish connections with other municipalities, such as neighboring villages, cities of similar size and function, or international partner cities, to facilitate exchange of best practices and coordinated action.

We believe that our research successfully highlighted the sustainability challenges facing Hungarian cities, including those in Hungary as well as Hungarian-led city in Transylvania. While these challenges are diverse and complex, significant progress can be achieved through committed stakeholders and adequate financial resources. Our goal has been to offer concrete suggestions for expanding and deepening sustainability practices at the urban level.

We are confident that the recommendations presented here—grounded in empirical data—can guide cities in enhancing their sustainability work. For future research, we plan to increase the number of structured interviews beyond the nine included in this study and to conduct more in-depth analysis using specialized qualitative research software.

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INTERPRETATION OF DEBRECEN AND ITS CATCHMENT AREA BASED ON TOURISM ASPECTS

BAGDI RÓBERT

Abstract

In 2016 the organisational system of Hungarian tourism underwent fundamental changes whose main element was Act CLVI, ratifying public tasks in connection with the development of tourism destinations. The destination of Debrecen was officially created in 2017, and it consists of 27 settlements belonging to two different planning-statistical (NUTS2) regions and, within them, to four different counties. Only four towns from Hajdú-Bihar County are the part of the newly determined destination and the area of Hortobágy.

Keywords: destination, tourism region, tourism development

1. Introduction

Based on the number of guest nights, Budapest's leading role in Hungary is undeniable with around 9.5 million guest nights, followed by Hévíz in second place with 854 thousand and Hajdúszoboszló in third place with 765 thousand guest nights in 2023. Following them in the ranking were Bük, Zalakaros, Sárovar, Debrecen, Szeged, and Gyula, meaning that in Hungary today, the most significant tourism destinations all have spas. Essentially, the ranking does not change if we only consider the data of foreign guests, because according to the 2023 data, Budapest had 7.8 million, followed by Hévíz with 395 thousand, and Bük in third place with 333 thousand guest nights in 2023. Debrecen ranked 7th in the overall ranking in 2023, with 448 thousand guest nights. Both Debrecen and Hajdúszoboszló therefore hold national significance. Two cities located just a less over 20 km apart can be interpreted as rivals in a certain sense. However, considering their roles in the settlement network, there is a significant difference in that, in terms of population, Debrecen, as a county seat with a population of 200,000, is roughly ten times more populous than Hajdúszoboszló. Despite the size difference on one side, the tourism role on the other hand improves Hajdúszoboszló's position enough that, for example, InterCity trains stop here. There is no other domestic example where IC trains stop in settlements so close to each other. In our article, we will review Debrecen's connection with the surrounding towns it attracts from a tourism perspective.

2. Material and Methods

I am presenting the definition of the destination's tourism image and the development of the official destination organizational framework through a literature review. I rely on officially published statistics to illustrate the past and current tourism potential.

3. Results and Discussion

3.1 Geographical review

Debrecen, which has functioned as the intellectual centre of Tiszántúl for centuries, became the seat of Hajdú County in 1876. The city's territory included the territory of Hortobágy to its west, and at one point even extended to the Tisza River. (Szikla 2020) In 1950, there was a general racialisation of the county-system, and because of this Debrecen become the seat of Hajdú-Bihar County. Forming an organic unit needed a long developmental process in fact, this has not yet concluded. István, Süli-Zakar diplomatically expressed the fate of the villages along the state border and in the plain of Bihar

by saying that these settlements did not always feel like they were on the ‘winning side’. (Süli-Zakar, 1994) The economic relations defining the present era – including the complex catchment areas that span county borders – were described by Zoltán, Bujdosó (2009). According to János, Péntes (2014), outside the attracting zone of Debrecen, settlements are clearly in a peripheral situation even today. The theoretical framework was given by József, Nemes-Nagy who developed the theory of territorial inequality (Nemes Nagy 1990) and he gave mathematical and statistical indexes to determine territorial differences (Nemes Nagy 2007).

3.2 Historical roots – the first steps

Hajdúszoboszló was originally a typical agricultural settlement from the Great Hungarian Plain. Moreover, between the two world wars, most of the population of Hajdúszoboszló lived within very poor conditions; among domestic towns, it had the highest proportion of people (56%) receiving social benefits in 1933. (Pécsi Napló 1933) However, life began to change in the fall of 1925 when thermal water at a temperature of 73°C erupted because of hydrocarbon research conducted by Ferenc Pávai Vajna. The thermal water containing iodine and bromine, so local people realised very soon its medical strengths. To take advantage of the opportunities provided by the medicinal water, a joint-stock company was established in 1927, which set up a bath capable of accommodating 3,000 to 4,000 people within that year. (Taár 1977) The growing importance of the spa is indicated by the fact that the local government of the county town of Hajdúszoboszló took over the management of the thermal bath for 280,000 pengő on October 1, 1930. (Debreceni Újság 1930)

The second half of the 1920s also brought changes to Debrecen, as the summer university program series was launched (the local government supported the event organized by the university for tourism reasons as early as 1928). IBUSZ, in turn, opened an office in the town. In the meantime, thermal water was found not only in Hajdúszoboszló but also in Karcag, so Debrecen was also looking for the opportunity to find natural gas and/or thermal water in the settlement thanks to deep drilling. (Simon 2015)

The city needed developments in several areas, so Debrecen intended to take out a loan to realize these investments. Finally, through a two-year research project in Nagyerdő, co-financed by the Ministry of Finance, thermal water at 68°C erupted from a 1400-meter-deep well on January 15, 1932. Five months later, the summer pool was completed, and by mid-November, the indoor winter pool was also finished. In the first three months, an average of 169 people visited the swimming pool daily, generating daily revenue of 100 pengő. (Tatay 1933) Meanwhile, the city prepared and sent out various promotional brochures and publications to potential domestic and foreign interested municipalities. We also have information about visitors arriving in the city irregularly, so in the spring of 1933, nearly 4,000 ‘foreigners’ visited Debrecen in two spring months. (Városok Lapja 1933) We already have official statistics on domestic tourism data for the years 1936 and 1937, which indicate that besides Budapest, the tourism of only other twelve towns including Debrecen. In 1936, 28,886 domestic guests arrived at Debrecen, while in 1937, 26,604 domestic guests came. At the same time, in 1936, 726 foreign visitors arrived, and in 1937, 6,012 came from abroad. These data were around half of the Transdanubian town, Pécs. (Magyar Királyi Statisztikai Hivatal 1938)

After World War II, until 1960, tourism and its developing weren’t accepted in practice, but later the leaders of the communist party realised the country needs hard currency. Meanwhile, Hajdúszoboszló was designated as a health resort by the Ministry of Health with decree No. 30.886/1958. (III.1.). The popularity of Hajdúszoboszló is indicated by the fact that in 1960, the spa had already 825,000 visitors, and in 1969, it managed to surpass the one million visitors. (Csath 1975) Hajdúszoboszló needed some improvements like building hotels, Béke Hotel, which was a social resort (SZOT), was officially opened in 1963. With its 400 beds, it became the largest accommodation facility in the country. (Kollár 1967) The Hortobágy Executive Committee was established in 1963 to promote the development of tourism, and it was responsible not only for the Puszta but also for Hajdúszoboszló and Debrecen. (Erdei 1966)

The improving perception of tourism is also indicated by the fact that we have official statistical figures from 1964 to 1975, although the concepts and classification criteria used at that time do not completely align with those currently in use. Moreover, during that era, there were various ways of traveling, meaning that the counting of those who visited corporate resorts appeared in some statistical works, while in others, these higher numbers were not mentioned at all. From the early 1960s, a system of discounted vacations also operated in Debrecen, under which the 32-room, 100-person Cooperative Workers' Resort was inaugurated in the fall of 1963. In early 1964, the Kohász SZOT Resort opened its doors in Nagyerdő, which had 71 rooms and could accommodate 141 guests at once. During school breaks, they only accommodated families. (Erdei 1966) Miklós, Abella (1966) reported in relation to the year 1964 that there were 419 hotel beds available in Debrecen, while in Hajdúszoboszló there were only 136. According to the official statistics he provided, 59,249 guests arrived in Debrecen, while 8,102 guests arrived in Hajdúszoboszló. (Abella, 1966) We also have county data from 1965, according to which "nearly 190,000 domestic tourists spent 800,000 guest nights and 35,000 foreign tourists spent 58,000 guest nights in the county". (Erdei 1966:383) Of this, Debrecen and Hortobágy accounted for approximately 118,000 visitors (including 19,500 foreigners), with 299,000 guest nights. Likely, by subtracting the Debrecen–Hortobágy data from the county data, we can practically calculate the number of guests realized in Hajdúszoboszló.

3.4 Historical roots – official statistics during the Kádár Era

The numbers of social purpose vacations – about which the reports are sparse – are certainly included in the official publications. Neither Debrecen nor Hajdúszoboszló belonged to any officially determined domestic resort area, yet between 1964 and 1975, the data for Hajdúszoboszló were presented in official statistical publications alongside the nationally aggregated data of other settlements not belonging to destination areas, highlighted and displayed as a separate line. All of this was due to the main motivational goal of those arriving in Hajdúszoboszló, which was health tourism. Based on the data, during this period, the number of "holiday facilities" in Hajdúszoboszló increased from 20 to 53, but the number of accommodations only grew by 40.2%. The number of people vacationing in Hajdúszoboszló increased from approximately 30,000 to nearly 47,000 per year, with an average length of stay of 12–13 days. (Table 1)

Table 1 The most important indicators of tourism in Hajdúszoboszló between 1964 and 1975

year	Holiday facilities		Holidays	
	number	capacity	people	days
1964	20	1652	29456	391613
1965	20	1510	29644	396073
1966	21	1541	29015	390962
1967	21	1607	30297	402278
1968	29	1849	33297	444753
1969	35	2007	37407	489161
1970	35	2057	36037	478455
1971	42	2117	37833	484054
1972	46	2355	43573	560129
1973	48	2325	44467	563499
1974	52	2356	47332	593181
1975	53	2316	46827	580347

Source: Statistical Yearbook 1964–1975

In summary, in 1964, 8,102 people stayed in hotels in Hajdúszoboszló, while slightly more than 20,000 others stayed in guesthouses, campsites or in other accommodations. For the capacity

expansion realized in Hajdúszoboszló, for example, the Délibáb Hotel, inaugurated by the Hajdú-Bihar County Hospitality Company in 1969, also contributed (and it had to be expanded in 1987). (Figyelő 1988) The Statistical Yearbook from 1972 onwards did not include overnight stays by employees and workers in the tourism data! (Yearbook 1972)

In the case of Debrecen, we must make do with even narrower official statistical data, because until 1969, the data of other (non-holiday resort) settlements were presented as a single cumulative row. We have sporadically published data in some professional journals from the years preceding 1969. In 1967, for example, there were 3,125 total accommodations (number of beds) in Debrecen, and throughout the entire year, 116,318 guests stayed, of which approximately 30,000 came from abroad. The average length of stay was thus 1.9 days. (Fridvalszky 1968) Between 1969 and 1975, based on official data, approximately 50,000 foreign and nearly 100,000 domestic guests visited Debrecen, according to published data on the number of guests staying in hotels and other accommodations. Another interesting fact is that from 1970 onwards, the official numbers were rounded to the nearest thousand. (Table 2) The average length of stay in Debrecen, for example, was 2.2 days in 1970.

Table 2. Number of guests arriving in Debrecen between 1969 and 1975

Year	number of visitors (from 1970 rounded numbers)			
	capacity	foreign	domestic	total
1969	1683	46158	94093	140188
1970	3407	50	93	143
1971	2257	48	93	141
1972	3126	56	96	152
1973	2148	54	96	150
1974	2466	61	96	157
1975	2049	60	99	159

Source: Statistical Yearbook 1969–1975

Data reporting with the same structure as that of Hajdúszoboszló only occurred in two years, 1974 and 1975. There were only two hotels considered as holiday facilities in the city, which had 361 beds, and a year later 365 beds. The number of vacationers in both years slightly exceeded 11,000, and in 1974, 125,729 vacation days were realized, while a year later, 131,923.

The numbers, therefore, indicate that these destinations were becoming increasingly popular, but other signs of progress were also evident: in 1976, the new wing of the Aranybika was inaugurated, which doubled the accommodation capacity. (Mérleg 1979) In the six-story new wing, they were able to provide 149 rooms with bathrooms, thus offering 298 new accommodations for the visitors. (Hajdú-Bihari Napló 1976) The prosperous years of the Kádár era followed, peaking in the mid-1980s. By this time, a health and resort centre had developed in the Nagyerdő of Debrecen over 9 hectares, which had already hosted a million guests by 1979.

In terms of guest numbers, 1986 was the ‘peak’ year, when 412,000 guests arrived in Hajdú-Bihar (30% of whom were foreign), resulting in a total of 2.309 million guest nights. Of this, Hajdúszoboszló accounted for 183,000 guests and 1,553,000 guest nights. (Hegedűs 1988) According to the head of the county Tourism Office, the population of the city practically doubled in the summer, while regarding the locally available accommodation capacity, he stated that “the capacity of commercial accommodations exceeds ten thousand, and the capacity of SZOT and corporate resorts, as well as private resorts, is of a similar magnitude”. (Hegedűs 1988: 14)

3.5 Tourism statistics after 1990

After Budapest and Lake Balaton, Debrecen and Hajdúszoboszló, which had the third highest number of visitors, showed a decline in tourism data after 1986. According to the 1991 data, the number of domestic guests in the county halved compared to the 1980s. In Hajdú-Bihar County, only 174,000

guests were registered in commercial accommodations in 1992 (60% of 1986). (Szilágyiné Bíró 2002) During these years (1990s), the ratio of guest nights between Debrecen and Hajdúszoboszló began to shift. All this meant, in numerical terms, that in 1990, Debrecen accounted for 47% of the county's guest nights, while Hajdúszoboszló accounted for 45%. By 2000, Debrecen's share had fallen to just over one-third, while its western rival had increased its share in the county to 61%. The trio, which included also Hortobágy, contributed 93% to the county's tourism overnight stays in 1990, which increased to 97% by 2000. Moreover, the number of guest nights realized in commercial accommodations increased by only 353.5 thousand between 1990 and 2000. The number of hotels increased from 11 to 30, while the number of guesthouses rose from 11 to 50. (Szilágyiné Bíró 2002)

3.6 Tourism region of Northern Great Hungarian Plain

Regions in Hungary have no historical roots and they were created only in the decade before 2000 preparing to the EU-accession. Three counties were grouped together in one region, without changing their administrative borders determining seven NUTS 2 level regions altogether. The nine tourism regions were determined based on the boundaries of the newly established NUTS 2 level regions in 2000. Two new tourism regions were created in the case of two lakes extending over the boundaries of the NUTS 2 regions: Lake Balaton and Lake Tisza. The territory of Lake Tisza tourism region is an inner periphery area (Nemes-Nagy, 1996) in Hungary showing large revenue inequalities and segregation of population. There are no larger cities; 68 settlements – mostly villages and significantly less densely populated towns dominate the landscape, which area administratively belongs to four different counties (Hajdú-Bihar, Jász-Nagykun-Szolnok, Heves and Borsod-Abaúj-Zemplén) and two NUTS 2 regions (Northern Great Plain and Northern Hungary). This region received less than 2% of the total domestic guests' nights during the decades after 2000. Debrecen and its attracted settlements belonged to another tourism region of Northern Great Plain.

3.7 Tourism destination of Debrecen

In 2016, the organizational structure of domestic tourism fundamentally changed, with the most important element being the CLVI law adopted in December, which regulated the state's responsibilities for the development of tourism areas. This law considered destinations as the framework for future tourism developments, instead of tourism regions. During 2016–2017, five prioritized tourism development destinations were delineated, starting with Balaton and Sopron–Fertő, then thirdly Tokaj, Upper Tisza, Nyírség, fourthly Debrecen, Hajdúszoboszló, Hortobágy, Tisza Lake, and finally, Dunakanyar appeared in a government resolution.

In August 2017, the Government of Hungary established the officially called (between 2017 and 2020) Debrecen, Hajdúszoboszló, Hortobágy, Tisza Lake designated tourism development area with its 1522/2017 (VIII. 14.) resolution [HUNGARIAN OFFICIAL GAZETTE 2017]. This area consists of two larger units: the Debrecen–Hajdúszoboszló designated tourism development area, which includes four towns (Debrecen, Hajdúszoboszló, Hajdúböszörmény, Balmazújváros), and the Hortobágy–Tisza Lake designated tourism development area, which includes a total of 23 settlements. The creation of the new tourism development destination was justified by the region's, primarily Hajdúszoboszló's, previous outstanding results in guest nights. The municipalities determined in the Government Resolution are in two tourism regions (Tisza Lake, North Great Plain). The Debrecen, Hajdúszoboszló, Hortobágy, Tisza Lake designated tourism development area, which renamed in 2020 to Debrecen and surroundings consists of 27 settlements. However, these settlements belong to two planning-statistical regions (Northern Great Plain and Northern Hungary) and, within them, to four different counties: Hajdú-Bihar, Jász-Nagykun-Szolnok, Heves, and Borsod-Abaúj-Zemplén. The destination designated in the government decree fundamentally consists of two units: on one hand, the part named Debrecen-Hajdúszoboszló, which includes Hajdúböszörmény and Balmazújváros in addition to the eponymous cities.

The other unit is the Hortobágy-Lake Tisza designated tourism development area, which includes, on one hand, the settlement of Hortobágy, whose administrative area is not the same as the entire area of Hortobágy National Park, and from Hajdú-Bihar, Tiszacsege and Egyek also belong to this unit. The map delineation of the determined tourism development area is presented in Figure 1.

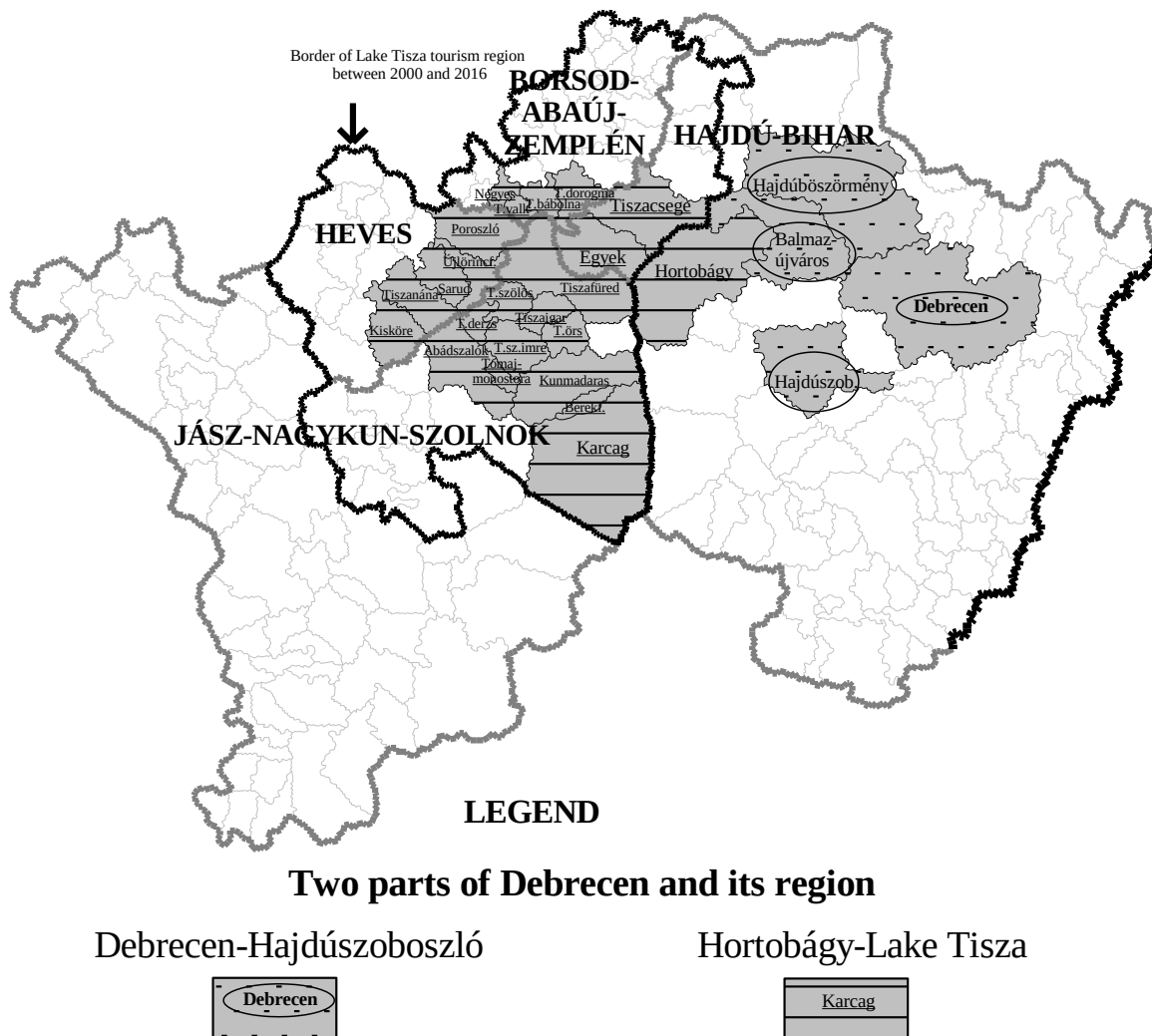


Figure 1 Debrecen and surroundings destination from 2017
Source: Own edition

The destination also includes settlements typically located on the shores of Lake Tisza or a few kilometres away from it. From Heves and Borsod-Abaúj-Zemplén, only the settlements closest to Lake Tisza could become part of the new unit. Thus, in Heves, starting from Kisköre as the southernmost point and moving north, Poroszló forms the northern boundary. In the neighbouring county, there are only four villages that could become part of the destination: Négyes, Tiszavalk, Tiszabábolna, and Tiszadorogma. In Jász-Nagykun-Szolnok County, however, not only the “lakefront” but also the more distant settlements belong to the newly determined destination according to the government decree. Karcag, located more than 40 km away from the lake by road, marks the southern boundary, so the town and the area between Abádszalók, Berekfürdő, Kunmadaras, and even the village of Tomajmonostora could become part of the destination. In the municipalities that make up the destination, the number of registered guests at commercial accommodations showed an increasing trend between 2012 and 2016. Both the number of registered domestic and foreign guests showed an increase. The average absolute change in the number of

registered domestic guests during the examined period was 28,955, while for foreign guests it was 7,534.5. In the case of the peak season maximum guest numbers, the increase between 2012 and 2016 was 23,443 people (36.7%).

In the eastern region known as Debrecen–Hajdúszoboszló, comprising four municipalities, the percentage distribution of domestic registered guests during the 2012–2016 period ranged from 62.2% to 84.9%, while that of foreign guests varied between 15.1% and 37.8%. Both the number of domestic and foreign registered guests increased in the commercial accommodations of the Debrecen–Hajdúszoboszló designated tourism area between 2012 and 2016. The number of domestic guests increased by 106,243, while the number of foreign guests increased by 30,621 during the examined period.

In the Hortobágy–Tisza Lake designated tourism development area, the distribution of guests was as follows: the proportion of domestic guests ranged from 77% to 97.2%, while the proportion of foreign guests varied between 2.8% and 23%. The number of domestic guests registered at commercial accommodations increased by 9,737 in the Hortobágy–Lake Tisza designated tourism development area during the examined period, while the number of foreign guests showed only minimal change.

If we examine the change in the number of registered guests in business-oriented accommodations separately in the two highlighted tourism development areas, it can be stated that in the case of the Debrecen–Hajdúszoboszló destination, the number of registered guests continuously increased during the period from 2012 to 2016. In the case of the Hortobágy–Lake Tisza designated tourism area, no annual trend of decrease or increase was detectable. However, in the case of the Hortobágy–Lake Tisza destination, we can state that typically (90.9%) domestic tourists utilize the other accommodations intended for business purposes.

Years from 2016 to 2019 showed a continuous developing and reaching totally 769 thousand guests and 2.2 million tourism overnights. Covid-19 pandemic caused decrease in the numbers, but I do not present it details because Csobán et al. summarised it in 2022. The total number of overnights fell below 700 thousand in the whole destination, the number of guests was 46% of the previous year, but the number of foreign tourists decreased by 73.3%. (Csobán et al. 2022)

Debrecen has no agglomeration zone but only an attracted zone. During the latest 40 years all scientists thought that only Ebes, Hajdúbagos, Hajdúsámson Mikepércs and Sáránd belonged to the attraction zone of Debrecen, but they categorised the other settlements different ways. (Kozma 2024) If checking the official statistics after 2021 about guests overnights these five mentioned settlements live in shadow of Debrecen. For example, Mikepércs has accommodation only during the summer season, which means less than 200 people arrived there during one year and spent totally a few hundred guest overnights (587 nights in 2024) but its neighbour Sáránd do not have any accommodation possibilities!

Balmazújváros and Hajdúböszörmény were not mentioned whereas they are the part of the official destination. Balmazújváros received 7667 guests who spent 16,784 overnights in 2024. In the same year Hajdúböszörmény proved to be more important with 10,867 guests who slept in the town totally 41,320 overnights. Both towns play insignificant role behind Debrecen and Hajdúszoboszló. Hajdúszoboszló received 362,133 guests who 1,192,562 overnights in 2024 while Debrecen 235,159 guests and realised 690,881 overnights.

4. Conclusion

Debrecen and surroundings destination was determined in 2017 and only 27 settlements belonged to it from four counties. Its geographical features and shape are not like the attraction zone of Debrecen. The most unique feature of the newly determined destinations (from 2020 Hungary has 11 ones) that a tourist destination does not necessarily have to consist of a single contiguous area; its territory can be mosaic-like. Between Debrecen and Hajdúszoboszló there is village called Ebes that is not the part of the destination. None of the neighbouring settlements of Hajdúszoboszló are the part of the destination! This is probably not so important, since Debrecen is only around 20 km away from it, and they are connected by the main road number 4. Currently, the M35 motorway ends at the border

of Hajdúszoboszló, thus connecting it to the capital is ensured. The Inter-city trains also stop in the town.

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6. Author's address

Robert, Bagdi

University of Debrecen

Faculty of Economics and Business

Collage Associate Professor

bagdi.robert@econ.unideb.hu

VILLAGE CARETAKER SERVICE, THE WAY TO REDUCE ISOLATION

KOLTAI ZOLTÁN

Abstract

As urban dwellers, or simply as people living in a settlement with a larger population, we rarely find ourselves short of the goods that are essential to our daily needs. We take it for granted that there is a wide choice of grocery shops, there is a local pharmacy, a local doctor, and offices are at hand. We have a rich offer of cultural and leisure facilities, and a kindergarten and school for children. At the same time, these basic social functions are often inaccessible to people living in small villages. This is particularly problematic in ageing small communities with social problems, where the lack of a private car and poor public transport links make it almost impossible to live a full life. For them, the village caretaker may be the only way to reduce isolation. This paper summarises the main findings regarding villages in our questionnaire research on the competitiveness of Hungarian municipalities, also explores the circumstances of the establishment of the village caretaker service and the main elements of the related training programme.

Keywords: village caretaker service; village; place of residence; demographic trends

Introduction

The basic idea of the village caretaker service, and later the spread of the services, is linked to the name of Bertalan Kemény, an agricultural engineer and regional planner, who was given the task of preparing a development proposal for the suburban settlements and small villages of Somogy County in 1982 (Faludi 2013). In the spirit of the National Settlement Network Development Concept in force, these settlements without functions, excluded from any development opportunities, were in fact designated for humane elimination, but Kemény sought a different solution. In line with his firm belief that every settlement and human community has the right to life and to shape its own future, he aimed to reverse this unfavourable trend (Faludi 2004). Among other things, he proposed the territorial expansion of small-scale production by providing an optimal environment for small-scale full-time farmers, and he called for the strengthening of local autonomy, thus promoting the revival of the internal relations of local society and local patriotism. Lastly, he specified a person or small group of people known as village caretakers or village caretaker service to run small villages. Focusing on the latter element of the diverse package of recommendations, a few years later, in 1990, with the active participation of the Association of Cserehát Settlements, the service was launched in small villages of Borsod-Abaúj-Zemplén County in the most disadvantaged position. In the following year, with the support of the Ministry of Public Welfare village caretaker services were set up in Baranya and Somogy counties, followed in the 1990s by the small villages of other counties. The service, which initially operated in settlements with less than 500, later 600, and now less than 1000 inhabitants, had nearly 2100 village and farm caretakers in 2024 (tamogatoweb.hu/falu-es-tanyagondnoki-szolgalat). Their work is supported by 11 regional village caretakers' associations operating in the country, which not only bring together the village and farm caretakers, maintainers, professionals, NGOs and volunteers involved in the service, but also provide consultancy, professional advice, information, the organisation of programmes and networking to support and develop the services. In 2000, services started operating in Transylvania (in Szentgerice, Mures County) and in 2010 in Serbia. The Romanian Association of Village Caretakers has been in operation since 2007, and it coordinated 30 services in 2022 (Csörsz Zelenák – Sümeginé Ország 2022).

1. Legal regulation and the core values of the village caretaker service

Although the service function was launched in August 1990, it was not legally regulated until the adoption of Act III of 1993 on Social Administration and Social Benefits of 1996: "The purpose of the village and farm caretaker services is to alleviate the disadvantages of small villages and rural or other outskirts settlements and farms resulting from the lack of institutions, to provide access to services and public services to meet basic needs and to certain basic services, and to help meet individual and community needs." (Act III of 1993 on Social Administration and Social Benefits, § 60.1)

According to the Decree 1/2000 (7 January) of the Ministry of Social and Family Affairs, the following direct personal services are considered as basic tasks of the village caretaker service:

- a) assistance in the provision of meals, home help, community and social information,
- b) provision of access to health care, such as transport to the general practitioner's surgery, transport to other health care facilities, purchase of medicines and access to medical aids,
- c) transport of children of kindergarten and school age, such as transport to kindergarten, school and other transport of children.

Residential services that are considered as additional tasks:

- a) organisation and promotion of community, cultural, sporting and leisure activities,
- b) assisting in the handling of individual official affairs, forwarding requests from the public,
- c) contributing to the provision of other services to the public, other basic social services and child welfare.

The following are defined for the village caretaker service as an indirect service to assist in the performance of municipal tasks:

- a) the delivery of food to a municipal institution,
- b) the dissemination of municipal information to the public,
- c) the tasks related to the operation of the village caretaker service.

The latter tasks, which qualify as indirect services, may account for up to 50% of the service provision (Decree of the Ministry of Social and Family Affairs 1/2000 (I. 7.) on the professional tasks of social institutions providing personal care and the conditions of their operation, § 39.1).

It can be stated that the village caretaker service is a locally initiated solution designed to meet local needs, which should bear the specific characteristics of the given settlement as a "fingerprint", whether these are of geographical, economic, demographic or institutional and infrastructural origin (Csörszné Zelenák – Sümeginé Ország 2022). The needs assessment, which is the starting point, is as indispensable for the introduction of the service as it is for the further development of the existing service. Based on all this, it is not an exaggerated statement that the farm and village caretaker service can function as a local solution to the manifold problems of the Hungarian countryside by strengthening the spatial links of services (Tóth 2018).

The core values of the service can be summarised in the following seven points (Kemény 2004b):

- The village caretaker service is a school of democracy, because caretakers are elected by those whom they serve. They can only do their job well where the social environment is cooperative, where there is public trust, goodwill and openness in everyday life (I would refer to the results of our questionnaire research, which showed that being a community is typically associated with positive human relations, cohesion, mutual attention and helpfulness, as shown in Figure 1).
- The specific professional content of the task is site-specific and always defined in consultation with the stakeholders. Local specificities, rather than central requirements, can give the service a flexible content.

- Assistance is personalised, hence its predictability and reliability.
- Local and human skills, humanity, competence and acceptance are the main criteria in the selection of the village caretakers.
- The service must never be partial, the fairer and more important request, the affair of the village, is always given preference.
- The value of the service is that the excursions and leisure activities enrich the daily lives of people who are tied to a place and find it difficult to get out.
- All these together contribute to bringing people closer together, and listening to each other, solidarity and responsibility for community members creates functioning village communities.

Based on these, the most important personality traits of a village caretaker are empathy, credibility, lack of prejudices, flexibility, helpfulness, patience, good relationship building and problem-solving skills, decisiveness and precision (Csörszné Zelenák – Sümeginé Ország 2022).

When applying for the position of village (or farm) caretaker, candidates must have at least 8 years of primary education and a valid driving licence (a minibus with 8+1 seats is typically the most suitable for the task) and must declare that they will undertake to attend the training course for village and farm caretakers required for the job.

The Village Development Society, founded in 1989 at the time of the regime change, has placed from the very beginning great emphasis on training participants. The training of village caretakers was initially provided in a one-week and then in a multi-week in-school format and is currently provided through a 170-hour programme comprising 52 hours of theory and 118 hours of practical training (Bódy et al. n.d.).

The main curriculum units currently follow the structure below:

- Basic skills of the village and farm caretakers (history of the village and farm caretaker service, the provision of tasks and their documentation, health, legal, ecological and vehicle operation skills)
- Social and community skills
- Social work and the assistance profession
- Developing communication skills and professional self-awareness
- Practical exercise on the spot

One of the main benefits of the training programmes is an expanding network of contacts, friendships, increased awareness and confidence required for work, a positive attitude, increased openness, a sense of systemic thinking and perhaps most importantly, a sense of being "in the right place."

2.1. Living conditions in small settlements

In the framework of our questionnaire survey on the competitiveness of Hungarian settlements, we wanted to know, among other things, how the Hungarian population perceives the everyday living conditions provided by small settlements. The nationwide stratified survey was based on questioning 1,000 respondents, and the four aspects of the survey were the distribution of the Hungarian population by regions, gender, age and educational attainment. Thanks to the personal questioning, the completed questionnaires were suitable for evaluation almost without exception.

It was assumed that those who prefer this settlement level with the smallest population would primarily attribute it to positive human relations and a clean, tranquil living environment, while the main reasons for rejection would be lack of amenities, inadequate employment conditions and unfavourable demographic trends (Koltai 2014, 2022).

Our hypothesis about the advantages of living in a village was confirmed, as almost half of the responses (49.1%) were related to a healthy, clean and quasi-natural residential environment. Positive

human relations, social cohesion, mutual attention and helpfulness were also mentioned by many (30.6%), while the third most frequently mentioned advantage was the possibility of homestead farming, gardening and related self-sufficiency (10.3%). Better public safety was mentioned by 7.5% of respondents, while lower property prices and shorter distances within the municipality were option in the “other” category (2.5%) (Figure 1).

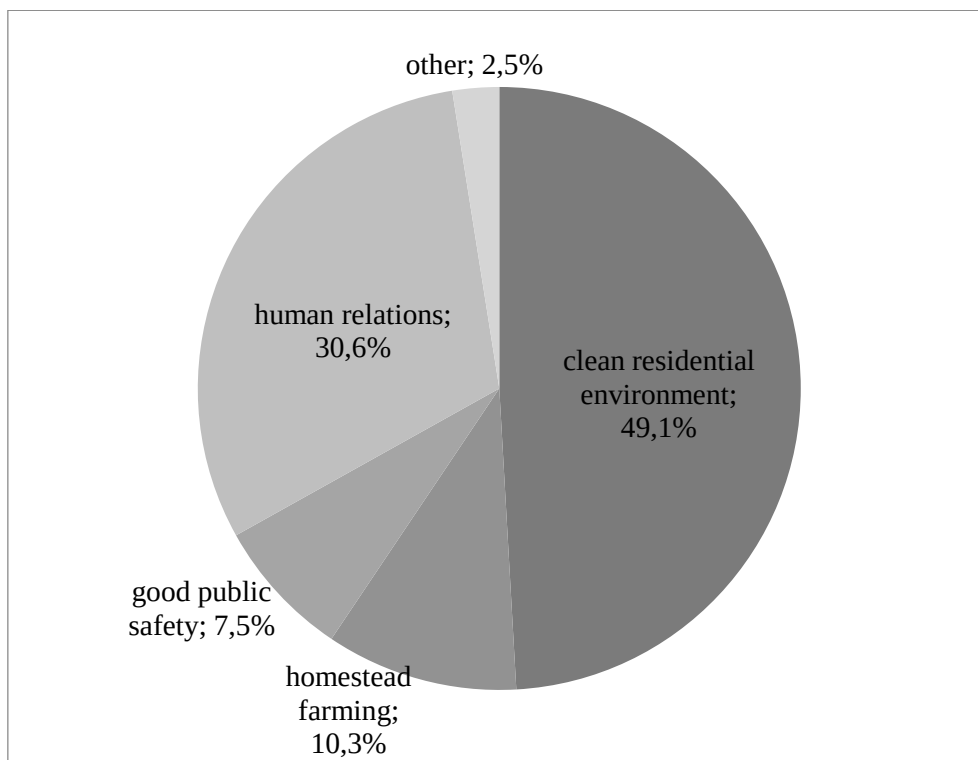


Figure 1. Distribution of the advantages of living in a village according to the survey of the Hungarian population, (N=1000)
Source: Koltai, 2014, 151.

Most criticism was directed at the lack of services and facilities in the villages, with two-thirds of the responses (67.7%) mentioning this as a disadvantage. Nearly one in four (23.7%) of the responses mentioned employment problems, lack of job opportunities and low incomes. The “other” category (8.6%) included depopulation, ageing, disadvantaged ethnic composition, but also problems of being too well known, lack of public safety and isolation.

Looking in detail at the group of services, the majority of negative opinions were related to transport infrastructure (35.5%), but many mentioned limited access to local health services (18.7%) and deficient educational system from kindergarten to secondary education (13.7%). Slightly less criticism was express about the development level of commerce and the supply of goods (13.2%) and the often limited and cumbersome facilities for administration of affairs (7.6%), but more people (11.3%) considered the lack of leisure and recreational facilities to be a problem (see Figure 2).

The finding of our questionnaire research, the main disadvantage of people living in villages is the lack of services, including limited transport and health care, the lack of education, commerce network, cumbersome administrative facilities and limited leisure time, is fully reflected in the basic and additional tasks of the village caretaker service.

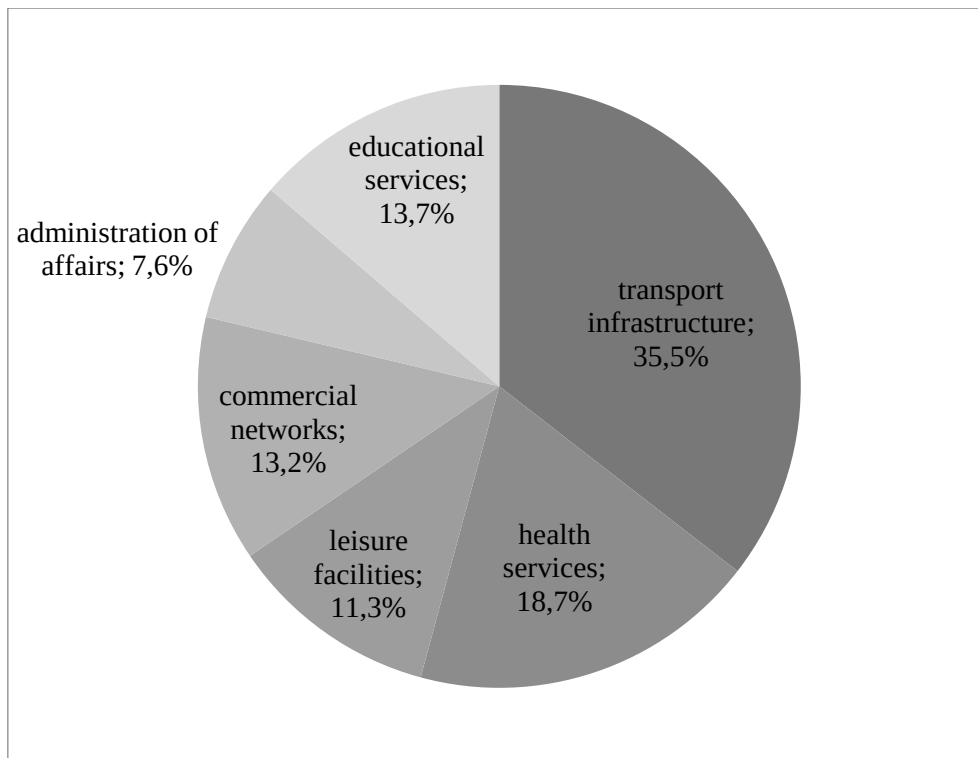


Figure 2. The underlying reasons for the disadvantaged position of small settlements in terms of supply and service conditions, according to the survey of the Hungarian population (N=1000)
Source: Koltai, 2014, 152.

2.2. How will the target group evolve in the future?

In 2010, more than half of the Hungarian settlements (1 758 settlements, 55.8%) had a population of less than 1 000 inhabitants, while the population of settlements with less than 1 000 inhabitants (768 060 inhabitants) accounted for 7.7% of the total population. These figures increased further by 2023 (1 833 settlements, 57.7% and 783 629 inhabitants, 8.2%). The opposite trend is observed in settlements with 1000-1999 and 2000-4999 inhabitants.

If we look at the demographic characteristics of the Hungarian counties, the largest number of settlements with less than 1000 inhabitants can be found in six counties of Hungary. Table 1 shows the number of settlements with less than 1,000 inhabitants in these six counties, the share of these villages from the total of settlements within the counties, and the number of inhabitants in these counties and their proportion from the total of the respective county populations. These figures clearly designate those counties where the effective operation of the village caretaker service is of particular importance is clearly visible (ksh.hu).

It can be assumed that the demographic processes in the small villages taken as the target group of the caretaker service will further appreciate the future role of the service. This assumption is also reinforced by a report by Halloran and Vera on basic social services in rural settlements in Hungary (Halloran – Vera 2005).

Table 1. Number of villages with less than 1,000 inhabitants and the proportion of their population in their counties

	number...	proportion from the total settlement stock of their counties, in per cent, ...	total population...	proportion from the total population of their counties, in per cent, ...
	of villages with less than 1,000 inhabitants			
Baranya	261	86.7	82,033	23.1
Borsod-Abaúj-Zemplén	238	66.5	97,338	15.6
Zala	221	85.6	74,140	28.3
Vas	186	86.1	69,418	27.8
Somogy	185	75.2	73,812	25
Veszprém	161	74.2	66,145	19.5

Source: edited by the author, using ksh.hu/stadat_files/fol/hu/fol0013.html

Conclusion

According to Bertalan Kemény, the founder of the service, "A good village caretaker notices every problem, helps with what he can, and tries to solve what he cannot (due to lack of time, petrol, knowledge). He is interested, seeks information, asks for it, mediates it, encourages action, gives ideas, forms opinions, shapes the opinion of the 'public'. In short, he works to make the village community work again, to make it viable again." (Kemény 2004a:21)

It is a welcome fact that although small settlements in Hungary are currently in a rather ambivalent situation, as their residential environment and the possibility of positive human relations make them attractive, all these are negatively offset by their lack of services and unfavourable labour market conditions, the population of Hungarian settlements with less than 1000 inhabitants has increased in relation to the total population in the last decade. The negative effects of unfavourable labour market cannot be mitigated by the village caretaker service, but deficient transport links, the lack of health and education facilities, and limited local commercial, administrative and leisure facilities can.

The shrinking range of locally available, market-based services and public institutions, the decline of community life, and an ageing and lonely population due to the outward migration of young people, all point to the growing importance of the future role of the service. We believe that the service can be a real retention factor both by the strengthening of the external relations of the villages, on the one hand, and by making the internal operation of the communities more effective, on the other hand.

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CULTIVATING PROSPERITY — INNOVATIONS IN AGRICULTURE AND RURAL ECONOMICS

THE ROLE OF MIGRATION THEORIES IN FOREIGN EMPLOYMENT IN SZEKLERLAND

PÉTER EMŐKE KATALIN – VARGA JÓZSEF

ABSTRACT

In our study we examine the theoretical background to working abroad in Romania. In this context, we will review different types of migration theories, distinguishing between macro-, meso- and micro-level theories.

Macro-level economic theories of migration examine the economic causes and effects of migration at the national or global level. Macro-level theories of migration analyse the interaction of structural and economic factors. Macro-level theories of migration examine population movements in the context of economic, social and political factors, in particular labour market and development disparities.

The macro-level analysis of migration analyses the interaction between structural and economic factors.

Mesolevel theories examine how social relations influence international migration. Here, the new economic theory challenges many of the factors of neoclassical theory, thereby looking not at the individual as the decision-maker, but at the family as they seek to minimise risk while maximising their income.

The micro-level theories look at the decisions of individuals, using cost-benefit calculations to determine migration. Within this group, we analyse the micro-level theory of neoclassical economics and present the theory of value expectation.

Key words: foreign employment, economic causes of migration, economic effects of migration, migration theories,

1. INTRODUCTION

Research on foreign guestwork is a topical section of the current literature on public economics. However, relatively little empirical research and information is available on the importance of the chosen topic. The experience so far suggests that the organisation of the work of workers leaving Romania for work outside Romania, the registration of workers and the regularisation of their legal status have taken on a professional entrepreneurial character. The importance of this area for the national economy is significant not only for the labour market but also for the Romanian balance of payments.

The economic relevance of the topic justifies the theoretical aspects of the migration process before analysing the empirical data (which we plan to do in another paper). In our study we will explore this topic by analysing the specificities of the different theories of migration.

2. LITERATURE REVIEW

In terms of the duration of migration, it is important to distinguish between commuting and short-term and long-term migration. The term 'commuter' is used to refer to persons who are permanently

resident and habitually resident in a country but who regularly travel to another country for work on a daily or weekly basis.

The main difference between short-term and long-term migration is that in the former case the individual stays in another country for less than a year, while in long-term migration the individual lives in another country for more than a year. It is also important to clarify the relationship between migration and commuting. Commuting is a specific form of migration where the place of work and the place of residence are different, but the work is done in a place other than the place of residence. Commuting is characterised by twice-daily inter-municipal flows. This flow can take place not only between countries but also between municipalities, counties and regions. Commuting can be considered as forced or voluntary, depending on the reasons for which the individual takes up a job in another municipality.

Migration types are defined according to several criteria. For example, Cseresnyés (1996) approaches migration in terms of spatial, temporal, decision-inducing reasons and scale. From a spatial point of view, he distinguishes between internal and international migration and, in the case of international migration, between continental and intercontinental migration. In terms of duration, migration may be permanent or continuous. The grouping of reasons for the decision defines voluntary and involuntary migration. In terms of scope, we can also distinguish between individual and group migration (Cseresnyés, 2005).

Migration has played an important role in the life of humanity throughout history. Its role, alongside mobility, is to ensure people's ability to live and work. These migrations have contributed to the efficient use of labour and other resources in a given area. Migration also entails changes in the educational structure of the population, cultural development and the expansion of domestic and foreign markets. In addition to these factors, migration has had a number of negative effects, such as loss of leisure time, population decline and changes in population structure, 'forced' urbanisation and many others.

Today, there are around 8 billion people on Earth, only 9.8% of whom live in Europe. This proportion is gradually declining due to negative natural reproduction and migration. In the first half of the 20th century, international migration flows in Europe were typically influenced by three factors: labour shortages in Northern and Western Europe, European decolonisation (the end of colonialism) and the rise and subsequent fall of communism. In non-communist Europe, three overlapping migration flows were observed after the Second World War.

Labour migration due to labour shortages in Northern and Western Europe, family migration for family reunification and post-industrial migration of skilled labour. Post-colonial migration was also a feature of this period. The scale and direction of migration was determined by economic transition, political change and ethnic conflicts in Central and Eastern Europe (Kliment, 2018).

The most common type of migration in the European Union (EU) is migration for work, which is mainly based on the wage gap between Member States, as free movement of labour is allowed at EU level, but strict rules apply to those from outside the EU. Thanks to the free movement of workers, the wage gap between East and West is gradually narrowing. In the long run, wage convergence could lead to a reduction in labour migration (Elvira, 2015).

The possibility of free movement of labour that came with EU accession has triggered a flow of labour from east to west, towards developed countries. The accessions of 2004 and 2007 (2004: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovenia, 2007: Bulgaria, Romania)

created some uncertainty, thus imposing temporary restrictions on the EU host countries. With the exception of Sweden, Ireland and the United Kingdom, these restrictions have been gradually lifted, with Germany and Austria being the last to do so in May 2011.

By 2017, the share of labour immigrants in the EU had reached 10%, mainly in the developed Western regions. With increasing east-west migration, the principle of a single market is moving ever closer.

The post-accession emigration was significant in countries with high unemployment (Romania, Poland, Slovakia and the Baltic countries). As a consequence of emigration, unemployment in these countries has, of course, decreased (Hárs, 1992).

2.1. MIGRATION THEORIES

There are several theories on the interpretation of international migration, which examine the fact of migration from different perspectives, but they have in common that they try to identify the causes of migration and the factors that influence it. These theories can be grouped around three levels: micro, meso and macro (Czibik et al., 2014)

2.1.1. MACRO-LEVEL THEORIES

Macroeconomic theories of migration examine the economic causes and effects of migration at the national or global level. These theories are based on different economic models and explore the factors that influence migration and its consequences for sending and receiving countries.

Hein de Haas (<https://heindehaas.org/wp-content/uploads/2016/03/de-haas-2010-imr-migration-and-development-a-theoretical-perspective-2011-hungarian-translatoin.pdf>)

The theory of push and pull

The push and pull theory attempts to explain the spatial factors of migration, but the individual, who is the actual decision-maker with respect to migration, is given an important role (Galovics, 2019). An individual who wishes to move is induced to migrate by factors favourable to him/her in the destination country, but on the other hand, he/she is encouraged to migrate by unfavourable factors in his/her home country. Disincentives include all economic, social and political factors that affect an individual's life, such as low living standards, poor living conditions, wars, natural disasters, etc. The group of attractive factors includes those factors that encourage an individual to migrate in the desti

The macro theory of neoclassical economics

This theory states that migration is based on wage differentials between countries, so that when wage differentials are equalised, migration stops. If other markets have no effect on migration, countries can influence migration through the income they provide.

According to the macro-level theory of neoclassical economics, migration is fundamentally determined by economic incentives, in particular wage differentials and labour market conditions. The theory assumes that labour flows between countries or regions from lower to higher wage areas until the differences are equalised (Golovics, 2021).

According to the neoclassical model, migration is an equilibrium process that leads to a more efficient allocation of economic resources in the long run. When there is a labour surplus in a country, low wages cause some of them to emigrate, reducing supply and thus increasing wages in the sending

country. At the same time, the increased labour supply in the receiving country reduces wages and, over time, the wage gap narrows.

Under this model, migration acts as a **self-regulating mechanism** that contributes to achieving global equilibrium. However, if labour mobility is hampered by legal or social barriers (such as strict immigration policies or cultural differences), the equilibrium process is slower.

In sum, neoclassical economics interprets migration in **terms of economic rationality** and sees it as a market process that promotes a more efficient allocation of labour and a reduction in wage differentials.

The theory of the dual labour market

The theory of the dual or segmented labour market was first explored in the 1950s, but at that time it was only analysed in terms of the internal workings of larger companies. They concluded that within a given company, the market is segmented and sub-markets are separated.

The dual labour market does not look at the intentions of individuals and the forces that influence them in terms of international migration, but studies migration in the context of a whole society. Thus, according to the theory, for states that are engaged in industrial activity, continuous labour migration is essential to reduce labour shortages (Hautzinger et al. 2014).

2.1.2. MESO-LEVEL THEORIES

Mesolevel theories examine how social relations influence international migration (Czibik et al. 2014).

The theory of the new economics

This theory of migration challenges many of the factors of neoclassical theory, thus looking not at the individual as the decision-maker, but at the family, who seek to maximise their income while minimising risk.

In addition to working at home, family members have the option of working abroad in the hope of better working conditions and higher wages. In this case, if economic conditions at home were to deteriorate, a family member working abroad could be a significant help to a family in difficulty at home.

In developed countries, private insurance is used to reduce income risks, but there is also a well-established credit system that can help families with investments and unexpected expenses. In developing countries these options are not available, so many people choose to migrate to avoid high risks (Sik, 2012).

Network theory

This theory examines changes in migration by taking into account the forces (family, friends) that influence the individual's decision. This analysis is based on the relationship of cumulative causality, as the number of people in a society who wish to emigrate increases as the migration network develops. A well-developed network of connections allows many people to emigrate more easily, while reducing the costs associated with emigration. Adequate connectivity reduces the uncertainty associated with emigration, changing people's attitudes towards migration, leading to a strengthening of network theory (Galovics, 2019).

Institutional theory

Institutional theory seeks to create institutions/organisations that facilitate migration. These institutions can take many forms, from profit-seeking, exploitative, illegal institutions to fully formal and formal institutions. As migration becomes more widespread, various businesses are also intervening in the management and subsequent integration of migration. These enterprises can be service companies, transport companies, but also humanitarian organisations providing social assistance. Regardless of their field of activity, their common objective is to attract as many people as possible to use their services, thereby gaining exposure and profit (income).

It is relatively difficult for the state to regulate migration processes, as international migration is gradually becoming institutionalised and difficult to regulate (Hautzinger et al., 2014).

2.1.3. MICRO-LEVEL THEORIES

Micro-level theories examine the factors that influence individual migration decisions from political, economic and social perspectives.

Micro-level theory of neoclassical economics

The microeconomic theory of migration focuses on the choices of individuals and households, taking into account cost-benefit analysis and rational choice. The theory suggests that people choose to migrate if it is likely to increase their income or quality of life. The decision may be influenced by the wages available in the destination country, job opportunities, living conditions and the situation at home, such as unemployment or low earnings (Schultz, 1983).

According to neoclassical theory, migration occurs because of labour market imbalances: people migrate from low-wage regions to higher-wage areas. Human capital theory adds to this by arguing that the decision to migrate may be motivated by skills and improved employment opportunities (Galovics, 2019).

According to the household economic model, migration is not only an individual decision but also a family decision to reduce risk and diversify income. The decision to migrate is rational: individuals carry out a cost-benefit analysis that takes into account differences in expected incomes, the costs of travel and settlement, and legal and social barriers. Workers migrate to where their productivity is higher and economic opportunities are better.

The microeconomic theory focuses on the result of the complex interaction of economic and social factors in migration. The route is chosen by individuals according to where they can earn the highest income. In order to achieve this goal, the individual faces various expenses, which may be related to: expatriation, subsistence, language/culture learning, but also the psychological costs of adapting to a new environment.

Individuals who decide to migrate calculate the benefits of the different options, taking into account the income and costs involved. The final decision depends on the extent of the benefits (Sik, 2012).

Value expectation theory

Value expectancy theory extends the micro-level theory of neoclassical economics by stating that an individual chooses between two options which are more useful to him. Thus, the individual's action is determined by what is more beneficial to him. Furthermore, the value expectancy theory states that

the existence of expectation is given space alongside personal preferences. Unlike neoclassical economics, which focuses primarily on returns, this theory also takes other benefits into account. These benefits can be broadly related to many things, from personal well-being to social conditions. Overall, this theory suggests that an immigrant may not only be a person working for an income, but also an individual belonging to different political, ethnic, religious groups. It is also important to note that immigrants often evaluate their decisions afterwards (Czibik et al.2014).

3. SUMMARY

In our study, we have examined different types of migration theories as a theoretical background for the study of foreign employment in Romania. We consider our study as a missing work in the economics literature because the research on foreign guestwork is a neglected field compared to its significant one.

The economic theories of migration at different levels (macro, micro and meso) examine the economic causes and effects of migration. In our work, we find that the operation of the labour market for labour leaving Romania outside Romania has taken on a distinct entrepreneurial character. This has made working abroad significantly easier and less risky.

Working abroad is also important for the Romanian labour market and for development disparities, as the language and work experience gained by workers abroad increases the quality of the domestic labour market and thus reduces Romania's development gap. The experience so far shows that the importance of this area for the national economy, in addition to its impact on the labour market, is also important for the Romanian balance of payments, as it contributes significantly to the balance of payments.

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Péter Emőke Katalin

Hungarian University of Transylvania, RO-530104, Miercurea Ciuc, P.Libertatii,1

Varga József

Faculty of Economics, Socio-Human Sciences and Engineering, Sapientia Hungarian University of Transylvania, RO530104 Miercurea Ciuc, Romania

Institute for Rural Development and Sustainable Economy, Hungarian University of Agriculture and Life Sciences, H-7400 Kaposvár, Hungary. varga.jozsef@uni-mate.hu

Department of Macroeconomics, Corvinus University of Budapest, H-1093 Budapest, Hungary

ORCID ID 0000-0002-9199-2599, researcher ID [AAN-9605-2020](#)

ENERGY POVERTY IN THE CENTRAL AND NORTH-WESTERN DEVELOPMENT REGIONS OF ROMANIA - LIVING CONDITIONS OF FAMILIES

PÉTER EMŐKE KATALIN - SZABÓ ÁRPÁD

Abstract

Poverty and social inequalities directly affect access to and distribution of food. Growing food insecurity in most parts of the world poses serious challenges for governments and international organizations and requires special attention in agricultural and economic policy planning.

In contrast, energy poverty is a condition where a household cannot provide enough energy to meet its basic needs. This can include adequate heating, cooling, lighting and water heating. Energy poverty can have a number of negative consequences, including physical and mental ill health, social exclusion and economic hardship. Like energy poverty, energy vulnerability has become a serious social problem today. It refers to a combination of factors that can lead a household into energy poverty, even if only temporarily.

Energy poverty in Europe has increased in recent years. According to a European Commission report for 2023, 9.3% of EU households will not be able to heat their homes adequately. This means that around 45 million people in Europe are living in energy poverty. By contrast, in Romania, the energy poverty rate was 26.7% in 2020, but by 2023, 49% of households will be affected, far above the EU average (9.3%). This means that around 5.5 million households in Romania will have problems ensuring adequate heating.

Based on a quantitative survey in the Central and North-Western Development Regions of Romania, this empirical research aims to identify the most common causes of energy poverty. These include low incomes, rising energy prices and a high number of low energy efficient buildings.

Keywords: poverty, energy poverty, low incomes, household costs

JEL: D12, D13, D14, D15

Introduction

Energy poverty—defined as the inability of households to access and afford adequate energy services such as heating, cooling, lighting, and appliance use—has emerged as a critical socio-economic challenge in Europe, particularly in Central and Eastern European (CEE) countries (Thomson, Snell, & Bouzarovski, 2017; Boardman, 2010).

The phenomenon is especially acute in Romania, where structural housing deficits, rural underdevelopment, and rising energy prices have compounded vulnerabilities.

The World Bank reports some key figures about Romania (World Bank Group, 2024):

- 25% of Romanian population experiencing from some form of energy poverty in 2021,
- 63,8% of households in rural areas used wood, coal or oil stoves as heating source,
- 8,7% of total household expenditures allocated to energy in 2021,
- 17,8% of households facing difficulties with unpaid bills in 2022,
- 15,2% of households struggled to maintain warmth within their homes in 2022

In 2023, nearly 49% of Romanian households experienced energy poverty, significantly above the EU average of 9.3% (Péter & Szabó, 2024; European Commission, 2023).

The Central Region of Romania, encompassing counties such as Harghita, Covasna, Mureş, Braşov, and Alba, presents a poignant case of energy deprivation. Although rich in renewable energy potential, the region is characterized by outdated residential infrastructure, reliance on traditional heating fuels (e.g., firewood), and limited access to high-efficiency heating systems (Péter & Szabó, 2024). Rural households are especially vulnerable; over 80% still heat with wood, often using inefficient clay or metal stoves, and many buildings are built from low-quality or damp-prone materials (ORSE, 2022).

Energy poverty in Romania must be understood not only through the lens of material deprivation but also through the concept of energy vulnerability, which refers to the structural susceptibility of households to fall into or remain in energy poverty due to socio-economic, environmental, and institutional factors (Bouzarovski & Petrova, 2015). This framework emphasizes the dynamic and externally conditioned nature of energy insecurity—one that transcends income alone to include housing quality, geographic isolation, and limited access to information or support mechanisms (Middlemiss & Gillard, 2015; Sovacool, 2012).

A recent empirical study conducted between February and April 2024 surveyed 585 respondents from nine counties, with a focus on Harghita County. The findings revealed that energy poverty cuts across socio-economic groups: 24% of PhD holders and 36% of low-level managers reported deferring energy bill payments to afford food and medicine, while 15% of all respondents were unable to heat their entire home during the 2023/24 winter season (Péter & Szabó, 2024). These outcomes confirm earlier findings that energy poverty correlates not only with income but also with housing tenure, education, and employment status (Walker & Day, 2012; Reames, 2016).

Moreover, the political and economic repercussions of the war in Ukraine have further exacerbated household energy stress. As heating costs soared in 2022–2023, many households were forced to choose between essential goods and energy payments, thereby reinforcing long-term vulnerability (Péter & Szabó, 2024; Ember, 2024).

At the European policy level, initiatives such as REPowerEU and the Green Deal offer strategic direction and funding for improving energy efficiency and decarbonization (European Commission, 2023). However, Romania's absorption of such programs has been limited by administrative fragmentation and low institutional capacity at local levels (Bouzarovski, 2018). Without targeted interventions—such as retrofitting programs, smart metering expansion, and energy-efficient boiler subsidies—the risk remains high that entire segments of Romania's population will be left behind in the green transition.

The objective of this article is to analyze the structural, behavioral, and institutional dimensions of energy poverty in Romania's Central Region. By leveraging new empirical data and synthesizing European and national-level policy frameworks, the article seeks to identify actionable policy measures that can mitigate household-level energy vulnerability and promote a just energy transition.

Material and method

The questionnaire for the quantitative survey was edited on Google Forms and it was reachable on the Internet from February to April 2024. The questionnaire was freely shareable and was initially shared through social media and e-mail groups gathering mostly two main categories: friends and colleagues of the researchers, and alumni of the universities where they are employed. This way the sample is not totally random.

After data cleaning, 585 assessable samples were obtained. Respondents came from 9 counties in Romania, but the largest number of respondents (67%) completed this questionnaire from Harghita County. Half of the respondents (50.8%) live in big cities of the country, 13.6% in county centres, 13.9% in small towns and 21.6% in rural areas. Winter heating is provided by gas (52.1%) and wood (38.6%). 14.7% do not heat their entire home during the winter months in the 2022/2023 heating season and the

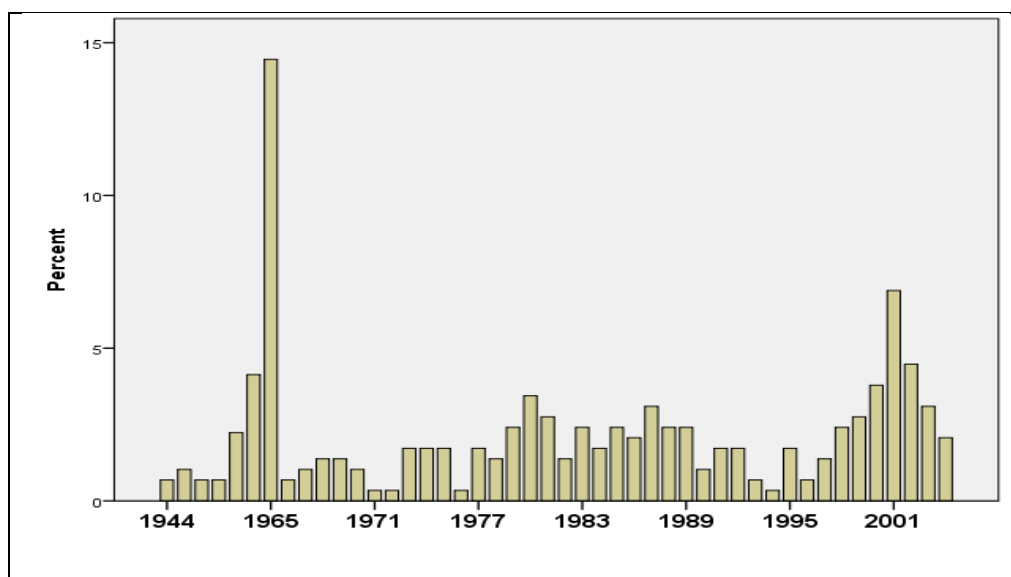
majority (45%) try to ensure 20-21 °C in their living room in winter. In contrast, for the same respondents, in the 2023/2024 heating season, 15% did not heat their entire home and 47.7% had an average temperature of 20-21 °C in their living room. The data were analyzed and figures were edited using SPSS statistical analysis software.

Results

1. Demographic and socio-economic data

Starting with demographical and socio-economic data of the respondents and the households they are living in, we can see from Figure 1.1. that there are two peaks in the respondents birth years: 1965 and 2001. As mentioned earlier, the first respondents were the friends and relatives of the researchers and the alumni of their universities.

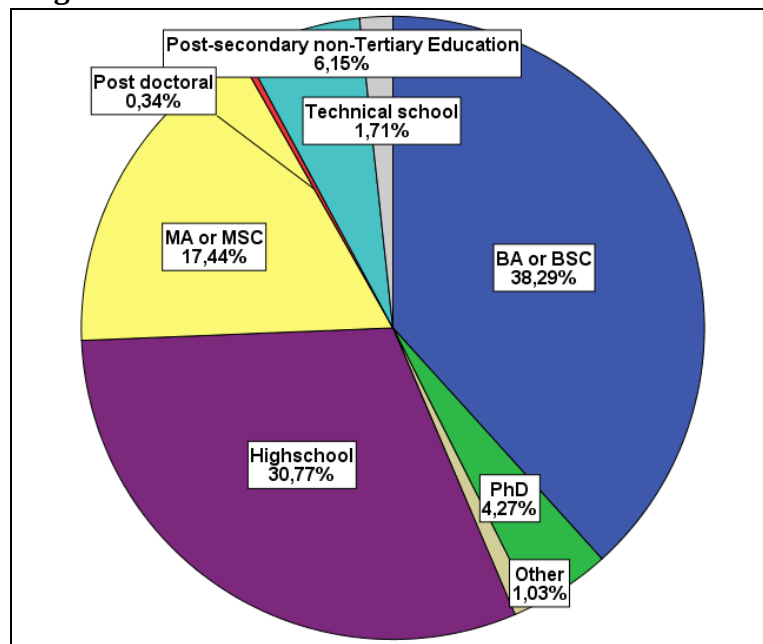
Figure 1.1: Year of Birth



Source: own editing based on the surveyed data

Figure 1.2. shows that more than 60% of the respondents have bachelor or higher level of studies, 30% are highschool graduates and just 10% have lower levels of study, which brings less data about the (probably) poorer social categories.

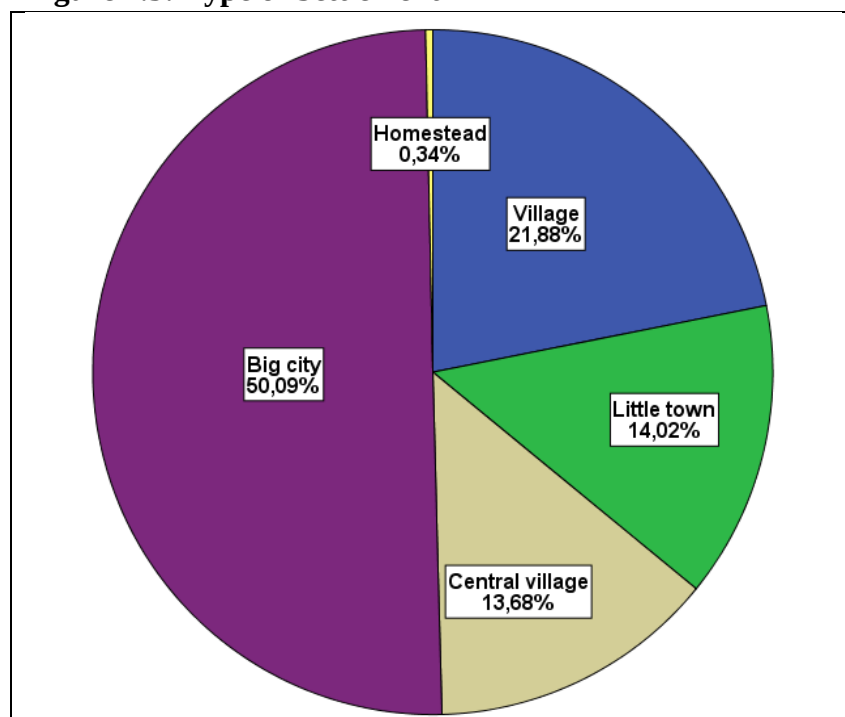
Figure 1.2: Level of studies



Source: own editing based on the surveyed data

54% of the respondents live in urban areas as seen in Figure 1.3, the waste majority of those coming from big cities (municipalities or capital cities of counties).

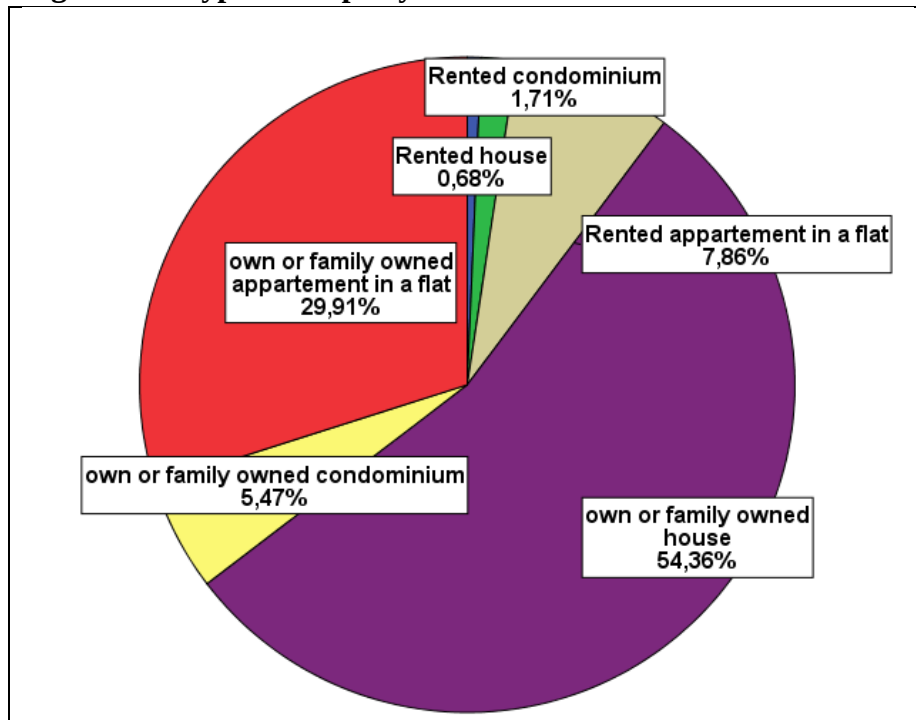
Figure 1.3: Type of Settlement



Source: own editing based on the surveyed data

90% of the respondents have their homes in their own property (phenomenon met in many Central and Eastern European countries), 2/3 of the owners live in houses.

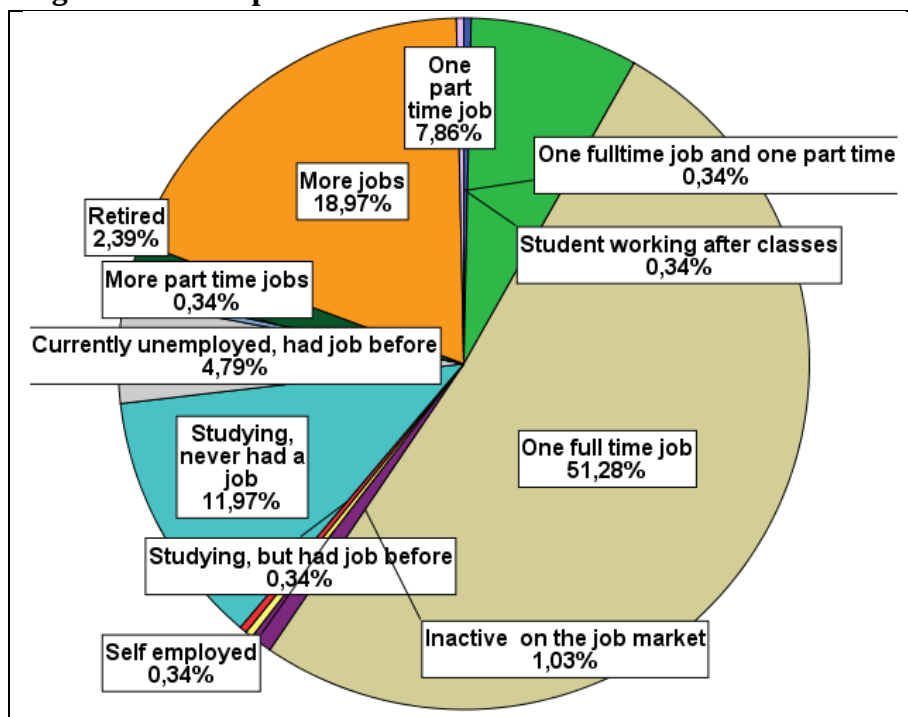
Figure 1.4: Type of Property and house



Source: own editing based on the surveyed data

Only 5,8% of the respondents are unemployed or inactive, 2,4% are retired, 12,5% are studying. 70% have one or more jobs.

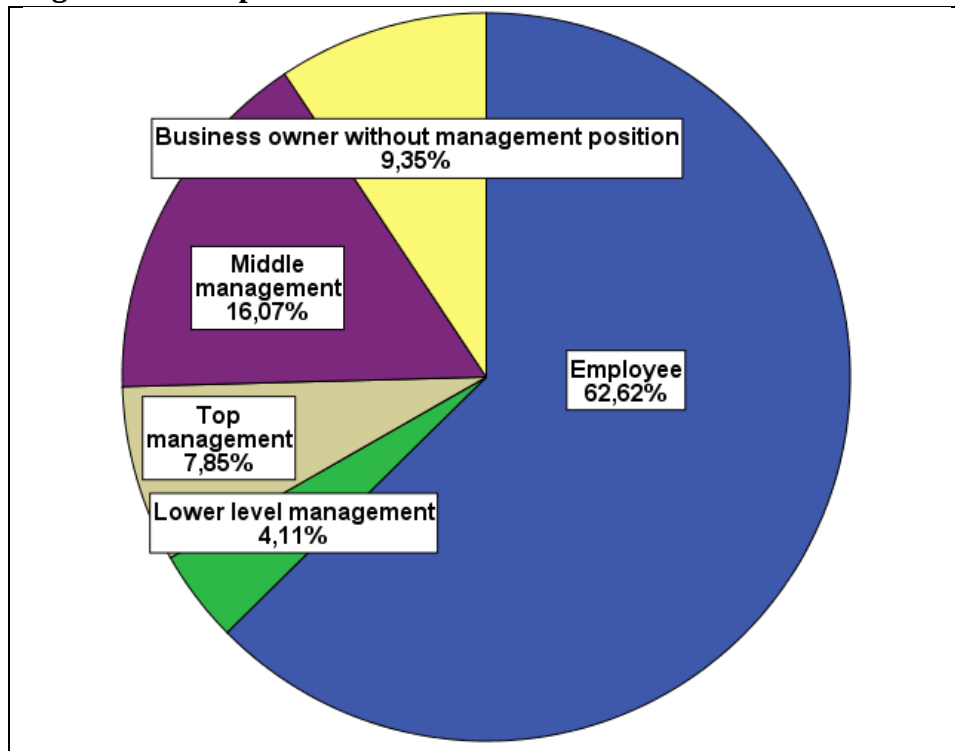
Figure 1.5: Occupation



Source: own editing based on the surveyed data

9,4% are business owners without having management position, 62,6% are employees and 28% have different management positions.

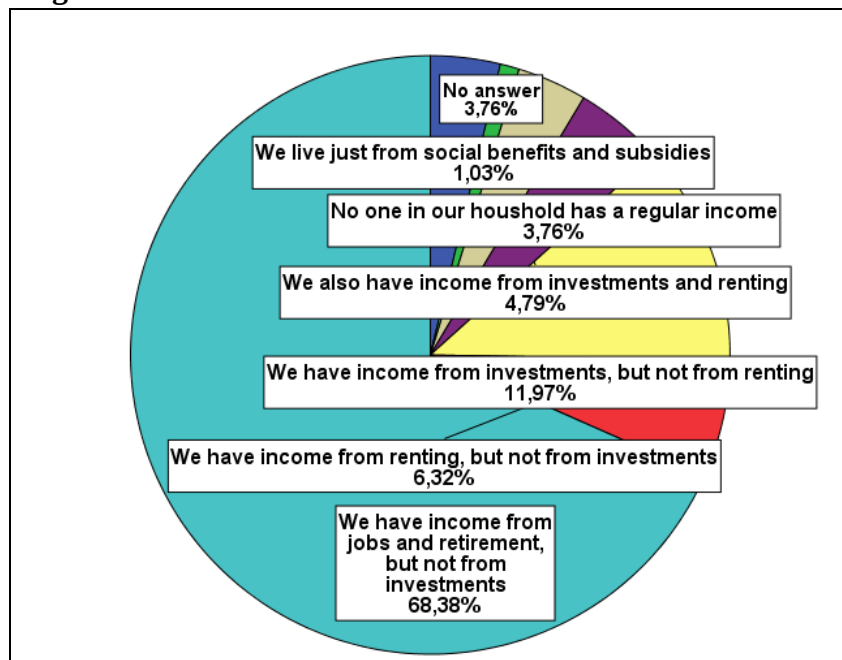
Figure 1.6: Job position



Source: own editing based on the surveyed data

4,8% declare that they live on social benefits or doesn't have any regular income at all, 4,8% real estate and other type of investments, but 68,4% declare no income from investments. Almost 3/4 of the respondents are financially vulnerable.

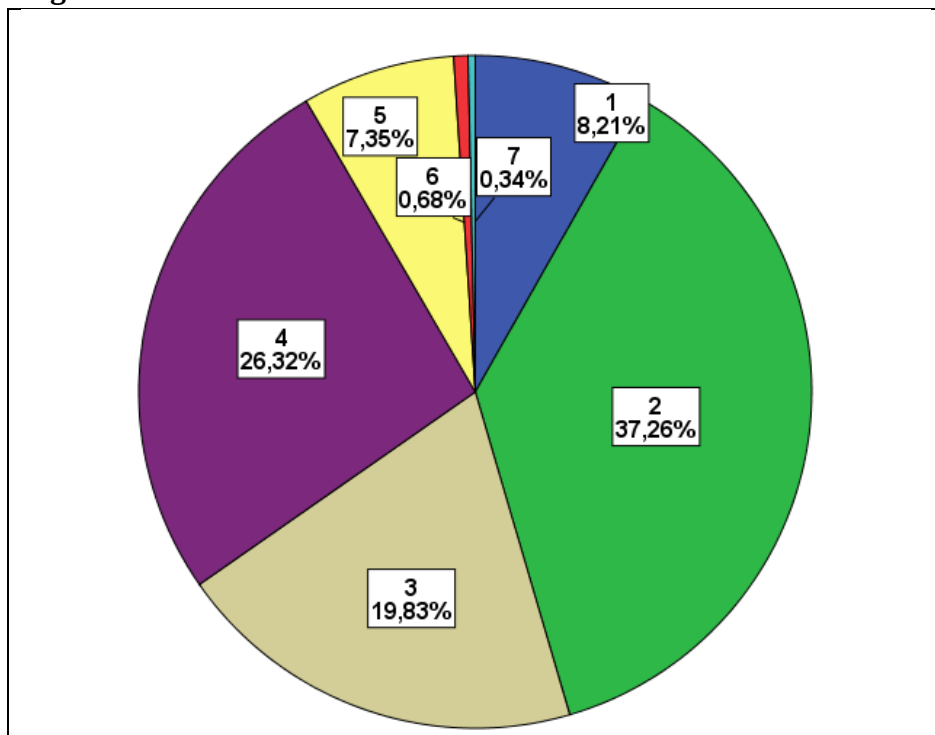
Figure 1.7: Income structure



Source: own editing based on the surveyed data

1/3 of the respondents declare that they live 4 or more persons in the same household, 8,2% are alone in their houses. 57,1% are living 2 or 3 persons in a household.

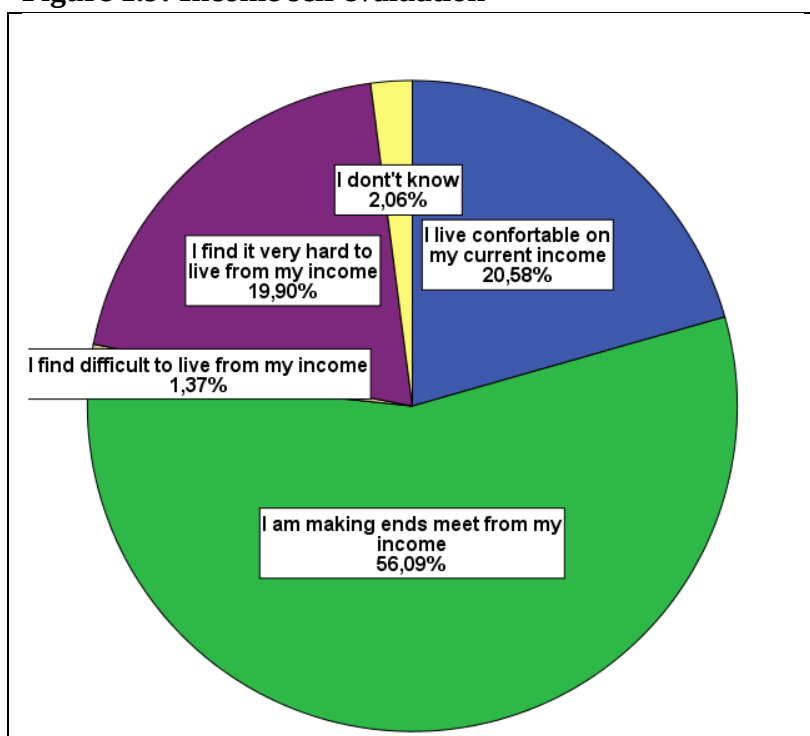
Figure 1.8: Persons in same household



Source: own editing based on the surveyed data

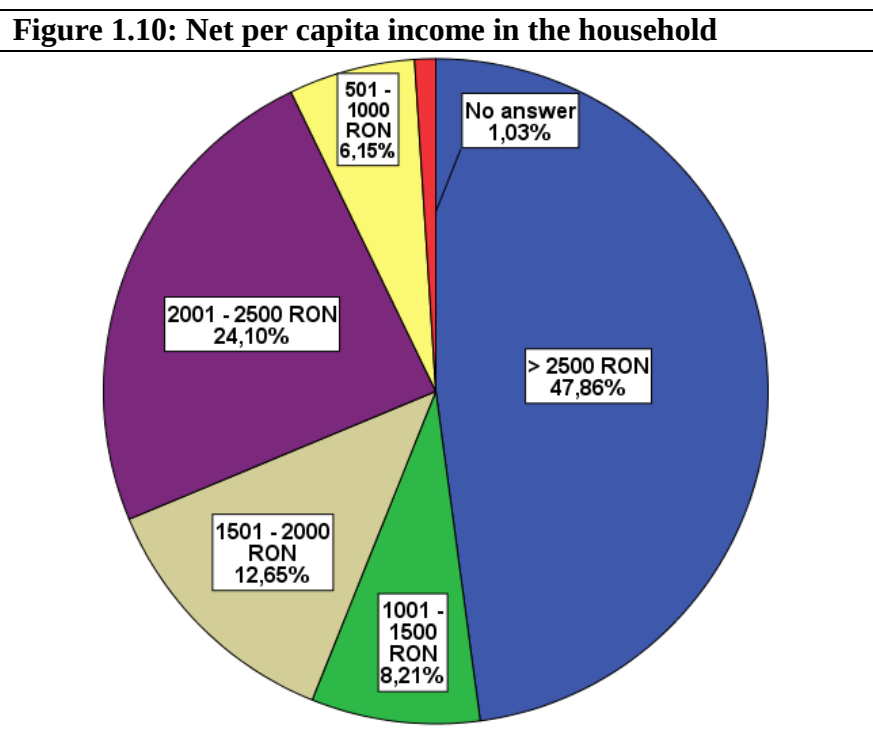
1/5 of the respondents declare that they live comfortable on their current income and 56% are making ends meet. So 24% have financial difficulties.

Figure 1.9: Income self evaluation



Source: own editing based on the surveyed data

For more years the exchange rate between the New Romanian Leu (RON) and EUR was stable, fluctuating between 4,7-4,9 RON/EUR. So Figure 10 shows net per capita income in increments of roughly 100 EUR.

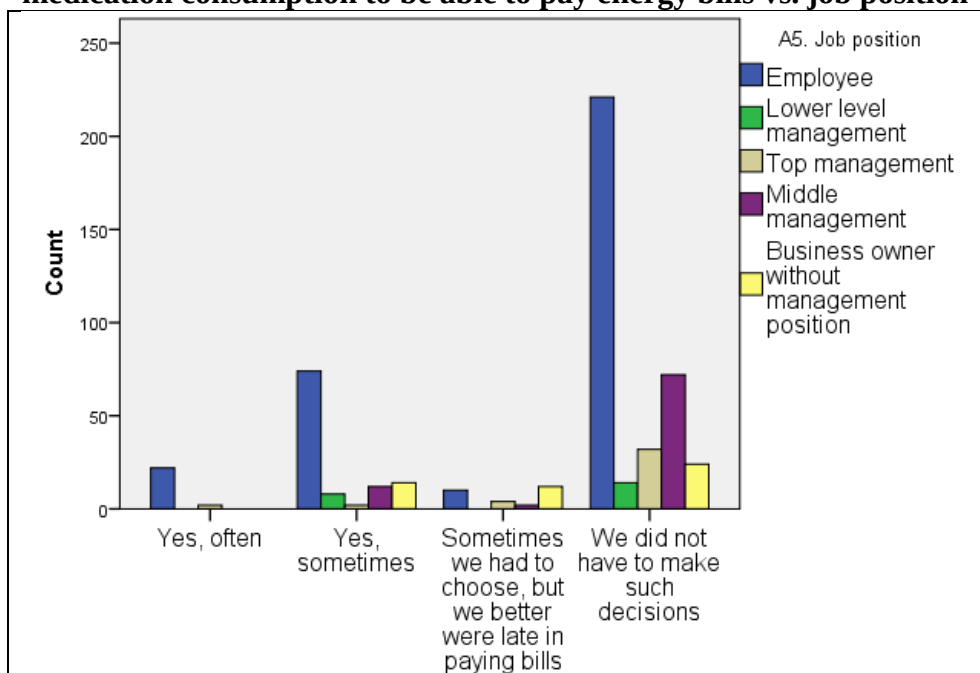


Source: own editing based on the surveyed data

2. Relations between variables

Regarding some results of our research, Figures 2.1 and 2.2 represent the households' decisions to restrict food or medication consumption to be able to pay energy bills versus job position and level of studies.

Figure 2.1: In the last 2 years did you have to restrict food/ medication consumption to be able to pay energy bills vs. job position



Source: own editing based on the surveyed data

69,1% of the respondents declare that they did not have to make such decisions. Interestingly from those who declared the problem occurring often were 5% of the top managers!

Table 2.1: In the last 2 years did you have to restrict food/ medication consumption to be able to pay energy bills vs. job position

	Employee	Lower level management	Top management	Middle management	Business owner without management position	Total
Yes, often	6,7%	0,0%	5,0%	0,0%	0,0%	4,6%
Yes, sometimes	22,6%	36,4%	5,0%	14,0%	28,0%	21,0%
Sometimes we had to choose, but we better were late in paying bills	3,1%	0,0%	10,0%	2,3%	24,0%	5,3%
We did not have to make such decisions	67,6%	63,6%	80,0%	83,7%	48,0%	69,1%
Total	100 %	100 %	100 %	100 %	100 %	100 %

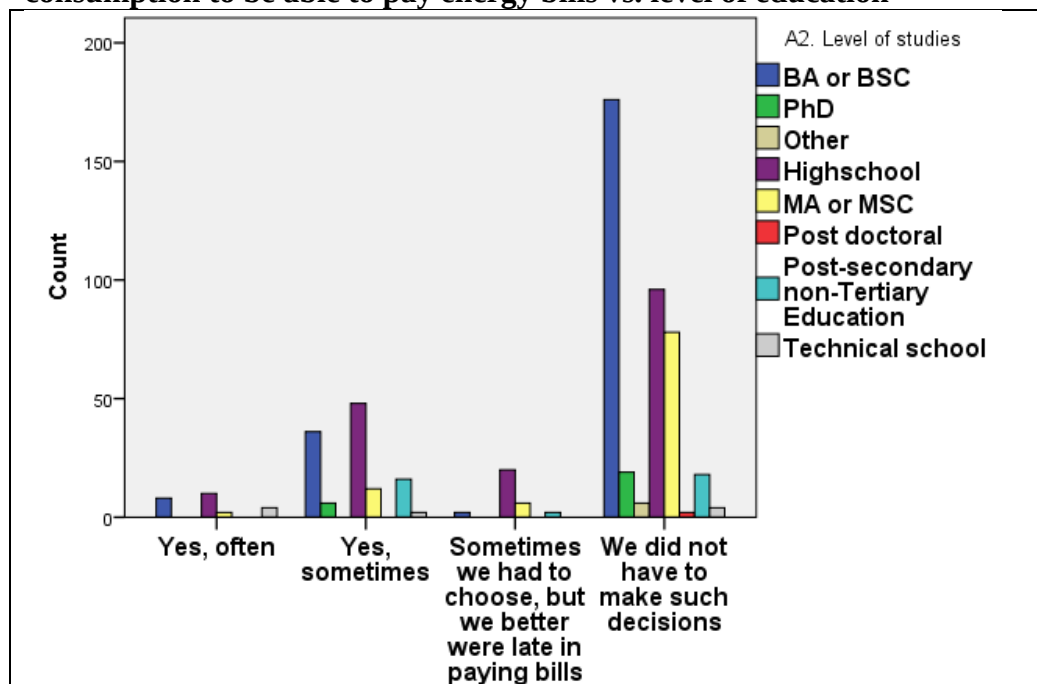
Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	68,428 ^a	12	,000
Likelihood Ratio	63,858	12	,000
Linear-by-Linear Association	3,256	1	,071
N of Valid Cases	525		

The Chi – Square tests show no significant relation between the decision to restrict food or medication consumption to pay energy bills and the job position of the respondents.

a. 9 cells (45,0%) have expected count less than 5.
The minimum expected count is 1,01.

Figure 2.2: In the last 2 years did you have to restrict food/ medication consumption to be able to pay energy bills vs. level of education



Source: own editing based on the surveyed data

Comparing the same answer with the level of studies we see that 60% of technical school graduates have to make such decisions and 33% of highschool graduates have the same problem.

Table 2.2: In the last 2 years did you have to restrict food/ medication consumption to be able to pay energy bills vs. level of studies

	BA or BSC	PhD	Other	Highschool	MA or MSC	Post doctoral	Post-secondary non-Tertiary Education	Technical school	Total
Yes, often	3,6%	0,0%	0,0%	5,7%	2,0%	0,0%	0,0%	40,0%	4,2%
Yes, sometimes	16,2%	24,0%	0,0%	27,6%	12,2%	0,0%	44,4%	20,0%	20,9%
Sometimes we had to choose, but we better were late in paying bills	,9%	0,0%	0,0%	11,5%	6,1%	0,0%	5,6%	0,0%	5,2%
We did not have to make such decisions	79,3%	76,0%	100 %	55,2%	79,6%	100 %	50,0%	40,0%	69,6%
Total	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	94,077 ^a	21	,000
Likelihood Ratio	80,893	21	,000
Linear-by-Linear Association	13,057	1	,000
N of Valid Cases	573		

a. 16 cells (50,0%) have expected count less than 5. The minimum expected count is ,08.

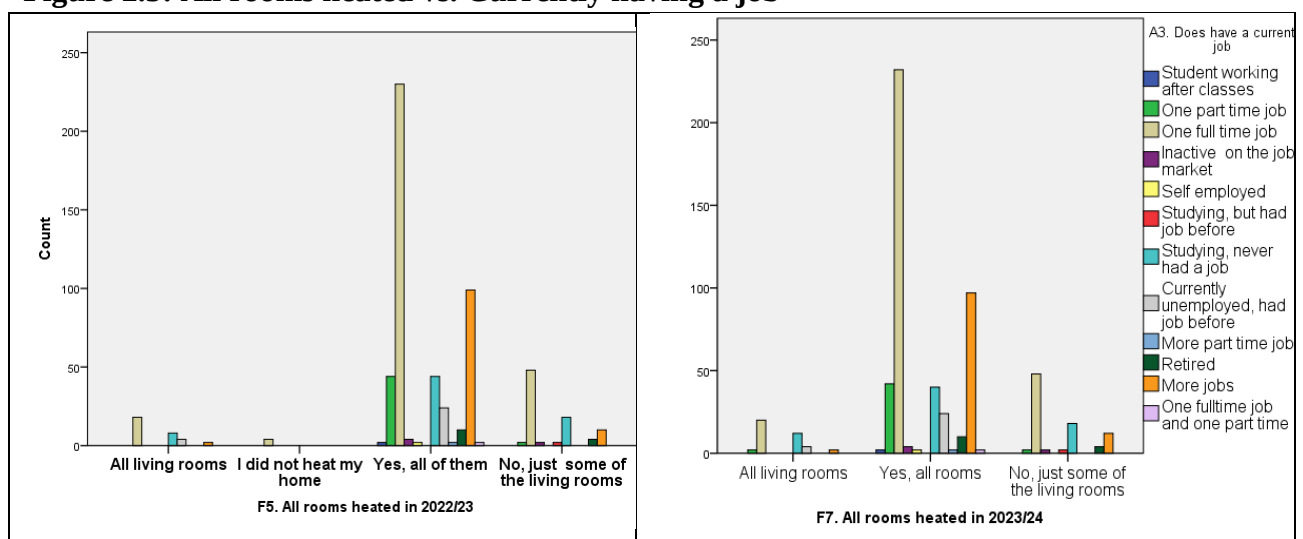
The Chi – Square tests show no significant relation between the decision to restrict food or medication consumption to pay energy bills and the level of education of the respondents.

The following figures analyze if all the rooms of the homes could be heated in the winters of 2022/2023 and 2023/2024. If they did not heat their bathrooms, kitchens and hallways, they could declare some as all of their living rooms. We combined these variables with having jobs, income self evaluation, type of settlement of the respondents' homes, the type of their homes and the condition of the buildings. Correlations were calculated for the later winter.

None of the variables had strong correlations. Because almost 80% of the respondents afforded themselves to heat all their rooms, the remaining 20% is a too small sample to draw general conclusions.

That is the reason why just the tables showing the percentages of the answers and the figures will be presented in the following pages.

Figure 2.3: All rooms heated vs. Currently having a job



Source: own editing based on the surveyed data

78,1% of the respondents declared, that they could heat all the rooms of their houses. 14% of the unemployed heated all they living rooms, but not the others, 1/3 of the inactive on the job market did not afford to heat all living rooms.

Table 2.3: Does have a current job vs. All rooms heated in winter 2023/24

	One part time job	One full time job	Inactive on the job market	Studying, but had job before	Studying, never had a job	Currently unemployed, had job before	Retired	More jobs	Total
All living rooms	4,3%	6,7%	0,0%	0,0%	17,1%	14,3%	0,0%	1,8%	6,8%
Yes, all rooms	91,3%	77,3%	66,7%	0,0%	57,1%	85,7%	71,4%	87,4%	78,1%
No, just some of the living rooms	4,3%	16,0%	33,3%	100 %	25,7%	0,0%	28,6%	10,8%	15,0%
Total	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %

Surprisingly 13,3% of the respondents who declared that they live comfortable on their current income told that they did not heat all the rooms of their houses. Probably a research could be made about why is this happening.

More than 50% of all income categories heated all their rooms in the winter of 2023/24, even those who declare difficulties or hardships to live form their incomes.

Figure 2.4: All rooms heated vs. Income self evaluation

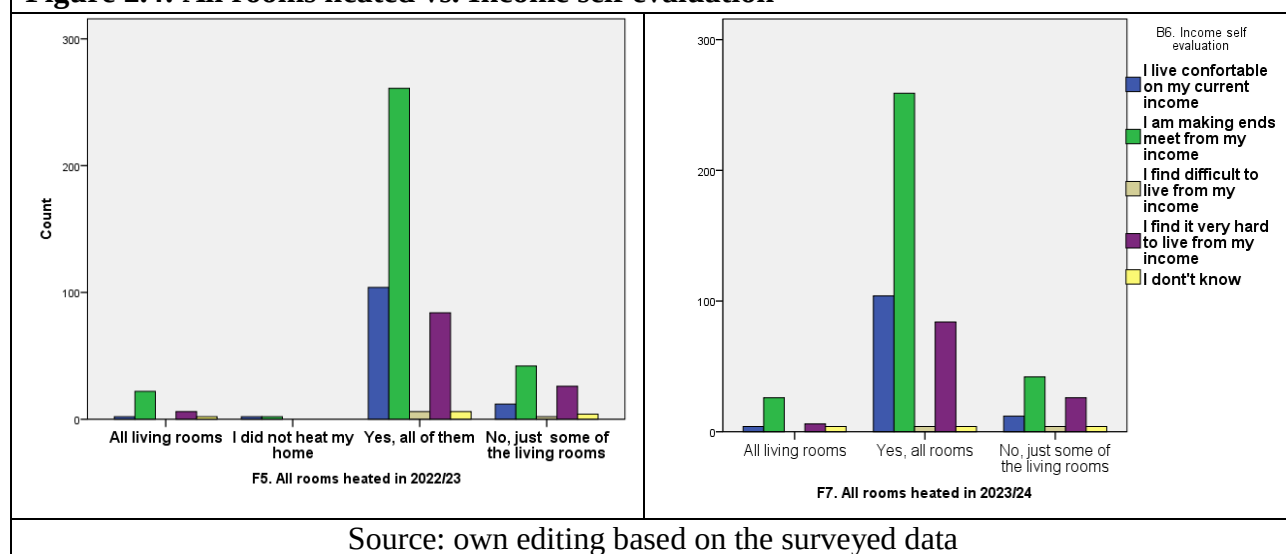


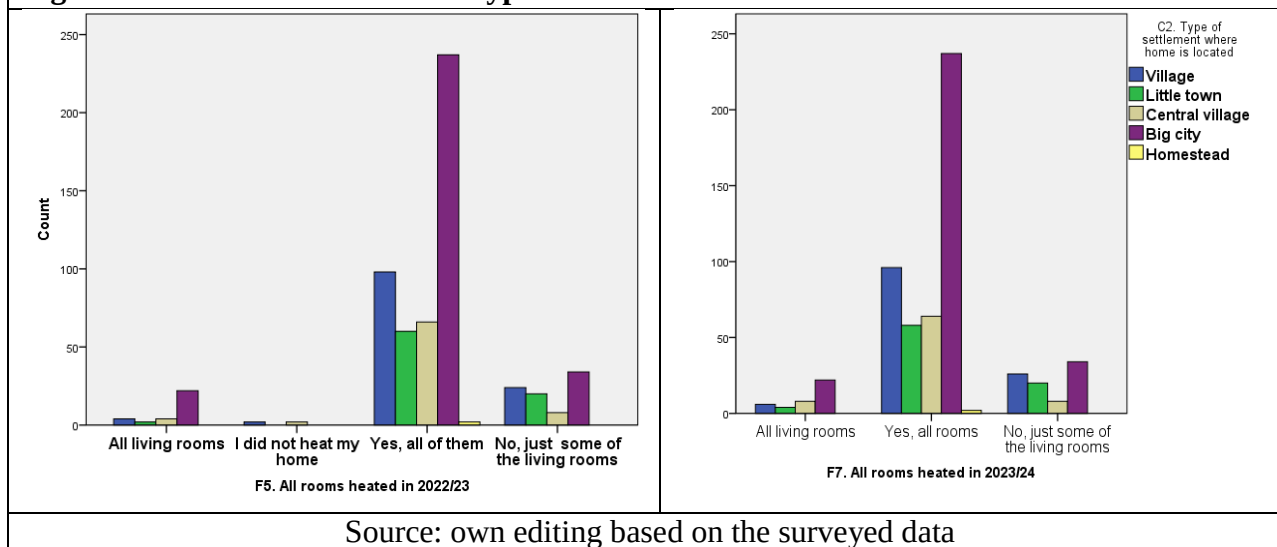
Table 2.4: Income self evaluation vs. All rooms heated in winter 2023/24

	I live comfortable on my current income	I am making ends meet from my income	I find difficult to live from my income	I find it very hard to live from my income	I don't know	Total
All living rooms	3,3%	8,0%	0,0%	5,2%	33,3%	6,9%
Yes, all rooms	86,7%	79,2%	50,0%	72,4%	33,3%	78,0%
No, just some of the living rooms	10,0%	12,8%	50,0%	22,4%	33,3%	15,1%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

When looking at the type of settlement where the respondents are living we have found a surprise. (Table 2.5). Results don't show a gap between urban and rural areas, but between big and small cities. 24,4% of those living in little towns declare that they could not afford to heat all their rooms, while just 20,3% living in villages and 10% of those living in the central villages (the administrative centres of rural governments) admit the same thing. In big cities and municipalities this is true for 11,6% of the respondents.

Probably residents of rural areas go to the forests and gather (or "steal") wood for heating. They survive with the help of these procedures even if their homes are energetically (and financially) inefficient.

Figure 2.5: All rooms heated vs. Type of settlement

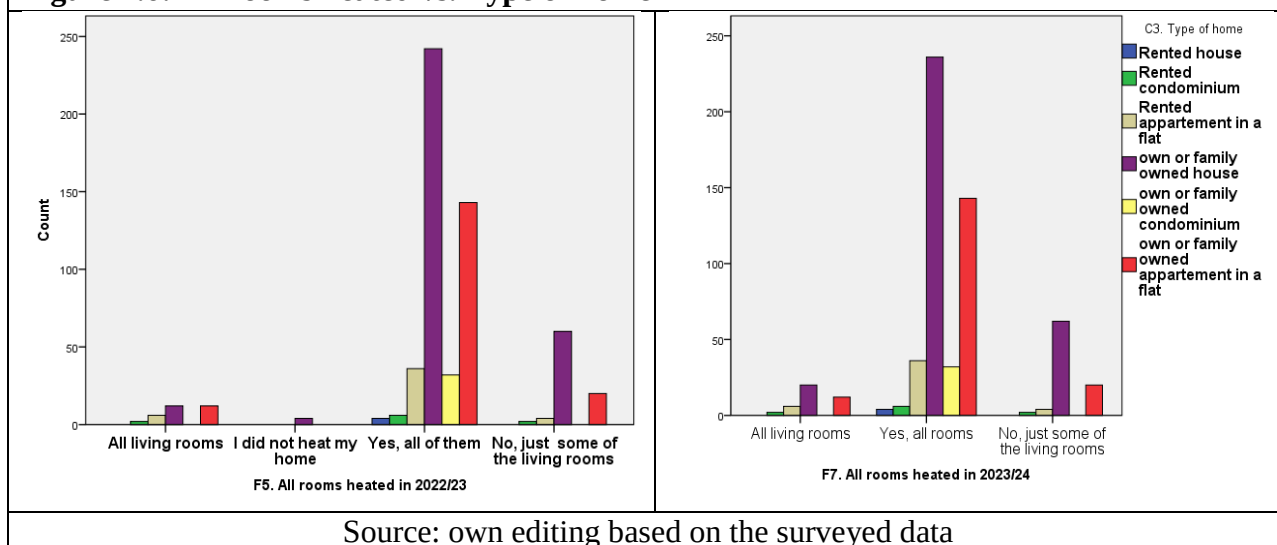


Source: own editing based on the surveyed data

Table 2.5: Type of settlement where home is located vs. All rooms heated in winter 2023/24

	Village	Little town	Central village	Big city	Total
All living rooms	4,7%	4,9%	10,0%	7,5%	6,8%
Yes, all rooms	75,0%	70,7%	80,0%	80,9%	78,1%
No, just some of the living rooms	20,3%	24,4%	10,0%	11,6%	15,0%
Total	100,0%	100,0%	100,0%	100,0%	100,0%

Figure 2.6: All rooms heated vs. Type of home



Source: own editing based on the surveyed data

Considering the type of property and the affordability of heating, we can see that more than 60% of all categories declared that they heated all their rooms. Those who rent their homes on condominiums seem to have a bigger problem (20% heat just their living rooms and another 20% just some of their living rooms). Probably they are those who can't afford to buy their homes even on credit.

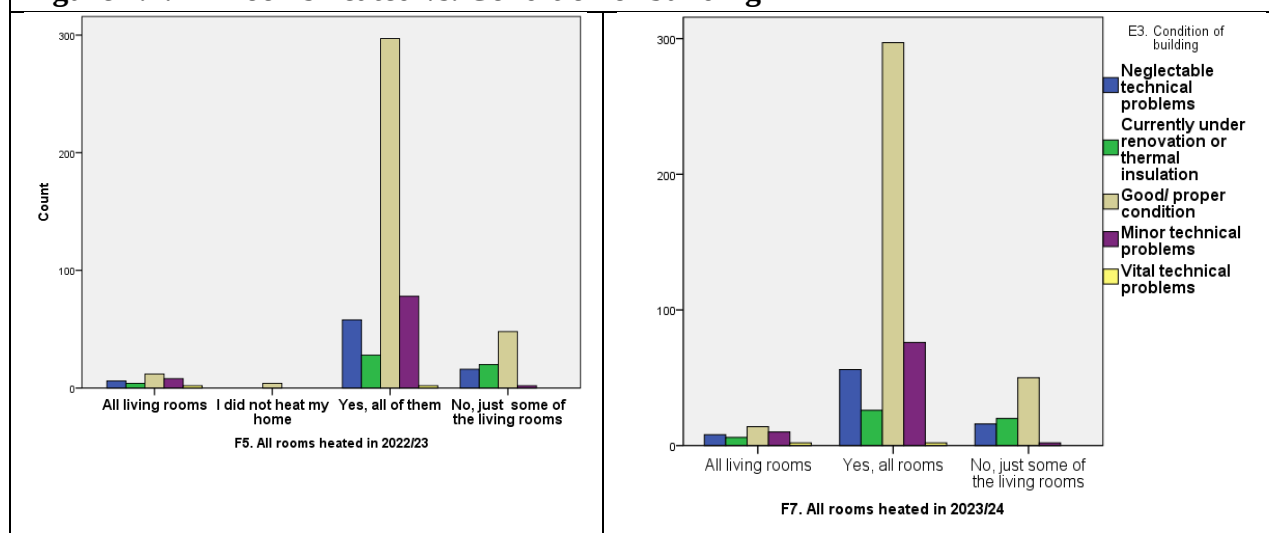
Table 2.6: Type of home vs. All rooms heated in winter 2023/24

	Rented house	Rented condominium	Rented appartement in a flat	own or family owned house	own or family owned condominium	own or family owned appartement in a flat	Total
All living rooms	0,0%	20,0%	13,0%	6,3%	0,0%	6,9%	6,8%
Yes, all rooms	100,0%	60,0%	78,3%	74,2%	100,0%	81,7%	78,1%
No, just some of the living rooms	0,0%	20,0%	8,7%	19,5%	0,0%	11,4%	15,0%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Finally, regarding the decision to heat all rooms compared to the condition of the building we can conclude that 38,5% of those who declared their homes currently being under renovation or thermal insulation did not heat just some of their living rooms. This means that further investigations should make clear if this is due to the undergoing work or due to financial problems.

Surprisingly those who declared vital technical problems in their homes heat all their rooms or at least all their living rooms.

Figure 2.7: All rooms heated vs. Condition of building



Source: own editing based on the surveyed data

Table 2.7: Condition of building vs. All rooms heated in winter 2023/24

	Neglectable technical problems	Currently under renovation or thermal insulation	Good/ proper condition	Minor technical problems	Vital technical problems	Total
All living rooms	10,0%	11,5%	3,9%	11,4%	50,0%	6,8%
Yes, all rooms	70,0%	50,0%	82,3%	86,4%	50,0%	78,1%

No, just some of the living rooms	20,0%	38,5%	13,9%	2,3%	0,0%	15,0%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Summary/ Conclusion

Overall, today, more and more people in Romania are in a situation of energy vulnerability. Energy poverty can be considered as a serious social problem (Chapman, 1989). The research has shown that this phenomenon has been persisting for the last years, since the beginning of the war in Ukraine.

It affects lower, middle and upper managers equally. It affects both crowded cities and smaller towns, as well as rural areas. In our research, we asked about the prevalence of difficulties in paying energy bills over the past 2 years and priorities for food and medicine purchases. Respondents openly admitted to such financial problems, which the surveyed households very quickly and easily became involved in. It is true that they can exit this situation just as easily, but the risk of falling deeper into it is high. If an economic-political solution is not found (Thomson, Snell, & Bouzarovski, 2017), a significant proportion of the respondents will be pushed into a severe economic and social crisis in the future. In addition to health risks, this may also predict that those living in these families will find it difficult to become full members of society.

Our results show a gap between big and small cities. One quarter of those living in little towns declare that they could not afford to heat all their rooms, while just 20,3% living in villages and 10% of those living in the central villages (the administrative centres of rural governments) admit the same thing. Probably residents of rural areas go to the forests and gather wood for heating. They survive with the helps of these procedures even if their homes are energetically inefficient.

Taking in consideration that 78,1% of the respondents (457 persons) afforded themselves to heat all their rooms, the remaining 128 persons sample is too small to draw general and significant conclusions.

The on-line questionnaire is a cheap and fast method for getting responses, but the poorer and less educated people from rural areas who may be also hit harder by the energy poverty problem can not be reached by this surveying method.

We propose that further surveys targeting just the households with these problems should be financially funded and technically backed. We would happily be part of such research teams.

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Emőke- Katalin Péter, PhD

Sapientia University, Faculty of Economics, Socio-Human Sciences and Engineering, Department of Economic Sciences

Libertății square no.1, Miercurea Ciuc, 53 Miercurea Ciuc, 530104 Romania

peterkatalin@uni.sapientia.ro

Árpád Szabó, PhD

Partium Christian University, Faculty of Economics and Social Sciences, Department of Economics
RO 410209, Oradea, str. Primăriei nr. 27

szabo.arpad@partium.ro

CEREAL PRICE TRENDS IN BALANCED ECONOMIC PERIODS

MÁTYÁS LÁSZLÓ – PÉTER EMŐKE KATALIN

Abstract

In the present study, we examine the evolution of cereal prices in periods when economic conditions are broadly stable. These periods are essentially periods of peace, when there were no major wars in the region. Under such circumstances, prices of basic commodities are relatively stable and their variations are essentially continuous. We consider two such periods, the late nineteenth century and the current period spanning three decades. There are both similarities and differences between the two periods, and these are analysed in the paper.

Key words: cereal production, price of wheat between 1867 and 1878 on the market of Budapest, Hungary, price of wheat, on the bourse of Rouen

1. Introduction

During the evolution in time, the mankind arrived to certain stages, which have been evolving faster or slower. The 18th century brought sufficient clarity in different approaches, regarding social and scientific view of phenomena. Consequently, systematical steps arrived on developments, by which the results of innovations started to be seen in different aspects of life.

After a while certain productive processes required an accumulation of capital, the horizontal and vertical aspirations and pursuits became almost equally important. This means that after a while the human activity was dealing with creative contents and accumulative endeavors. At the dawn of Modern Era the different aspects of science and the inventions started to appear not only on efficiency of the industrial tools, but also on the precision of the armament used (Ferguson, 2011). The direct or indirect scientific communication brought an important development of tools. The evolution of ideas and production equipments became a result of not only of inventive aspirations, but also of competition on market and battle field.

In case the strong competing aspects became relatively equal, that may lead to certain periods, characterized with relatively balanced parameters. We try to analyze and compare certain such periods in 19th century and nowadays, highlighting the similarities and differences.

2. Historical background of economic periods

Until the mid-19th century, European cereal production was mainly based on self-sufficiency and aimed at meeting regional needs. Infrastructural changes following the industrial revolution made it possible to transport large quantities of grain relatively quickly and at a more advantageous price. The rural population that created the new towns and cities created a solvent demand for food.

Transport by rail and steamships, which became widespread in the second half of the 19th century, made it possible to bring larger quantities of cereals from the United States, Canada and Russia to European markets. Cheap grain from abroad led to intense price competition. Farmers in Eastern and Central Europe at the time could not compete with cheaper imported grain.

The sharp fall in cereal prices has led to unemployment and impoverishment of people traditionally dependent on agriculture. As a result of the fall in agricultural incomes and rising unemployment, many small farmers have left their homelands and moved to cities or even abroad. This agricultural market phenomenon has had an enormous impact on rural communities in Eastern Europe and has contributed to a large wave of emigration from Europe to the United States. Social tensions in some regions led to political radicalisation. High levels of rural poverty and inequality in land ownership led to long-term agrarian reforms.

At the same time, in Western European countries, cheap cereals lowered food prices, improving the living standards of the urban working class. In the wake of the intensive grain price changes, many countries tried to protect their own farmers with protectionist economic policies. The introduction of grain tariffs raised the price of imported grain, thus favouring domestic producers.

The cereal market situation in the first half of the 19th century was strongly influenced by the feudal structure of the time, but the agricultural revolution and industrial development brought about increased changes. European governments enacted a series of laws to ensure the supply of food, especially cereals for the population.

The central role of cereals as a staple food for national policies and international trade was a key factor in the regulation of cereal markets in the 19th and 20th centuries.

In England in the 19th century, the Corn Laws imposed high tariffs on imported grain to protect domestic producers, but the resulting rise in food prices caused social tension. The high tariffs were intended to protect landowners and producers from competition from American and Russian grain. This protectionist measure was abolished in the mid-19th century when the country opened up to free trade. In France, a protectionist measure was also introduced to improve agricultural production. The spread of new railways and steamships allowed a large influx of cheap American and Russian grain. Russia increased its grain exports to finance industrialisation and modernisation. To this end, it exported substantial quantities of grain to Western European countries, especially Germany and England, until the tariff system made this uneconomic (Tracy, 1993).

The rapid growth in international trade in the second half of the 19th century led to a reduction in cereal duties in many countries. The trade treaty signed between England and France included trade concessions, which later led to tariff reductions with other countries. After the Crimean War, Russia increased its grain exports in order to rebuild its economy, which was met by increased demand for food imports from industrialising Western Europe.

Russia remained the largest supplier of grain to European countries in the last years of the 19th century. As competition on the international market increased, European countries began to protect their domestic producers with tariffs and protectionist measures.

Hungary was a major agricultural producer in the first half of the 19th century. Despite the turbulent historical conditions in Hungary from the 1920s to 1950, the growth of cereal production - although industrial factors developed - was not significant.

An unfortunate consequence of Austrian policy was the failures in Italy around 1860. Austria lost considerable territory in the Austro-Sardinian War. After these events, the Austrian leadership had to understand that it could only succeed in foreign policy if it first sorted out its internal problems. This led to rapprochement and negotiations with the Hungarians, also beginning around 1860 and eventually leading to the Compromise of 1867.

3. Materials and methods

Because of the above presented facts, from 1860 onwards, real progress begins, leading to a virtual steady increase in grain production over the next fifty years. Maize production tripled between 1860 and 1910 (Berend 2003, Sándor, 1958).

For wheat, the ratio is even more favourable. Wheat production has increased fourfold in the 50 years mentioned above (Berend 2003). This is mainly the result of extensive production, i.e. the surplus production is the result of additional arable land being taken up.

In the second half of the 19th century, Europe underwent significant economic and social changes, mainly caused by the transformation of international trade and the development of industrialisation. Hungary's economic development was greatly influenced by protectionist measures introduced to counter cheap grain imports and the agricultural crisis. Thus, agricultural production, protected by high tariffs, helped the large landlord system to survive and made it difficult for the small peasantry to gain a foothold. Rural populations without access to land were forced to migrate, accelerating urbanisation and the growth of the industrial workforce. The role of agriculture became dominant as a result of agricultural protectionism, slowing down the pace of rural industrialisation. The heavy industry and manufacturing industries of the cities began to develop food processing. The rise of rural poverty and land scarcity contributed to a surge in emigration, which culminated in the decades around the turn of the century. Mass emigration to the United States reduced the domestic labour supply. Protectionism had less impact on smallholders and wage labourers, so that social differences between urban and rural populations persisted.

Protectionist policies encouraged technological development in Hungarian agriculture, especially in grain production and livestock breeding. The dominance of the agricultural sector kept the development of industry at a slower pace and hindered the empowerment of the urban working class (Berend, 2003).

In the second half of the 19th century, Hungary's agricultural economy developed as part of the Habsburg Empire. After the Compromise of 1867, within the framework of the Austro-Hungarian Monarchy, one of the main aims of Hungarian economic policy was to increase exports of agricultural products, especially cereals. However, competition and price volatility on international markets posed challenges for Hungarian producers. In times of agricultural crisis, agricultural tariffs were used to raise the price of grain, while the costs of production were reduced by rationalising the economy (Pólya, 1882).

By the end of 18th century the Hungarian wheat export to Austria was only 2,5-3%, around 1840 the export arrived to 10%. Meanwhile Austria afforded the 90% of Hungarian demand of textil products (Honvári 1998).

In the late 19th and early 20th centuries, Romania was primarily an agricultural country, where cereal production played a major role in the economy. In order to gain access to international markets, the

Romanian government introduced various customs measures to protect its own producers from foreign competition and to encourage exports. However, these measures often caused tensions with trading partners and also led to internal socio-economic challenges, such as widening income disparities between landowners and the peasantry (Voroveci, 2003).

World War I brought about major changes in customs laws and grain markets. Reductions in agricultural production led to major food shortages, which were filled by imports of American and Canadian grain. European countries sought to secure food supplies. Tariffs were abolished and some countries even nationalised the grain trade. The United States became a major exporter of food, and its agricultural production began to grow rapidly. After the war, European countries inevitably returned to protectionist policies. These regressive measures were designed to protect domestic producers from cheap American grain (Tracy, 1989).

The global economic crisis has forced several European countries to introduce protective tariffs. These measures meant a contraction of international markets. After the Second World War, the gradual reduction of customs duties between Member States led to the development of common customs policies through international cooperation.

After World War II, international cooperation was strengthened, in particular with the creation of the European Economic Community (EEC). Under the 1957 Treaty of Rome, customs duties between EEC Member States were gradually reduced, while a common customs policy was introduced with third countries. The United States also supported free trade, in particular through the 1947 General Agreement on Tariffs and Trade (GATT), which aimed to reduce tariffs and remove barriers to trade. However, under the 1962 Common Agricultural Policy (CAP), European countries continued to apply protective tariffs on US grain to protect their own farmers (Tracy, 1989).

The evolution of grain tariffs in the 19th and 20th centuries reflects the changing economic and political interests between Europe and America. While protectionism dominated in the first half of the 19th century, the second half of the century saw a shift towards globalisation and free trade. In the 20th century, world wars and economic crises led to a return to rising tariffs, while the post-World War II period saw the beginning of cooperation and trade liberalisation.

The agricultural crisis in the second half of the 19th century was mainly the result of European industrialisation and agricultural overproduction. Cheap grain from the United States and Russia depressed prices, which hit European agricultural countries particularly hard. The low prices led to the ruin of many farmers, resulting in social discontent and political instability (O'Rourke, 1997). The crisis was partly addressed by protectionist measures (e.g. protective tariffs), while the development of agricultural technologies and the adaptation of markets provided a long-term solution (Ecseri, 1906).

As an orientative information after the first world war the wheat production area have decreased to 55,4% relative to the situation before the war (Berend, 1978, p. 203).

The armed conflict in Ukraine, which started in 2022, not only created geopolitical tensions but also had serious economic consequences, particularly in terms of food prices and grain supply (Abdullah et al., 2024). Ukraine is one of the world's largest grain producers and exporters, so the disruption of supply chains has been felt globally. The impact of the war has led to a dramatic change in grain prices, resulting in significant economic and social challenges worldwide.

Before the outbreak of the war, Ukraine was one of the world's leading exporters of wheat, maize and sunflower oil. The country's fertile land played a major role in supplying markets in Europe, Africa and Asia. But the Russian invasion reduced agricultural production, damaged infrastructure and blockaded ports, preventing exports. In addition, global fertiliser supplies have also fallen, as Russia and Belarus are among the world's largest fertiliser producers.

After the outbreak of the war, global grain prices surged as investors and food market players worried about security of supply. Wheat prices, for example, reached decade highs in March 2022, while corn and sunflower oil prices also rose sharply. Speculation and supply insecurity have further exacerbated price increases, which have been a particular problem for low-income countries (Faquin et al., 2003).

In Europe, the rise in inflation was partly due to increases in cereal and food prices. Farmers have been hit hard by the dramatic increase in fertiliser and fuel costs, which has spread to the rest of the food supply chain. The European Union has tried to mitigate the effects through various measures, such as increasing the flexibility of the Common Agricultural Policy and seeking alternative sources of supply.

In the long term, diversifying agricultural production, improving food storage and using sustainable agricultural technologies can help reduce the impact of this type of crisis. Reducing food self-sufficiency and import dependency has become a key issue for the European Union. While some measures have helped to mitigate the crisis, the vulnerability of the global food system remains a major challenge. Long-term solutions and sustainable agricultural policies are needed to avoid future crises.

The impact of the war in Ukraine on cereal prices and food security has been felt around the world. Drastic price rises have hit poorer countries and developing markets particularly hard, while developed countries have also faced inflationary pressures and supply problems (Mukhtar, 2023). While some measures have helped to alleviate the crisis, the vulnerability of the global food system remains a major challenge. Long-term solutions and sustainable agricultural policies are needed to avoid future crises.

The common feature of both the 19th century cereal crisis and the fluctuations in cereal prices caused by the modern war in Ukraine is that the disruption of global food supplies had significant economic and social consequences. At the same time, the causes and crisis management mechanisms differ.

Overall, both the 19th century and the modern cereal crises have highlighted the vulnerability of food supply, but while industrialisation and market restructuring were the main causes of past crises, geopolitical conflicts are the main threat to food security today.

4. Results

Time series of investigated periods

In the following we present two periods, when the wheat prices were relatively stable. Even in normal situation the price fluctuates around a value, certain unpredictable situations may lead to sudden change.

The first period in the 19th century, based on Sándor 1958. The evolution of wheat price, on the market of Budapest, between 1867 and 1878 is presented in Table 1.

Table 1. The price of wheat between 1867 and 1878, on the market of Budapest, Hungary.

Year	Price (Forint)
1867	12.06
1868	10.02
1869	8.98
1870	10.18
1871	12.18
1872	13.32
1873	14.76
1874	13.08
1875	9.72
1876	10.97
1877	12.3
1878	9.96

The graphical representation of this price evolution in time can be seen below. Figure 1. presents different prices at different years.

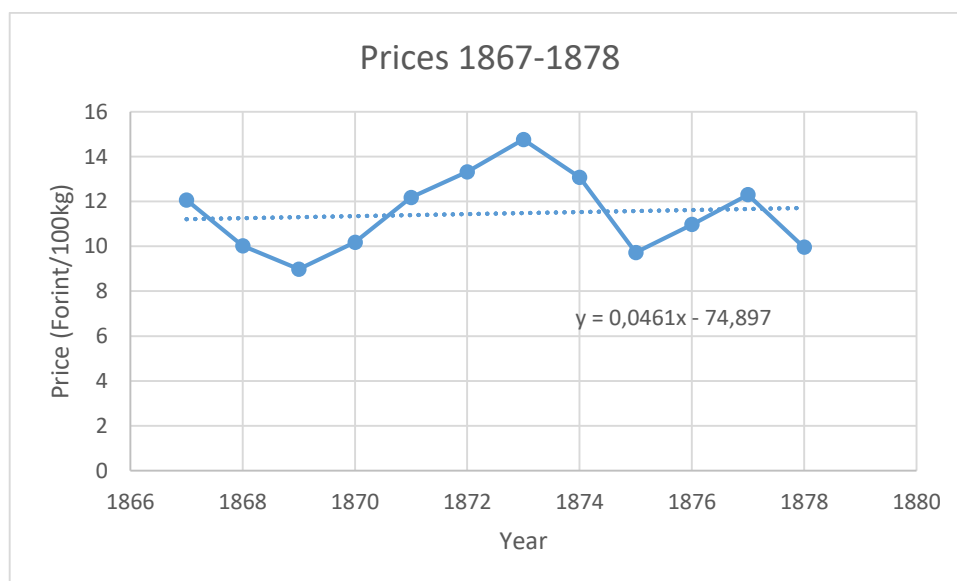


Figure 1. The price of wheat of one quintal – 100 kg – on the Market of Budapest.

Source: Sándor, 1958, 68 p.

The time evolution of the price on Figure 1. can be approximated by a linear regression line

$$y = 0.0461 \cdot x - 74.897 .$$

Because the steep of this line is very small relative to the term 74.897, one can say, that the price is practically constant in this period, the average value being 11.46 Forint/100kg.

Nowadays, we have a slightly different wheat price evolution. In spite of the fact, that in most of the countries is peace, in case if one or two wheat exporting countries is in war, that may influence considerably the wheat price. In the following we study the wheat price by choosing a market, which surroundings have certain stability. In Table 2 one can see the wheat price of the market of Rouen (France).

Table 2. The price of wheat, on the bourse of Rouen, in the period 06.01.2021 – 07.02.2024. Every week, there is one price, on the day of Wednesday.

Day No	Price(\$)	Day No	Price(\$)	Day No	Price(\$)	Day No	Price(\$)
1	278	42	329	83	350	124	254
2	287	43	335	84	356	125	246
3	293	44	340	85	336	126	243
4	290	45	338	86	334	127	246
5	279	46	344	87	341	128	252
6	279	47	349	88	336	129	267
7	285	48	331	89	345	130	248
8	300	49	334	90	348	131	248
9	296	50	319	91	345	132	250
10	288	51	335	92	352	133	277
11	275	52	324	93	347	134	279
12	270	53	320	94	333	135	253
13	260	54	321	95	342	136	263
14	256	55	320	96	343	137	247
15	268	56	326	97	336	138	249
16	283	57	310	98	339	139	254
17	301	58	308	99	346	140	245
18	296	59	309	100	336	141	245
19	296	60	333	101	332	142	252

20	301	61	405	102	333	143	249
21	280	62	450	103	331	144	244
22	292	63	427	104	342	145	245
23	286	64	449	105	328	146	250
24	255	65	421	106	328	147	248
25	251	66	415	107	325	148	244
26	251	67	444	108	321	149	253
27	242	68	442	109	326	150	250
28	250	69	441	110	329	151	247
29	255	70	416	111	328	152	245
30	261	71	430	112	309	153	250
31	276	72	466	113	300	154	246
32	288	73	441	114	289	155	244
33	307	74	429	115	294	156	246
34	299	75	419	116	280	157	241
35	299	76	413	117	296	158	245
36	295	77	404	118	285	159	238
37	305	78	387	119	281	160	241
38	305	79	344	120	283	161	235
39	307	80	357	121	274	162	231
40	318	81	360	122	266		
41	314	82	353	123	262		

Source: Eustat

The graphical representation of Table 2. one can see in Figure 2. The first part shows certain oscillations. The middle part shows a period with relatively high values – this period is in fact the beginning of war in Ukraine. The last third of the graphics, yields values which apparently returns to the price before the war, however after a more carefull analysis these values have different features from the others.

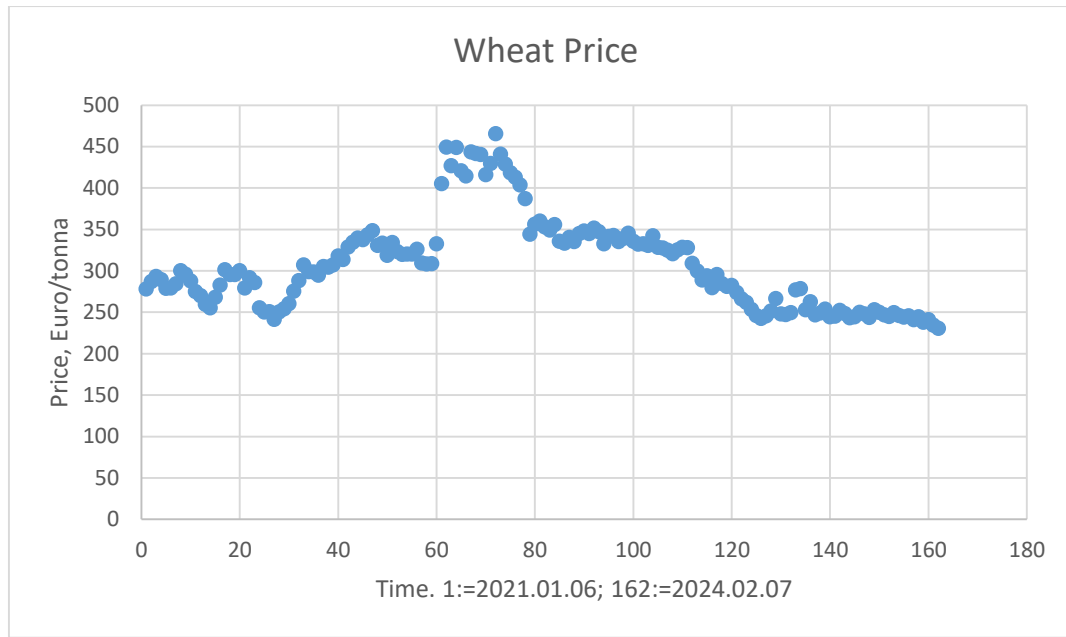


Figure 2. The price of wheat/ton at the bourse of Rouen (France).

The mean value between the first and the 59th data – i.e. starting with 06.01.2021 and ending with 16.02.2022 – is the following

$$\text{Average value}(1 - 59) = 297 \frac{\text{Eur}}{100\text{kg}}.$$

This means that during the peace time this is an average around the price is fluctuating.

The next average we evaluate from the beginning of 2023 – which is the 105th week – to the end of the period (162th week). This value is the following

$$\text{Average value}(105 - 162) = 266 \frac{\text{Eur}}{100\text{kg}}.$$

On the 117th week the price of the wheat was 296 Eur/100 kg, which is very close to the $\text{Average value}(1 - 59) = 297 \text{ Eur}/100\text{kg}$. From this consideration we evaluate the last average from this date/record. The average from the 117th week to the end of interval studied (162th week) is

$$\text{Average value}(117 - 162) = 253 \frac{\text{Eur}}{100\text{kg}}.$$

The relative change in price can be evaluated as follows

$$\begin{aligned} & \frac{\text{Average value}(117 - 162) - \text{Average value}(1 - 59)}{\text{Average value}(1 - 59)} = \\ & = \frac{253 - 297}{297} = -0.149 \cong -15\%. \end{aligned}$$

Furthermore if we refer not to the highest average – namely 297 Eur/100kg – , and not to the lowest average - namely 253 Eur/100kg –, but the mean mean value of the two

$$\text{Mean of the two averages} = \frac{253 + 297}{2} \frac{\text{Eur}}{100\text{kg}} = 275 \frac{\text{Eur}}{100\text{kg}}.$$

Taking into account this mean value the new relative change in price is

$$\frac{\text{Average value}(117 - 162) - \text{Average value}(1 - 59)}{\text{Mean of averages}} =$$

$$= \frac{253 - 297}{275} = -0.16 = -16\%.$$

This decrease in average price of 15% or 16% are periods which starts around the dates which regulates the permission of entrance of ukrainian cereals without the usual duties related to such goods.

5. Conclusions

As we presented above, in certain periods of time, the internal evolution becomes possible, which produces a considerable increase of grain production. However, the price of grain may depend not only on internal production, but also on the imported or exported quantity. We analyzed to periods, namely the second half of the 19th century and the period 2021-2023 (beginning of 2024). The rise or fall of the grain price may severely depends of external income in both cases.

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Faqin Lin ^{a 1}, Xuecao Li ^{b c 1}, Ningyuan Jia ^{d 1}, Fan Feng ^e, Hai Huang ^b, Jianxi Huang ^{b c}, Shenggen Fan ^a, Philippe Ciais ^f, Xiao-Peng Song(2003) , The impact of Russia-Ukraine conflict on global food security ^g Global Food Security, <https://www.sciencedirect.com/science/article/abs/pii/S2211912422000517>

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Mátyás László,

Department of Bioengineering, Sapientia Hungarian University of Transylvania,

Libertății sq 1, 530104 Miercurea Ciuc

matyaslaszlo@uni.sapientia.ro

Péter Emőke Katalin

Department of Economics, Sapientia Hungarian University of Transylvania,

Libertății sq 1, 530104 Miercurea Ciuc

peterkatalin@uni.sapientia.ro

CHALLENGES AND DEVELOPMENT OPPORTUNITIES OF THE AGRICULTURAL SECTOR IN HARGHITA COUNTY FROM THE PERSPECTIVE OF FARMER ORGANIZATIONS AND AGRICULTURAL EXPERTS

BALLA EMESE – NAGY KINCŐSÓ – SÁNDOR TIHAMÉR

ABSTRACT

The agriculture of Harghita County is in a special situation compared to the national average. Due to climatic and topographical factors, the productivity of the crop production sector is generally lower here, and land concentration is progressing relatively slowly. The market for agricultural products is also underdeveloped, however in the recent period, new investments have appeared in the region.

Although EU grants and funding opportunities offer assistance to farmers, access to development opportunities in Romania operates in a centralized system. As a result, farmers in Szeklerland are theoretically in equal competition with farmers in other regions of the country who have much more fertile arable land when it comes to obtaining grants. The region is characterized by many other problems, and it is crucial to find solutions to these issues and make the sector attractive to the younger generation.

The research included in the study is based on interviews with representatives of agricultural organizations and agricultural experts from Harghita County. The interviews refer to the operations of agricultural organizations and the main challenges and development opportunities in the agricultural sector (both in crop production and animal husbandry).

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KEY WORDS

Agriculture, Harghita county, farmer organizations, EU supports.

1. INTRODUCTION

In terms of agricultural production, Harghita County falls below the national average, primarily due to its topographical and climatic conditions. Despite this, a significant proportion of the rural population remains engaged in farming activities in some form, although official statistics indicate that only about 13%¹³ of the workforce is employed in agriculture. The most prevalent model of production is characterized by small-scale, subsistence-oriented farms, predominantly operated by individuals or families¹⁴ (Elek et al., 2024: 7).

The process of land concentration is progressing at a slow pace, due to several factors: members of the older generation are often reluctant to relinquish their land, which they typically use for producing staple foods or for supplementing their income. Others retain land primarily to access agricultural subsidies. In addition, the unclear legal status of land ownership further hampers the consolidation process.

Among the younger population, there is a marked tendency to avoid agricultural activities, which are associated with low profit margins, physically demanding labor, and a high degree of personal commitment. Instead, many opt for migration abroad in pursuit of better livelihood opportunities.

¹³ The source of the data: INS - Tempo Online database, FOM103D table

¹⁴ Elek et al., 2024: 7

Nevertheless, most farming households continue to rely on additional income sources beyond agriculture. According to certain studies, the presence of such supplementary income is in fact a prerequisite for the transition to agricultural entrepreneurship¹⁵ (Sandu, 1999).

Following the privatization processes after the political transition, the most significant change affecting agriculture was the introduction of the EU agricultural subsidy system, made available through Romania's accession to the European Union¹⁶ (Kiss–Csák, 2016: 69). These European subsidies offer crucial development opportunities for farmers, as the vast majority struggle with capital shortages and lack access to advanced agricultural technologies. Nevertheless, relatively few are able to apply successfully for such funds, due to challenges in meeting the necessary prerequisites, to obtain the own contribution, and later complying with EU requirements.

Climatic risks also play a significant role in the region. Several studies highlight that Harghita County is subject to a higher-than-average risk of drought compared to the national level (Mateescu, 2019; Alexandru, 2022)¹⁷. Moreover, damage from other extreme weather events, such as floods and hailstorms, is becoming increasingly frequent.

Another recurring issue affecting agricultural production is wildlife damage. According to data from the Harghita County Environmental Protection Agency, the estimated value of wildlife-related damages to agriculture in 2023 exceeded two million lei (approximately 400,000 euros) in the county (uh.ro, 2024).

Despite these aforementioned challenges threatening agriculture in Szeklerland, several positive trends have also emerged in recent years. Examining the relationship between agriculture and local society, Biró and colleagues found that over the past two decades, social attitudes toward agriculture have shifted in a more favorable direction. This has coincided with changes in consumer behavior, including increased demand for local products perceived as healthier. Furthermore, certain localities have begun to specialize in specific agricultural products. Artisanal goods are gaining popularity, accompanied by growing consumer trust in these products¹⁸ (Biró et al., 2022).

An increasing number of local initiatives have appeared, often operating at small scale, that focus on the processing of locally produced agricultural goods. At the same time, long-standing local markets are being revived. High-quality products made from local ingredients using traditional methods contribute significantly to the sustainability of family farms¹⁹ (Péter–Illyés, 2019: 204). In recent years, larger-scale investments have also begun to appear in the region, primarily linked to the processing industry, thus creating new market opportunities for agricultural products (e.g. milk collection centers, dairies, slaughterhouses, meat processing plants, potato processing facilities, etc.).

2. MATERIAL AND METHODS

As a first step, we analyzed the agricultural structure of Harghita County using available statistical data, with the aim of identifying characteristics within crop production and livestock farming that may represent a comparative advantage at the national level. In addition, we examined the level of application activity of farmers following EU accession, as well as the extent of area-based subsidies.

The core of the research is based on an interview-based survey, designed to identify the main challenges faced by agriculture in Harghita County and to explore potential solutions to these issues. We conducted semi-structured interviews with twenty individuals. The interviewees included representatives and presidents of agricultural organizations and associations, members of producer cooperatives, an expert from the agricultural payment agency, and a veterinarian.

The interview guide was structured around five thematic blocks:

1. Introduction

¹⁵ Sandu, 1999

¹⁶ Kiss–Csák, 2016: 69

¹⁷ Mateescu 2019, Alexandu 2022

¹⁸ Biró et al., 2022

¹⁹ Péter–Illyés, 2019: 204

What is the main activity of the agricultural organization? When was it established? How many members does it have? Etc.

2. The situation of the agricultural organization

What interests does the organization represent? Which are the activities of the organization? What difficulties does the organization face? What is its relationship with other agricultural organizations?

3. Problems in Szeklerland's agriculture

What are the main challenges facing agriculture in Szeklerland, and particularly in Harghita County? What production-related and market-related problems are farmers facing?

4. EU subsidies

How active are farmers in applying for EU funds? What are the main obstacles in accessing financial resources? How could the application process be made more efficient?

5. Problem management and proposed solutions

What potential solutions exist for addressing or avoiding farmers' current and future problems? What forms of support could improve farmers' situations? What is the anticipated future direction of agriculture in Szeklerland?

3. RESULTS AND DISCUSSION

3.1 Agricultural Characteristics of Harghita County

Land use and farm structure

According to data from the 2020 agricultural census²⁰, Harghita County accounts for only 2.5% of Romania's utilized agricultural area. Due to geographical location and relief, land use in the county diverges significantly from the national average: across Romania, 67% of agricultural land is arable land, 29% is used as meadows and pastures, and the remaining 4% comprises kitchen gardens, orchards, vineyards, and tree nurseries. In contrast, only 13% of agricultural land in Harghita County is arable land, while permanent grasslands and pastures represent 86%. Also based on the 2020 census²¹, Harghita county is home to 66,238 agricultural holdings. Of these, 46% have both agricultural land and livestock, 53% operate with land only, and 1% are livestock-only farms. At the national level, these figures stand at 61%, 37%, and 2% respectively.

Similar to the Romanian average (where the average farm size is the lowest in the European Union - 4.5 hectares), land fragmentation is characteristic of Szeklerland too. The average farm size in Harghita County is 4.86 hectares. One-third of holdings operate on less than 1 hectare, another fifth on just 1–2 hectares, and more than 90% of all farms are under 10 hectares. Large farms (over 100 ha) are rare in Harghita County, there are only 234 such holdings, of which just 17 exceed 1,000 hectares.

Crop production

The structure of arable land varies greatly across Romania. Harghita County is in a unique position: in addition to its mountainous terrain, several climatic factors, such as a shorter growing season, late spring frosts, and lower average temperatures, render conditions unfavorable for major national crops like wheat, maize, and sunflower. However, the colder and wetter climate is particularly favorable for potato cultivation. Nonetheless, drought risk has increased in recent years, likely as a result of climate change.

Crop structure

According to 2022 national data²², the most important crop in Romania is maize, covering approximately 30% of cultivated land. This is followed by wheat and rye (27%), sunflower (14%), rapeseed (6%), barley (5%), and lucerne (also 5%), with other crops occupying smaller shares.

²⁰ Agricultural Census, 13-TAB5-S-RGA2020-vol2 table

²¹ Agricultural Census, 1-TAB1-S-RGA2020-vol2 table

²² Own calculation based on NIS Tempo Online database (AGR108A table)

County's crop structure differs significantly. The proportion of maize is the lowest in the entire country, at just 4%. The leading crop is wheat, which occupies nearly one-third of cultivated land, followed by barley (13%) and potatoes (11%).

Yields

Among the most widely grown arable crops in Szeklerland, only potatoes achieve above-average yields compared to other counties in Romania. Wheat, maize, and barley yields in Harghita County are well below the national average. However, it is worth noting that yield levels for all three of these crops have shown a consistent upward trend over the past thirty years.²³

Animal husbandry

The natural conditions of Szeklerland, especially the mountain pastures, provide excellent opportunities for semi-intensive livestock farming. Nonetheless, the number of animals is declining, largely due to the fragmented structure of farms and the difficulties in meeting EU standards.

In terms of livestock numbers, Harghita County has a significant share of Romania's cattle population, while the numbers for sheep and goats are relatively low. Despite this, the cattle population has been declining over the past three decades, while the number of sheep has shown an upward trend since the mid-2000s. The pig population has declined even more sharply in the region, although there are some positive developments, such as increasing interest in mangalica pig breeding. Poultry numbers have not declined significantly, but their situation remains similar in terms of structure and sustainability.

Rabbit farming and beekeeping enjoy some popularity in the region, but their scale and income-generating capacity remain limited compared to other agricultural activities.²⁴

Utilization of support provided under the Common Agricultural Policy

The full utilization of area-based payments under the Common Agricultural Policy (CAP) is often hindered by the small size of parcels, which are frequently below the prescribed minimum, as well as by unclear land ownership rights. Regarding the utilization of direct payments (Pillar 1), the performance of Harghita County among the other counties is average. However, in the case of rural development subsidies accessible through applications, such as support for young farmers, farm modernization, and small farm supports, Harghita County ranks among the lowest performing groups. Based on some of our previous researches, it is worth noting that this situation does not necessarily apply to other types of rural development funding. For instance, in terms of funding accessible to local governments, Harghita County performs better than average.

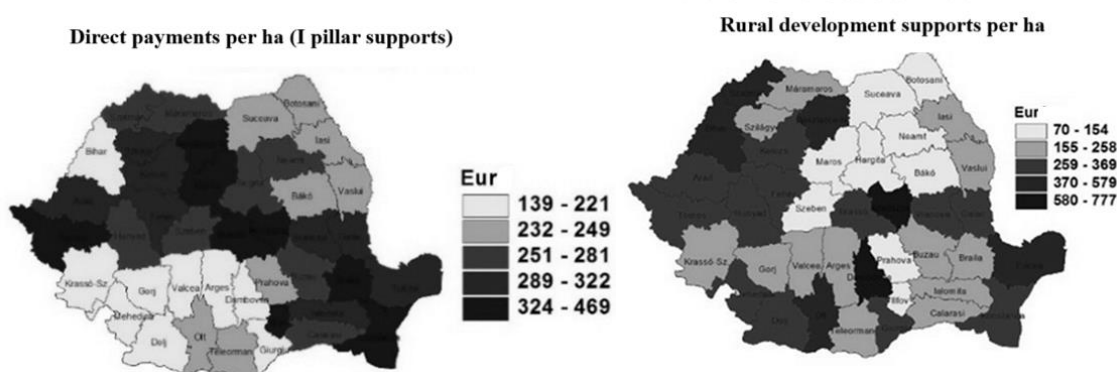


Figure 1: Value of CAP subsidies per hectare of agricultural land - direct payments in 2023 and rural development grants for farmers in the period between 2007 - 2020

Source: Own calculations based on the databases of the Agricultural Payment and Intervention Agency and the Agency for Financing Rural Investments

²³ Own calculation based on NIS Tempo Online database (AGR110A table)

²⁴ Own calculation based on Agricultural Census data (1-6.Tab-Specii-RGA2020-vol2 table)

3.2. The interview-based research

3.2.1. Introduction and the situation of the agricultural organization

Several interviewees confirmed that it is characteristic for Harghita County that, especially after 2010, a lot of agricultural organizations were established, some of them primarily through initiatives from Hungary, aimed at providing professional support and representation for farmers. Some of these organizations function relatively well and are active, organizing training sessions and other activities for their members, while others, although they started promisingly (e.g., organizing livestock fairs combined with exhibitions), are currently stagnating, with some considering transferring management or even dissolution. A positive example of the first category is the *Udvarhelyszéki Farmers' Association*, founded in 2013, which has maintained diverse activities over time and remains actively engaged. One of the association's key current activities is supporting local small-scale producers by facilitating a system whereby producers deliver their products to a hospitality venue; during a professional conference, dishes prepared from these products are offered to local entrepreneurs in the tourism and hospitality sectors. It is generally observed that following such promotional events, entrepreneurs place significant orders for various products from local small producers. Another positive example is the *Udvarhelyszéki Young Farmers' Association*, which supports its members professionally and with information, and organizes a training series called "*Udvarhelyszéki Butchers*." This program is led by a professional butcher and covers topics related to meat processing.

Interviewees mentioned various training opportunities, highlighting those organized by the *Association of Szekler Farmers' Organizations* and others on different thematic areas.

The establishment of cooperatives has become more characteristic in recent years, largely linked to EU Common Agricultural Policy, which increasingly favors this form of association for accessing funding sources. For example, the *Csíkmadaras Organic Milk and Meat Cooperative* was established for this purpose. The *Unitis Cooperative* built a modern stable using grant money, with seven founding and current members maintaining a breeding herd of 70 beef cattle. The *Carpatica Ghimes Cooperative* produces high-quality, small-scale food products sold in a local shop, which also stocks products brought in by approximately 40 other typically small farmers from a 50-kilometer radius. Although cooperatives existed previously too, they were few and the legal framework was less clear than today. For example, the *Nagy-Küküllő Agricultural Cooperative* was founded in 2011 to unite local dairy farmers dissatisfied with low milk purchase prices. They purchased an old, previously closed butter factory building in Cristuru Secuiesc (Székelykeresztúr) and decided to process and sell the milk themselves.

For Szekler farmers and their organizations, the *Association of Szekler Farmers' Organizations*, established through Hungarian initiative and operating with Hungarian support, holds particular significance. It functions both as an agricultural advisory network serving farmers in the three Szekler counties and as an umbrella organization for agricultural associations. Similar member organizations operate throughout the Carpathian Basin, and continuous training is provided for their advisors in Hungary.

The establishment of the agricultural advisory network was based on the principle of covering all agricultural sectors—from crop production to animal husbandry, including beekeeping—and other areas affecting farmers' activities, such as grant writing and agricultural digitalization. Each advisor is assigned a specific region to manage. The Association primarily targets small and medium-sized farmers, offering support including personalized consulting.

The COVID-19 pandemic also highlighted the vital role of small and medium-sized farms during crises. When shortages appeared in larger supermarkets for certain products, small and medium farms were able to provide meat, eggs, milk, and other essential foods. Beyond economic value, smaller farms also represent important social and cultural values, underscoring the importance of their support.

Relationship with political decision-makers

The majority of interviewees report a positive relationship with local government authorities. Several mentioned that local councils take pride in the activities of associations or cooperatives and support them with available resources. For example, the *Fenyőalja Association* in Ciumani (Gyergyócsomafalva) was provided with a former school building that was converted into an EU-standard kitchen for processing vegetables, fruits, and forest berries.

However, the attitude toward higher-level political decision-makers is predominantly negative, expressing disillusionment and skepticism. “*Politics will not solve our problems,*” “*the state often does not resolve these issues,*” and “*the Romanian state certainly pays attention, but mostly by constant monitoring.*”

Views on political engagement are mixed. Some emphasize the positive role of the Democratic Alliance of Hungarians in Romania (RMDSZ), which they feel effectively represents their interests to legislators. At the same time, many acknowledge that without political support, achieving goals is difficult. Conversely, some agricultural organization leaders claim to be “*apolitical,*” expressing distrust or rejection of political influence with statements like: “*Should politics dictate to us? Then it’s better if I do nothing.*”

Challenges faced by agricultural organizations

Contrary to expectations that internal member relations would be a main issue, most interviewees described cooperative and supportive relations among farmers. Members assist each other with procurement, work, and sales, often referring customers to one another. In some cases, groups have even organized night watches to guard crops. Organization leaders consider a strong community spirit a fundamental condition for success. Naturally, the quality of relationships depends on membership size and the ability to manage internal conflicts. Diverse personalities coexist, which sometimes leads to tensions (“*there’s the nervous type, the quiet type, the oddball*”).

Interviewees also noted increasing difficulty in motivating farmers to participate in professional conferences or trainings, typically due to time constraints, workload, or feelings of discouragement and burnout.

Cooperation with other organizations

Relations with other organizations vary widely. Generally, agricultural organizations maintain good relationships with neighboring groups, attend each other’s events, and collaborate closely with the *Association of Szekler Farmers’ Organizations*. Exceptions exist, however. Some organizations have strong ties with Hungarian counterparts but feel isolated from Romanian partners, while others maintain good relations with Romanian organizations operating in similar fields.

The issue of cooperatives

Among agricultural formations, cooperatives hold a special position compared to associations due to their legal status resembling business enterprises, which receive prioritized EU support. EU funding processes increasingly favor cooperatives, for example by reducing the required own contribution. It could be said that the EU exerts pressure on farmers to form cooperatives, as joint ownership and use of high-performance machinery improves cost-effectiveness and economic viability. Beyond funding advantages, cooperatives also enable contracting with large retail chains, fulfilling their demanded product volumes and quality standards on time—options not feasible for individual smallholders. Nevertheless, cooperative formation faces challenges. Many locals retain a communist-era aversion to cooperatives, feeling distrustful or alienated from the concept. Additionally, bureaucratic complexity deters many due to the time-consuming and stressful nature of administration, which detracts from animal care. Even cooperatives formed for grant purposes often encounter expectations they cannot meet. Farmers are generally unprepared for these demands, lacking guidance or information, as the cooperative model is still new to them. Assistance with cooperative management would be highly beneficial.

3.2.2. Problems of agriculture in Szeklerland

Although there are some specific problems related to the geographical location and the types of activities carried out, interviewees report many general difficulties that affect the majority of farmers.

Geographical location and conditions

A general problem is the location and mountainous character of the region, which results in lower crop yields compared to the plains. The region is less suitable for large-scale arable farming. However, livestock farming benefits from the availability of good-quality pastures. The situation differs for pig and poultry farming, as the feed required for these animals is difficult to produce locally. Consequently, few engage in large-scale pig and poultry production, but there exist positive examples. The beekeeping sector also faces specific problems such as hive abandonment and colony losses, often with unclear causes, alongside threats from mites and pesticides.

Small parcels

A characteristic problem in both Romania and Harghita County is the low level of land consolidation, often referred to as “*belt parcels*.” This situation adversely affects the economic efficiency of production and frequently complicates access to the plots. This is primarily because owners are attached to their land — some produce food for their own consumption, others maintain ownership to receive subsidies, and some hesitate to lease their land out for fear of losing ownership rights. Additionally, unclear ownership rights often prevent the sale or lease of these lands. Some interviewees, however, perceive a positive aspect in this fragmented ownership: it prevents large investors from buying up Szeklers’ lands, as the numerous small owners are unlikely to sell their land. Several interviewees also note that area-based subsidies are inefficient because some lands are not cultivated properly (owners live in cities or abroad) but still receive subsidies, even though larger farms would be interested in these plots.

Access to credit

Access to credit and high interest rates frequently emerge as problems. Although there is a great demand for loans to purchase equipment, farmers often cannot cover interest payments from their income. Thanks to the internet, farmers are aware of advanced technologies elsewhere and wish to develop, but they cannot afford the costly modern technology. Some interviewees point out that state-supported interest subsidies, similar to those available in Hungary, would be very helpful.

Energy prices

Several interviewees mention the excessive increase in energy prices—electricity and fuel—that has not been matched by rising product prices.

Climate change

Most interviewees regard climate change as a real problem whose effects they experience firsthand. *“Climate change is visible, it's not just empty talk, but a full reality. In fact, I could say we can feel this reality on our own skin from one year to the next.”* Changes in production practices and crop structures have occurred, with innovations such as rotational grazing being introduced to preserve pasture quality. In some cases, costly investments like pipeline installation and well drilling were necessary to secure water supply. High temperatures and drought are seen as major threats, especially for livestock watering. While farmers can adapt crop structures to climate change, soil erosion control and irrigation technology development remain crucial. From the perspective of sheep breeding, climate change brings some benefits: milder winters make animal overwintering easier.

Some interviewees see EU regulations, such as mandatory fallowing and green corridors, as indirect negative effects of climate change, which mean additional burdens on farmers. *“We need to find those solutions, those compensatory measures that ensure farmers don’t go bankrupt when, for example,*

they are required to fallow their land or leave areas uncultivated, or when they have to create green corridors on their arable land."

The beekeeping sector is particularly sensitive to climate change; irregular precipitation leads to a shortage of pollen in autumn, negatively impacting bee protein supplies.

Wildlife damage

The significance of wildlife damage varies across the county. In the Udvarhely region, according to some interviewees, wildlife damage is the biggest agricultural problem. In Felcsík region, bears cause substantial damage not only to livestock but also to crops, with losses in cornfields sometimes reaching 30–50%. In another case, a breeding bull was killed by a bear, and it still hasn't been replaced. In addition, the *"shepherd is under constant stress"* while out on the pasture due to the threat of bears. Damage caused by wildlife can also be significant for beekeepers at times. Other wild animals such as wolves, wild boars, deer, and roe deer also cause considerable damage. Although the state compensates wildlife damages, compensation only covers invested amounts, not the market value of animals, and the administrative burden and delays in receiving compensation pose additional challenges.

EU regulations

Farmers express considerable dissatisfaction with EU regulations, primarily due to the difficulty of compliance and bureaucracy. Many believe the regulations disproportionately burden small farms, with no preferential treatment compared to larger operators. One interviewee considered: *"Everything is geared toward making it impossible for small farms to survive"*, while another said, *"farmers are being burdened and tormented by countless regulations that are truly incomprehensible."* The requirement for farms to operate as legal entities to access subsidies is a barrier for many smallholders due to lack of capital and experience. High bureaucracy discourages many, and overlapping inspections by multiple agencies add to the burden. Dependency on area-based subsidies has led to the emergence of *"pseudo-farms"* that misuse funds. EU regulations are expected to become stricter, potentially increasing efficiency and reducing misuse.

Labor shortages and aging

Several interviewees identify aging and difficulties in generational renewal as the biggest challenges in the agricultural sector. EU subsidies help slow this trend by supporting farms that can modernize and mechanize. Farmers lacking successors often avoid investment and innovation. Improving working conditions is crucial to attract young people, yet agriculture suffers from negative perceptions. ***"When a farm reaches a certain level where working conditions improve, one can say that agriculture, too, can become a civilized workplace."***

"Young people lack motivation, and I believe the main reason is that this is considered a 'shameful' profession. Also, the commitment required in agriculture, along with its dependence on the weather, poses significant challenges." Reliable labor is hard to find, and many cannot afford permanent employees. Consequently, many small farms rely on family labor. *"People who take on agricultural jobs tend to go to Switzerland or Germany instead, where agricultural work is better paid."* Seasonal labor shortages are also severe. Efforts to bring in workers from countries like India and Tibet are underway, but this is in early stages.

Markets

Most interviewees believe there is sufficient demand for agricultural products, especially for high-quality and homemade foods. *"We've seen Ukrainian grain, Polish milk, Dutch pigs, and Danish pigs. They flood the market with huge quantities, yet there's still demand for ours as well."* However, low prices remain a widespread issue. In terms of market accessibility, an interesting duality emerges between the high-quality but small-quantity products of small-scale farmers and the demand driven by the market, primarily by large food chains, processors, or major trade fairs. There is strong demand for the homemade-style, high-quality products offered by small farmers and producers. For example,

the homemade syrups and jams of the Fenyőalja Association have been successful at several major national fairs, and have even made it as far as Manchester.

The situation is different for farmers with higher production volumes and greater capacity. In Harghita County, significant income is primarily generated from the sale and even export of live animals. There is strong demand for sheep, which are bought live and transported eastward via the Black Sea. However, in recent times, the outbreak of sheep pox has halted foreign shipments for now. As for beef, it's been noted that there is a lack of demand in Romania, as the country does not have a strong culture of beef consumption like some others. According to several interviewees, export is the only viable solution. However, for smaller farmers, this usually means selling their live animals to one of four or five large companies that then export the livestock. Their bargaining power over prices, however, is very limited. *"So there is no real functioning of supply, demand, or competition. It simply cannot be."* According to the interviewee, a potential solution would be to stop selling live animals and instead focus on processed goods, but that would require a ban on live animal exports, which is widely known to conflict with EU regulations. The issue of weak bargaining power against buyers also arises with other agricultural products. *"There is a market, but producers are highly vulnerable to buyers. Buyers are much more centralized and better organized."*

Several interviewees pointed out that in order to achieve competitiveness, some form of added value must be created. For example, milk and meat need to be processed. In the case of medium-sized farms, in addition to producing final products, it is also worthwhile to keep breeding animals or sell livestock as young stock or piglets, which can ensure a stable income for the farm.

A broader issue affecting all of Romania also arises in relation to sales: farmers and producers typically sell raw materials rather than finished or semi-finished products. Many see the lack of processing and storage capacity as a major issue. *"A large portion of what we produce is sent abroad in raw form just as it is, and then we end up buying the processed version back from abroad and that's what ends up on the shelves of storage facilities."* However, several interviewees noted that positive trends are beginning to emerge, there is a visible shift toward the development of shorter food supply chains.

The biggest challenge when it comes to selling in larger volumes is that local farmers must compete with foreign producers who operate more efficiently and with more modern machinery, allowing them to offer their products at significantly lower prices than domestic farmers and producers. Large retail chains represent a major opportunity as potential markets for farmers and producers. However, in order to access these markets, they must be able to provide the required products in pre-agreed quantities and quality, as outlined in contracts. *"The biggest weakness in marketing, in my opinion, is that our farmers are reluctant to plan ahead and sign contracts in advance... Very few farmers in Szeklerland are willing to take that step."*

Several interviewees emphasized the importance of fostering conscious consumer behavior among local buyers toward local products. At the same time, some noted the negative effects of rivalry or even envy among local farmers and producers, which can result in people choosing to buy from supermarkets rather than from familiar local producers. *"There's still this attitude among Szeklers that you shouldn't get ahead of me."*

A specific issue for beekeepers is that honey prices are heavily affected by cheap, low-quality imports from China, which drive down prices nationwide."

3.2.3. The issue of EU subsidies

Most interviewees agree that the application activity in Harghita County is relatively low. The primary reason for this is the difficulty in meeting the application requirements and related regulations, as the application systems and accounting procedures are complicated and excessively bureaucratic. Moreover, application enthusiasm has decreased in the region because recent calls favor cooperatives and large-scale farmers.

"The National Strategic Plan has practically put smallholders in a very difficult position; the entire system is designed for large investments," one respondent noted. *"When Romania first joined the EU,*

it was much easier to apply. Now it is twice as hard, requirements have doubled, and the system is heavily rewritten in favor of the big players."

A critical factor affecting application activity is the ability to provide own contribution. When smaller own contribution was required, farmers were able to submit successful applications independently and, in some cases, achieved significant development. The young farmer grant was mentioned by several as a good starting opportunity; in the previous programming period, its value was €70,000 with 75% pre-financing and no own contribution required. This type of grant will restart by the end of this year but with a higher amount (€200,000) and a minimum 20% own contribution requirement. Many are deterred by the requirement that applications can only be submitted by legal entities. For many farmers, this is unfamiliar territory; the paperwork, administrative tasks, and maintaining a registered company are intimidating.

Regarding ways to increase application activity, interviewees suggested:

"The fragmentation of land parcels, unclear legal status of properties and land ownership are basically the determining and stumbling blocks of the entire system. These should be simplified in the future."

"The application system could be made more efficient by not imposing uniform rules for all of Europe. Even within a country, one should consider what mountainous areas deal with, the scale of farming – small or large – and tailor the system accordingly."

"The application system is inaccessible for small farms; it barely offers an opportunity for a small business to grow into a sustainable, medium-scale agricultural enterprise. Therefore, many more grants accessible to small producers are needed."

Despite all difficulties, farmers have become more familiar with the application system, and there is less uncertainty than in the early years following EU accession. Regarding the use of the first pillar of the CAP, the area-based payments administered by APIA, Harghita County is in a relatively favorable position. However, this requires the paying agency to perform efficiently and effectively, which is the case in Harghita County.

Some interviewees criticize the effectiveness of current area-based subsidies: *"I believe subsidies should not be area-based or per head of animals but linked to production; the measure should be what the farm produces, and subsidies should be proportional to that."*

Several also criticize the over-standardization of the CAP: *"You cannot equate, for example, the high mountainous areas of France with our mountains. Even within Romania, the problems and conditions in Constanța County are completely different from those in Harghita or Suceava."*

Others believe that EU subsidies form a fundamental basis for sustaining many farms: *"If these types of subsidies (i.e., area-based or animal-based payments) disappear, I think about 50-60% of farmers here will disappear."*

There are also very positive opinions: *"Here in Harghita County, people are really resourceful. It is one of the most capable counties in terms of development."*

3.2.4. Addressing problems and proposed solutions

Several respondents believe that problems should be addressed at the lowest possible level, meaning that bottom-up initiatives ought to be supported. Many emphasize the need for more active involvement by local governments. *"Local governments operate quite well in managing agricultural records and issuing producer books. What is really important is that they also assist in the formalization of land ownership, to clearly establish who owns the land."*

Several interviewees point out the need for more support from the government. Others highlight the importance of supporting local production, even suggesting the use of protectionist trade measures such as increasing import tariffs or restricting exports of certain products. However, it is well known that such measures are incompatible with EU principles.

There is also a call for the introduction of special state subsidies, for example, in the beekeeping sector, following the Hungarian model by implementing animal welfare subsidies or pollination support programs. Some interviewees see potential for improvement through networks of rural

agricultural advisors (similar to those operating in Hungary), whereby each commune would have an advisor who could assist farmers with tax and bureaucratic issues. This would allow farmers to dedicate more time to actual agricultural activities.

Supporting specialized vocational training and its thoughtful integration into the education system is also considered important. Although some initiatives exist, such as food industry, agricultural machinery, and veterinary health departments, the practical training component remains largely insufficient.

Most interviewees perceive significant opportunities in revitalizing the processing industry, for example: *“Establishing a slaughterhouse on the farm that allows the monthly slaughter of 10-12 animals, complemented by a small processing facility, and seeking local markets to absorb this capacity.”*

There is also a need for a stronger presence of grant-writing companies focused on smaller farms, as some respondents claim that *“good grant-writing companies tend to specialize in large-scale applications.”*

Many emphasize the importance of raising consumer awareness and stimulating demand for local products. Promoting or legally protecting local products could also serve as a tourism marketing tool and attract visitors to the region. Although the protection process is relatively complex, requiring extensive research and being difficult to safeguard against future fraud, it is worthwhile and can generate notable success stories. However, this requires a unique, special local product and a dedicated individual to manage the administrative process and implement appropriate marketing strategies.

A change in the social perception of agricultural work is also necessary so that farming is no longer considered a *“shameful profession.”* Achieving this would primarily require innovation, mechanization, and improvements in working conditions.

Harghita County has significant potential for organic farming, especially in cattle and sheep breeding, due to its herb-rich mountainous pastures. Wild fruits and forest mushrooms are also abundant. However, the greatest challenge is that obtaining organic producer certification entails additional costs and bureaucratic hurdles, which many deem not worthwhile. Consequently, some farmers avoid engaging in organic farming altogether, while others produce organic goods without registering officially anywhere.

The future of agriculture in the Szeklerland

Opinions regarding the future of agriculture in Szeklerland are highly diverse. Some are optimistic, believing that young people currently working abroad as guest workers will broaden their horizons and acquire new technologies that they can later implement at home. However, others point out generational differences. *“It is certainly possible to make a living from agriculture. (...) But the current generation has greater desires and demands. It is surely worthwhile if it generates profit, but to earn enough to buy a fancy new car, build a stylish large house, and go skiing every year, the farm is simply too small.”*

In today’s globalized world, which increasingly focuses on innovation and digitalization, farmers require not only traditional agricultural knowledge but also new types of skills. *“The knowledge our ancestors had is no longer sufficient. More knowledge is needed, and one must learn marketing and sales.”*

Several interviewees also mention that the future will be significantly influenced by the development of the EU’s agricultural policies. *“I see that the farming community will be further filtered out; the number of active farmers will decrease. Those who remain will stay, and the rest will drop out. This is somewhat positive in that those who farm should continue to do so, and those who do not should leave the opportunity to those who can produce more competitively.”*

Most respondents believe this trend will continue, meaning that, similarly to Western farming practices, small farms in Szeklerland will gradually disappear, farm consolidation will accelerate, and a stronger presence of foreign investors can be expected. *“If things continue as they are, small farms will vanish. Large farms will either merge or be bought up by foreign investors.”*

“What happens in Western Europe will happen in Hungary in 10 years, and in our region in 10-15, at the latest 20 years.”

Some interviewees highlight that the Szekler mentality somewhat hinders this process: *“Here in Szeklerland, it is a bit harder for the Dutch to buy up everything because, fortunately, we have a mentality where we do not even sell land to each other.”*

Many also believe that there is a future for building on high-quality local products and regional characteristics. In addition, the processing industry and storage capacity are showing signs of development.

Overall, most interviewees predict a positive future for Szeklerland’s agriculture, which is undergoing transformation but still holds many untapped opportunities. *“We have to cut the bush. We are a sacrificial generation.”*

4. CONCLUSIONS

In recent decades, a relatively large number of organizations and associations have been established in Harghita County, which are clearly necessary for supporting producers and farmers as well as representing their interests. The activities of these organizations are significantly influenced by the *Association of Szekler Farmers' Organizations*, especially given that many smaller groups feel isolated and often lack connections with larger national organizations, resulting in weaker lobbying capabilities.

The number of cooperatives in Harghita County remains relatively low, despite the European Union’s explicit support for this organizational form, which also benefits from lower co-financing requirements in grant applications. This situation can be attributed to the EU’s development strategies favoring agricultural production on a larger scale. Thus, a shift towards large-scale farms is characteristic, although there is substantial local, national, and even international demand for high-quality local products.

Farmers and producers face numerous production-related challenges, including geographic constraints, climate change, damage caused by wildlife, capital shortages, difficulties accessing credit, challenges in obtaining grants, labor shortages, and foreign competition. Nevertheless, there is demand and a market for their products. From a bargaining position perspective, however, most interviewees report unfavorable conditions, facing low purchasing prices.

Despite these numerous problems and difficulties, the majority of respondents agree that there is significant growth potential for agriculture in Szeklerland, particularly in Harghita County. However, the sector is undoubtedly undergoing transformation, with the EU’s agricultural policy playing a substantial role in this process. The key question remains: who will be the ultimate beneficiaries of these developments?

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AUTHORS' ADDRESS

BALLA Emese PhD, assistant professor, Sapientia Hungarian University of Transylvania, Faculty of Sciences and Arts, Cluj-Napoca, ballaemese@kv.sapientia.ro
 NAGY Kincső, student, Sapientia Hungarian University of Transylvania, Faculty of Sciences and Arts, Cluj-Napoca, nagy.kincso@student.kv.sapientia.ro
 SÁNDOR Tihamér, student, Sapientia Hungarian University of Transylvania, Faculty of Sciences and Arts, Cluj-Napoca, sandor.tihamer@student.kv.sapientia.ro

Annex 1.

Interviewees

1. Géza Antal, *Pro Agricultura Association*, President
2. Alpár Benedek, *Young Farmers' Association from Udvarhelyszék (Odorheiu Secuiesc)*, President
3. József Boros, *Common Forest Ownership from Zetelaka (Zetea)*, President
4. Balázs Dávid, *Unitis Agricultural Cooperative*, President
5. Enikő Fazakas, *Nagy-Küküllő Agricultural Cooperative*
6. Imre Fazakas, *Csíkmadaras (Mădăraș) Organic Milk and Meat Cooperative*, President
7. László Fibula, *Harghita Wool Sheep Breeders Association*, President
8. György Hatos, *Association of Szekler Farmers' Organizations*, Rural Advisor, horticulture, beekeeping

9. Dr. Ernő Jakab, *Farmers' Association from Udvarhelyszék (Odorheiu Secuiesc)*, President
10. Zsolt Király, *Farmers' Association from Gyergyócsomafalva (Ciumani)*, President
11. Dávid Kolumbán, *Szeklerland Mangalica Breeders Association*, President
12. Réka Márton, *Agricultural Payment and Intervention Agency*
13. Melinda Orbán, *Fenyőalja Association*, Vice President
14. József Pálfi, *Farmers Association from Máréfalva (Satu Mare)*, President
15. Attila Sárig, *Association of Szekler Farmers' Organizations*, Rural Advisor, small farms, artisanal dairy processing
16. János Vízi, *Association of Szekler Farmers' Organizations*, Rural Advisor, cattle breeding
17. István Zöldi, *Harghita County Beekeepers Association*, Vice President
18. XY, President of an agricultural organization
19. XZ, President of a producers' association
20. XW, Veterinarian

REDEFINING COOPERATIVES IN A MODERN ECONOMY

ROMANIAN COOPERATIVES AND THEIR OPPORTUNITIES

PÉTER EMŐKE KATALIN - NAGY SZERÉNA

Abstract

European agricultural cooperatives have historically played a key role in the agricultural sector. They are not only an advantage for farmers, but also contribute to the development of rural communities and food security. Although they face many challenges, with the right strategies and innovations, these organisations can continue to thrive in the future. Collaboration and adaptability will be key to ensuring that producer cooperatives remain competitive in the European and global agricultural market. In the future, cooperatives are expected to place increasing emphasis on innovation, digitalisation and sustainable agricultural practices. EU support schemes, such as the new CAP reforms, will also encourage cooperatives to adapt to changing circumstances and take advantage of the opportunities offered by modern technologies. The study provides an insight into the past and present situation of agricultural cooperatives in Romania and focuses on the role that cooperatives can and will play in the digitalisation and modernisation of agriculture.

Key words: agricultural cooperatives, history of cooperatives, opportunities for cooperatives, Romania

Introduction

Agricultural cooperatives have long been integral to the development and sustainability of Europe's agricultural sector. Beyond offering economic advantages for farmers, these cooperatives support rural communities, enhance food security, and contribute to the modernization of agricultural practices. In Romania, agricultural cooperatives embody this vital role, evolving through historical shifts and adapting to contemporary challenges. This study aims to examine the trajectory and current status of agricultural cooperatives in Romania, emphasizing their capacity to embrace digitalization, innovation, and sustainability to remain competitive in the European agricultural landscape. By analyzing data from national registers and funding agencies, this research provides a comprehensive overview of the cooperative model's structure and development, while highlighting future opportunities shaped by technological advances and EU policy reforms.

Material and Methods

The present study focuses on the analysis of the development and structure of agricultural cooperatives in Romania, and also provides an insight into the history of agricultural cooperatives. The study has been prepared using data from the National Register of Agricultural Cooperatives (RNCA), which was established on the basis of information and data provided by the National Trade Register Office and the open database of the Romanian Rural Investment Financing Agency (AFIR). The study is based on a descriptive analysis of the cooperative phenomenon in Romanian agriculture.

Literature review

Ant Cooperative Movement (Hangya Szövetkezet)

One of the most significant cooperative initiatives was the Ant Cooperative Movement, founded in 1898. The aim of the Ant was to protect against the excesses of private trade by offering goods of reliable quality at a fair price. The cooperative's profits were often used for community purposes or distributed among its members. Antgya grew rapidly; by 1940 it had two thousand member cooperatives, with seven hundred thousand members and four hundred shops. It also had thirty canneries of its own and twenty industrial plants. In Transylvania, for example in Sepsis, a local branch of Antgya was established in 1915 and played a significant role in the development of the local economy.

In 1898, the Ant Cooperative (Hangya Szövetkezet) was established as a grouping to help and unite the rural farmers. In the year of its establishment, it had 29 cooperatives and by 1922 it had 1969 cooperatives and employed 1142 officials in the Ant Centre. Due to the economic decline of the small and middle nobility, the Ant Centre looked to local priests and teachers to form local cooperatives.

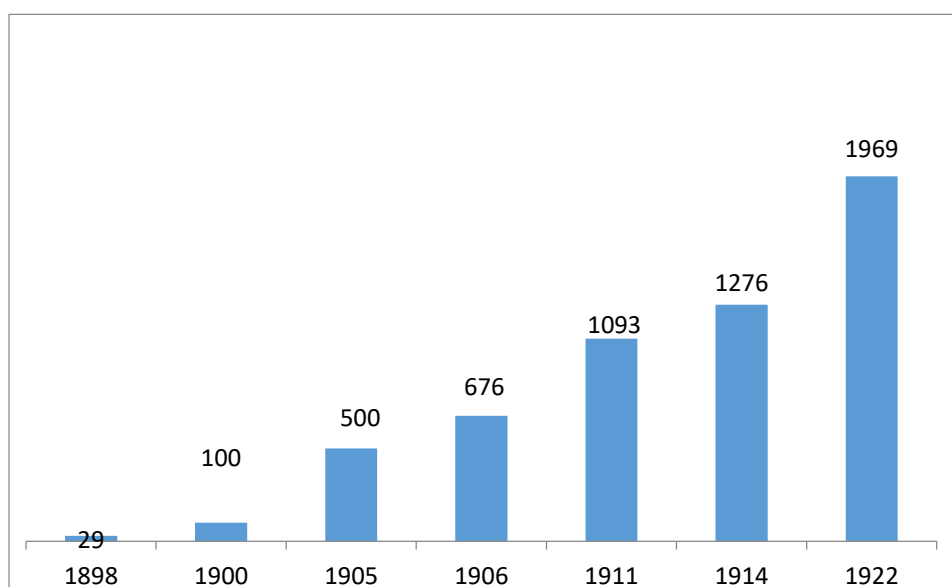


Figure 1.: Evolution of the number of Ant Cooperatives

Source Own edition, , based on *Hangya Termelő-értékesítő és fogyasztási szövetkezet, a Magyar Gazdaszövetség szövetkezeti központja Első 25 éve, A Hangya saját kiadása, Budapest 1923 adatai alapján*

The purpose of the establishment of the Ant Consumption Cooperative was first of all to supply the inhabitants of the villages, farmers and small-scale industrialists with good and cheap goods, to counteract the activities of the usurers represented by the village taverns and tavern keepers. The two most controversial issues of the statutes of the Ant Consumption Cooperative were the obligation of the members to buy from the cooperative shop and the distribution of the net income. In the cooperative's statutes, the members' obligation to buy from the cooperative shop was deleted and the distribution of income and the promotion of the aims of the Hungarian Farmers' Association were left to the respective management of the Hangya. The cooperative movement was particularly important for minority communities. Hungarian, German and other ethnic groups set up their own cooperatives to promote their economic and cultural interests. These cooperatives not only provided economic benefits but also helped to preserve and strengthen community identity. For example, Hungarian cooperatives have played a significant role in the economic life of Transylvanian Hungarian communities, facilitating the sale of local products and the maintenance of community institutions.

Table 1: Number of Ant Cooperatives

COUNTRIES	
THE CZECH REPUBLIC	597
ROMANIA	655
YUGOSLAVIA	39
AUSTRIA	56
TOTAL	1347

Source: own editing, based on Szilárd Pártos-László Pártos-Szilágyi, 1935

In the period before World War II, the Ant Cooperative was present in every settlement in Hungary. After the Second Vienna Decision, signed in 1940, the 179 ant cooperatives in the northern Transylvanian territories were transferred to Hungary. The remaining cooperatives remained in Southern Transylvania. Three-quarters of the cooperatives belonging to the Nagyenyed Ant Association, being in Northern Transylvania, were transferred to Hungary, but 25.08% of its member cooperatives remained in Southern Transylvania. Also across the border, a network of 130 credit, milk, producer and sales cooperatives, affiliated to the Ant Centre in Cluj-Napoca, remained without a centre. Within two weeks, until the new border was closed, the two Transylvanian cooperative centres were able to regroup the cooperatives of the Cluj Centre in Southern Transylvania into the Nagyenyed Antgya Association (Attila Hunyadi, Dénes Györfi 2007).

In addition to the changed territorial and transport conditions, it was a very challenging task for the consumer cooperatives to be supplied by the Arad warehouse. Therefore, the warehouse of the Nagyenyed centre started to supply the consumer cooperatives of the counties of Lower White, Cluj, Hunyad, Kisküküllő and Torda and the Arad warehouse was entrusted with the supply of the consumer cooperatives of the counties of Arad, Bihor, Krassó-Sörény and Timis-Torontál. As a result of this historic change, the Nagyenyed Ant Cooperative was left to maintain an organisation of 212 cooperatives. The cooperatives of South Transylvania remained in their own Transylvanian cooperative organisations, only the counties of Bihor, Satu Mare and Maramures were linked to the cooperative centres in Budapest due to their geographical location. (László Márton, 2007)

In September 1940, the consumer cooperatives left without a centre formed the Association of Transylvanian Ant Cooperatives in Târgu Mures with the agreement of the Budapest Ant Centre, but under pressure from the Budapest Ant Centre they changed its name to the Transylvanian Ant Cooperatives Centre in Târgu Mures

During the communist takeover, the assets of the Ant were confiscated without compensation. The rural Antgya shops and premises were mostly owned by farmers' cooperatives and then by cooperative-like companies that restricted the democratic decision-making rights of their members. As a result, the farmers' attachment to land and means of production was broken. The rest of the Ant's assets were squandered without legal regulation.

In the years of socialism, the assets of the Ant were confiscated and the idea of cooperative autonomy, with its violation of the sanctity of compulsory contributions and private property, erased the achievements of this successful cooperative movement.

“Hanza” Cooperative

The consumer cooperatives in the Czech lands, which belonged to the Ant Centre in Budapest in the Highlands, were united in Galanta under the name “Hanza”, which in 1933 had 168 cooperatives and 37,740 members. The Ant cooperatives in the Highlands and Transylvania tried to take advantage of the benefits of the cooperatives, but faced many difficulties due to the lack of state support.

The Hangya cooperatives in Austrian territory were affiliated to the Verbanddeutsch-Österreichischer Konsuvereine, with 32 cooperatives in 1930.

With the rise of the co-operative movement, more and more co-operatives and co-operative members deposited their savings at the Ant Centre, which required the establishment of a separate department and a vault in 1920. It collected unprecedented sums of money in the war loan subscription and also took on the custody of the war loan bonds. The Ant Treasury also provided the opportunity to trade in shares, in addition to the trading of securities and the sale of currency. As the activities of the Ant Co-operative Centre expanded, links with other financial institutions became essential. In 1920, it first conducted money transfers to facilitate international trade with the Vienna headquarters of the Allgemeine Verkehrsbank, followed by money transactions with banks in Germany and the Czech Republic. Later that year, in the autumn of 1920, a postal savings bank cheque account was opened for all branches and interbank operations were stepped up.

The old and new border regions created by the first Vienna decision in 1938 were in a different economic situation. The western part of these areas was more developed than the eastern parts. Antgya's aim was to strengthen the links with the approximately 350 old Antgya cooperatives, which were operating under the name of Hanza, and to take over the cooperatives with a view to building up a system of food supply and distribution for the population. The Budapest headquarters, thinking in terms of a single cooperative system for supplying the areas west of Ipolyság, sent consignments of Hangya goods to Hanza. Hanza, which insisted on its independent business policy and territorial rights, did not conceal its competing actions in the field of commodity purchases, and the Hangya-Hanza agreement was not concluded. (Štefan Gaučík)

In the period between the two world wars, the cooperative movement faced many challenges. Political instability, economic crises and state interference all affected the functioning of cooperatives. The 1929 Cooperative Law, for example, transformed the legal framework for cooperatives and increased state control. Nevertheless, cooperatives continued to play an important role in economic life, adapting to changing circumstances.

In the early 20th century, the cooperative movement in Romania played a significant role in economic and social development. Different types of cooperatives - credit cooperatives, consumer cooperatives, producer cooperatives - all contributed to improving the quality of life in rural and urban communities. The cooperative movement in Romania started to develop in the late 19th and early 20th centuries. The first cooperatives aimed to support small entrepreneurs and farmers by giving them the opportunity to exploit common resources and markets. Credit cooperatives, for example, provided low-interest loans to their members, thus promoting economic growth and social security.

After World War II, following the communist takeover, the cooperative movement underwent a radical transformation. In the wave of nationalisations in 1947 and 1948, cooperatives were absorbed into the state-controlled economic system, losing their autonomy and democratic character. The former voluntary cooperatives were replaced by compulsory collective farms, which often could not provide the benefits of the former cooperatives.

After World War II, Romania came under Soviet occupation and the Communist Party gradually took power. The collectivisation of agriculture was a central element of the communist system, which aimed to abolish private property and bring production under state control.

The establishment of communist agricultural cooperatives (CAP in Romanian) in Romania began in 1949 and lasted until the 1960s. Peasants' land was taken by force or intimidation and merged into cooperatives. In the cooperatives, production was common and the state determined the crop.

The creation of communist agricultural cooperatives had several aims:

- To increase production: the Communist Party hoped that collective farming would be more efficient than private farming and thus increase agricultural production.
- Control of the peasantry.
- Spreading socialist ideology: Cooperatives were a means of spreading socialist ideology in the countryside.

But the communist agricultural cooperatives did not live up to expectations. Production did not increase, and often decreased. There were several reasons for this:

- Peasants lost motivation: Peasants lost interest in work because they did not feel ownership of the land and the crops.
- Incompetent management: the leaders of the cooperatives were often incompetent people who were Communist Party people, not professionals.
- Poor management: cooperatives were often mismanaged, using resources wastefully.

Communist agricultural cooperatives had a negative impact on Romanian agriculture and rural society. The peasants became poorer and the countryside was depopulated. After the fall of the communist regime, the cooperatives were dissolved and the land was returned to the peasants. The story of the communist agricultural cooperatives in Romania is a tragic example of the damage that communist ideology and forced collectivisation can do to agriculture and society. The principles and methods of supply of the Romanian communist agricultural cooperatives (CAP) underwent significant changes in the period from the post-World War II period until the end of the regime, but their essence remained the same: to provide the state with food and agricultural products.

The basic principle was that part of the wealth produced had to be handed over to the state, the rest being at the disposal of the cooperatives. The prices for the supply were set by the State and were generally lower than market prices. This meant that the state obtained food cheaply, but the cooperatives and the peasants suffered a serious loss.

The rate and method of supply varied constantly over the period. In the early years, supplies were proportional to the quantity produced, but later they became increasingly focused on increasing production and meeting state needs. The levies were not only on agricultural products, but also on livestock and other products.

The methods of supply were also varied. In the early period, the supply was on an individual basis, i.e. each peasant was obliged to supply a certain quantity. Later, with the creation of cooperatives, the supply was on a collective basis, i.e. the cooperatives were responsible for supplying the goods.

Surrender was often carried out by violent methods. Peasants and cooperatives were intimidated if they did not fulfil their obligations to deliver. The authorities often raided the villages and confiscated crops if they were not found on the delivery lists.

The system of deliveries had many negative consequences. Peasants and cooperatives lost their incentive to increase production, as they did not receive the full value of the goods produced. This led to a decline in production and food shortages. The system of subcontracting contributed to the decline of agriculture in Romania and the impoverishment of the rural population.

After the fall of the communist regime, the system of services was abolished and agriculture gradually shifted to market-based production. However, the damage caused by the servitude system had a long-lasting impact on Romanian agriculture.

After the fall of communism, there has been a resurgence of the cooperative movement in Romania. In the 1990s and the following period, a number of initiatives were launched to revive and modernise the cooperative tradition. For example, social cooperatives play an important role in the integration of disadvantaged groups into the labour market and in the development of local communities. Although they face many challenges, these cooperatives still have considerable potential to address social and economic problems

Today, agricultural cooperatives play a key role in European agriculture. They enable farmers to pool resources, reduce risks and improve their market position. Producer cooperatives are also a key element of the European Union's agricultural policy, as they promote the development of sustainable agriculture, support rural communities and contribute to food security.

It is true that agricultural cooperatives had already begun to be known in Europe in the 19th century, mainly due to the economic and social problems of the time, but the rapid industrialisation and urbanisation of the region made it increasingly difficult for small farmers to remain competitive. Cooperatives offered them the opportunity to pool resources and markets. During the 20th century, producer cooperatives became increasingly integrated into European agricultural systems. The European Union's Common Agricultural Policy (CAP) also encouraged the creation and development of cooperatives through various subsidies and regulations. Today, there are thousands of agricultural cooperatives in the EU Member States, which play an important role in food production and processing.

The cooperatives operate on the principle of cooperation, with farmers organising production, purchasing and sales together. Their advantages can be summarised as follows:

- Cost reduction: joint purchasing gives farmers cheaper access to inputs such as seeds, fertilisers and machinery.
- Increased market power: Cooperatives can produce more and more stable quality products, which can lead to more advantageous contracts with wholesalers and retail chains.
- Risk sharing: joint operations allow farmers to share risks from weather, market fluctuations or other external factors.
- Facilitating technological development: cooperatives often invest in new technologies, research and development and innovation that individual farmers could not afford.
- Sustainability and environmental protection: cooperatives can promote sustainable agricultural practices such as precision farming, organic farming and the use of low-carbon technologies.

Although agricultural cooperatives have many advantages, they also face many challenges. These include:

- The impact of globalisation: increasing international competition makes it harder for smaller cooperatives to compete in a global market.

- Demographic change: the ageing of Europe's rural areas and the low number of young farmers may threaten the sustainability of producer cooperatives.
- Organisational and governance problems: effective functioning requires well-organised governance and transparent decision-making mechanisms.
- Sustainability requirements: Increasingly stringent EU environmental regulations present challenges but also opportunities for green innovation

In the future, producer cooperatives are expected to place increasing emphasis on innovation, digitalisation and sustainable agricultural practices. EU support schemes, such as the new CAP reforms, will also encourage producer cooperatives to adapt to changing circumstances and take advantage of modern technologies.

European agricultural cooperatives play a key role in the agricultural sector. They not only benefit farmers, but also contribute to the development of rural communities and food security. Although they face many challenges, with the right strategies and innovations, these organisations can continue to thrive in the future. Collaboration and adaptability will be key to ensuring that producer cooperatives remain competitive in the European and global agricultural market.

Cooperatives in Romania

Concept and types of agricultural cooperatives in Romania

An agricultural cooperative is an autonomous association with an unlimited number of members and variable capital, which carries out economic, technical and social activities. The legal entities associated in agricultural cooperatives must be active farmers according to the legislation in force or have a CAEN code according to sector A. 'Agriculture, forestry and fishing', sector 01 or sector C. 'Manufacturing', sectors 10, 11, 12 or sector H. 'Transport and storage', sector 52. In Romania, a minimum of 3 members is required for the establishment of an agricultural cooperative. These members can be natural persons or legal entities, but all of them must be active farmers or have a CAEN code corresponding to one of the indicated sectors of activity (Legea 566/2004).

Agricultural cooperatives can be:

- Grade 1 (Gradul 1 cooperative agricole):

These are associations of natural persons (persoane fizice), i.e. the members are individual farmers. This level is the basic unit of the cooperative, where individuals can join in collective production and services. Members can be natural persons, sole proprietorships and/or family businesses, farmers.

- Grade 2 (Gradul 2 cooperative agricole):

Type 2 agricultural cooperatives are made up of legal persons and/or natural persons, authorised natural persons, sole proprietors and family businesses. They can also be cooperatives.

- Grade 3 (Gradul 3 cooperative agricole):

Tertiary agricultural cooperatives are legal entities that consist of second-level agricultural cooperatives and carry out joint investments in accordance with cooperative principles.

Types of agricultural cooperatives:

- Agricultural service cooperatives: which provide services on a cooperative basis
- Agricultural purchasing and marketing cooperatives: which organise the purchase of inputs and technical equipment for agricultural production and the sale of agricultural products for members.
- Agricultural cooperatives for the processing of agricultural products: which offer typical, branded products on a permanent basis.
- Agricultural producer cooperatives and small agricultural cooperatives
- Agricultural cooperatives for the exploitation and management of agricultural, forestry, fisheries and livestock areas
- Agricultural cooperatives which may jointly carry out the activities referred to in (a) and (e) (a) and (b);
- Agricultural cooperatives for mutual assistance and agricultural insurance;

After the amendment of the law in 2004, the number of new cooperatives has been increasing year by year: the first 30 agricultural cooperatives were established in 2005, while in 2021 (January-September) no fewer than 248 new agricultural cooperatives were created, and since 2016 the number of cooperatives has increased exponentially each year: 44 newly established cooperatives were registered in 2014, 287 in 2018. However, in 2023, according to official ONRC data, there were 2,620 agricultural cooperatives in Romania and the number of cooperatives has increased compared to the beginning of 2020 (previous research). This could be due to the benefits granted to agricultural cooperatives by the laws 21/2019 and 265/2020 and the EU agricultural subsidies and tenders (Legea 566/2004).

According to 2023 data, the main activity of cooperatives was trade (35%), followed by livestock (16%) and cereals (14%). 10% of cooperatives had a mixed activity (a combination of crop and livestock production).

In terms of types of cooperatives, most agricultural cooperatives were of type 2 - a total of 1,699, mixed (containing legal persons and/or only legal persons), while 827 were of type 1. This development can be explained by several factors, such as the trend of consolidation of medium-scale commercial agriculture in Romania (according to the results of the 2020 General Agricultural Census, there were 2.88 million registered farms, about 1 million less than in the 2010 Census, and the number of farms without legal personality decreased by 25.3%), as well as the legislative changes and tax benefits received by agricultural cooperatives and their members after 2016 (RNCA, 2025).

According to the business register, in the first quarter of 2023, 2,526 agricultural cooperatives were registered in Romania, while 94 more cooperatives have been dissolved, are in liquidation, have become insolvent or have been deleted from the register. (AFIR, 2025), (CRPE 2024).

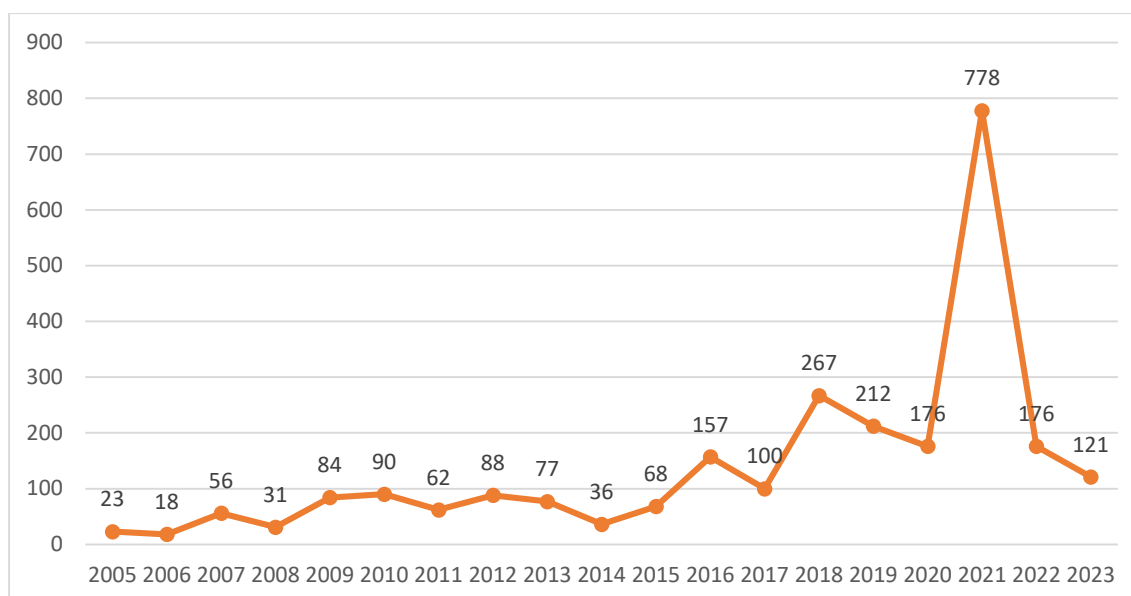


Figure 2: Evolution of the number of agricultural cooperatives created by year, N=2620 created between 2005 and 2023

Source Own edition (CRPE 2024)

After 267 cooperatives were created in 2018, the highest number ever, a record 778 were created in 2021. In 2022, the number of new cooperatives will fall to 176, and in 2023 the number of newly created cooperatives will fall to under 200 (ONRC) (2025), (CRPE 2024).

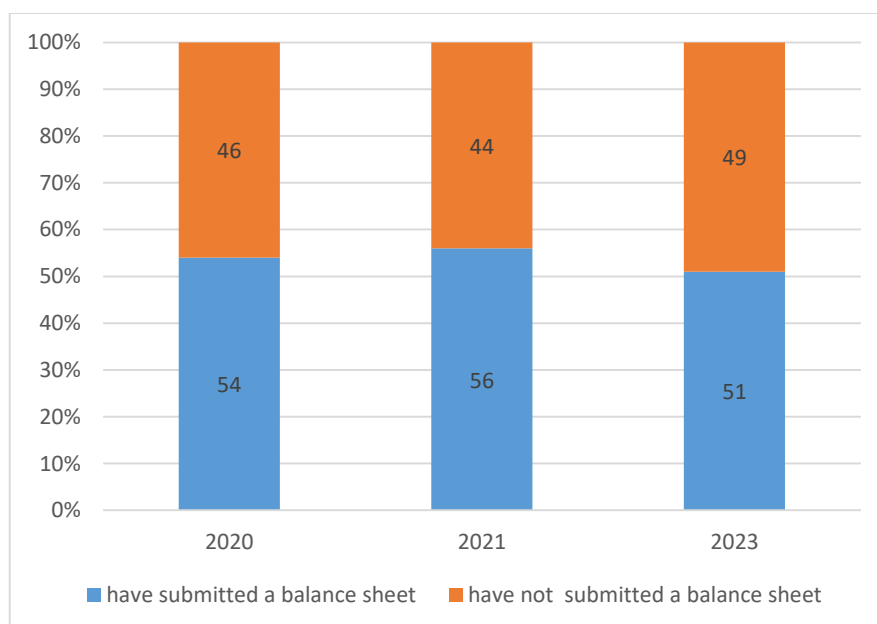


Figure 3: Situation of cooperatives by balance sheet, by year, total cooperatives in operation (in the respective years)

Source Own edition (CRPE 2024)

In 2021, a record number of cooperatives were created - 778 - but many of them (294) did not close in 2022 and 6 were liquidated. The data show that around half of the cooperatives have taken their balance sheet in the years under review. (CRPE 2024)

Table 2: Financial situation of cooperatives

	Cooperatives with balance sheet	Total turnover	Total profit
2022	317 (26%)	4.261.456.540	2.942.540.215
2021	471 (38%)	2.942.540.215	68.607.431
2020	294 (31%)	1.604.714.776	43.910.008

Source Own edition (CRPE 2024)

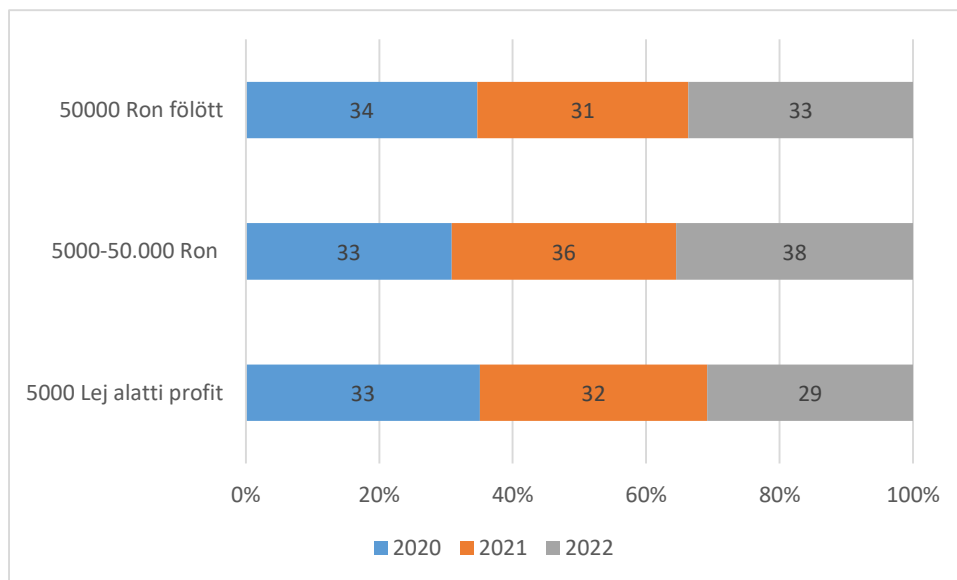


Figure 4: Distribution of cooperatives by profit

Source Own edition (CRPE 2024)

Regardless of how many cooperatives are created each year, the proportion of cooperatives with a balance sheet at the end of the year remains constant - just over half of the cooperatives in operation are still in business and probably have a balance sheet. At the end of 2022, there were just over 1300 economically active cooperatives in Romania (with a balance sheet at the end of the year).

In 2023, the combined turnover of the 1235 cooperatives with a balance sheet in 2022 was about RON 4.26 billion, this amount is increasing year by year, in 2021 it was about RON 2 billion, in 2021 it was RON 2.95 billion, in 2020 it was about RON 1.6 billion. In 2022, 54 of the cooperatives had a turnover of 0 (although they had a balance sheet, they did not carry out any economic activity). Of the 317 cooperatives that had a balance sheet, 317 did not provide financial data related to their turnover. Of all cooperatives, 23% had a turnover of less than EUR 10 000 and a further 24% had a turnover of between EUR 10 000 and EUR 100 000. The proportion of cooperatives with a turnover of less than EUR 10 000 (in the three categories mentioned above) is steadily increasing, with 39 % in 2020, 45 % in 2021 and 53 % in 2022. In 2022, 339 cooperatives reported losses, while nearly 748 reported cumulative profits of nearly RON 128 million (around EUR 25.5 million), an increase compared to the previous year. edition (CRPE , 2024)

As for the market share of agricultural cooperatives, it is increasing year by year, depending on the agricultural sector. While the market share of cooperatives was 2% in 2020, it doubled in 2022 to 4%.

Conclusion

Agricultural cooperatives, as a form of association of farmers in Romania, have become increasingly active in recent years, proving their ability to provide a new organisational tool through which farmers can develop their activities. This development has been determined by a complex combination of factors such as the recent trend of consolidation of agricultural holdings in Romania, legislative changes and tax benefits granted to cooperatives after 2018, as well as the support from European funds for their creation, the priority given to the forms of association in access to finance, and the pandemic. At the same time, the majority of cooperatives (almost half) only "exist" but are not economically active, some are beyond the start-up phase but are financially fragile.

There is a need for the state (public policies) to constantly encourage the creation of new agricultural cooperatives, but also for policies to explicitly seek to consolidate existing ones, making them more competitive in a variety of ways:

1. Financial - sustainability, capitalization, risk management, improving collective investments.
2. Horizontal expansion (increasing the number of members/memberships) and improving the capacity of rural communities (e.g. through the development of food hubs and other short-term production/production).
3. Vertical integration - creating a 3rd degree cooperative neighbourhood.
4. Diversification of farmers' functions

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ASSESSMENT OF PRIOR KNOWLEDGE AND ALGORITHMIC SKILLS AMONG FIRST-YEAR COMPUTER SCIENCE STUDENTS

PIROSKA BIRÓ – ZSUZSANNA TIMEA NAGY – MÁRIA CSERNOCH

Abstract

The high attrition rate of Computer Science (CS) students questions the students' readiness for these studies or indicates a gap between secondary and tertiary education. Previous studies found that the CS curricula and the widely applied learning-teaching approaches did not meet the requirements of tertiary studies. In the meantime, modified curricula were introduced that emphasize the importance of programming. Our present study repeated a previous test on programming and provided novel test results. It was found that, in general, the algorithmic and programming skills of students starting their tertiary CS studies are at a level of Grade 5–8 students, and they are rather rote skills instead of transferable schemata. It was also found that students' graduation exam results are misleading, especially the middle-level exam since they are much higher than the test results. These findings indicate that the modified curricula have not reached their assigned roles, the maturation exams and the preparation for them have only minor effects on the students, and students lack fundamental computational thinking skills. It was also clarified that further studies are needed to reveal the root causes of these discrepancies and find approaches to remediate these problems.

Keywords: programming education, maturation exam, computer science students, algorithmic skills, computational thinking

1. Introduction

The high attrition rate in Computer Science indicates that students' expectations and universities' requirements do not match. To find the root cause of these differences, we launched a series of tests in 2014 entitled Testing Algorithmic and Application Skills (TAaAS) (Csernoch et al. 2015). Back then, it was found that students had a low level of computational and algorithmic skills and were not able to transfer their knowledge among the various fields of CS (Biró and Csernoch 2014, 2015, Csernoch and Biró 2017, Csernoch et al. 2015). This result implies that students were taught in a system where the teachers mostly had a belief in a “fixed” instead of an “incremental” nature of science (Chen et al. 2014). In this system, the performance goal of the teaching process is that students should demonstrate knowing truths on a test.

In the meantime, the modification of the National Curriculum was introduced in 2020 (OFI 2012, OFI 2020a, 2020b, 2020c), where programming is taught from Grade 3 to Grade 11. In the TAaAS test, repeated in 2024, we were interested in seeing how students were prepared for their CS studies in accordance with the changes in the curriculum.

2. The Sample

2.1. Participants

The test was conducted with first-year Computer Science (CS) BSc students at the beginning of their tertiary studies ($N = 193$). According to the National Curriculum introduced in 2012 and modified in 2020 (OFI 2012), all elementary and secondary education students study programming (OFI 2020a, 2020b, 2020c). Among the 193 participants, three students stated that they did not learn programming (Table 1). 42% of the students took the middle and/or 49% the upper-level maturation exams; 15% took both. 46 students (24%) did not take either of the exams or did not answer the question (no data).

Table 1. The number of participants, middle and upper-level maturation exams in Informatics, and those who studied programming in school.

	N	%
participants	193	
middle-level maturation exam	81	42%
upper-level maturation exam	94	49%
both maturation exams	28	15%
no maturation exam	46	24%
learned programming	190	98%

2.2. Tasks

The present paper focuses on the conditional counting task of the test. The task was borrowed from the Nemes Tihamér Programming Contest, designed for Grades 5–8 students (ELTE, 2008). Task P2 was the second task of the programming test with the picture, the data, and the three pseudo-codes (P2_1, P2_2, P2_3) (Figure). The original tasks expected the explanation of the pseudo-codes with the shortest possible expressions.

The task was modified by asking for the value of the DB and M variables at the end of the algorithms. Task P3 is a graphical version of P2, designed by our research group (Figure). Tasks P2_1 and P2_2 are conditional counting (the number of points larger than 800 and the number of valleys, respectively), while Task P2_3 is to determine/calculate the largest increase between two neighboring values. In general, fundamental algorithms were presented in the test that CS students should be familiar with.

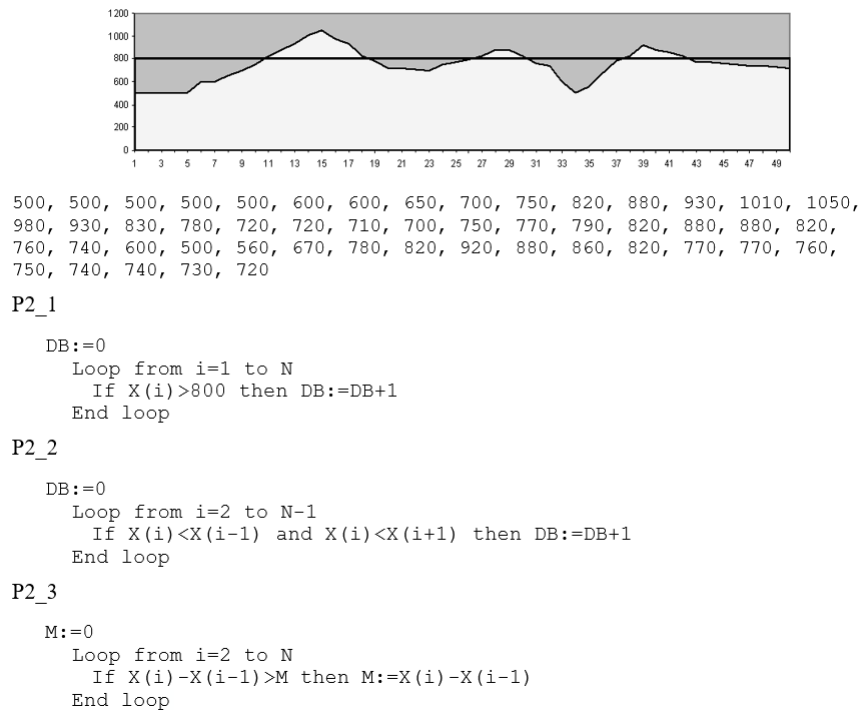


Figure 1. Task P2.

Task P3 was based on Task P2_1, where our purpose was to reveal whether there is any difference between the different presentations of the same algorithm. In Task P3, the numbers are substituted with smiles of different sizes to illustrate the value. Furthermore, the variable that collects the number of smiles fulfilling the condition is also a symbol.

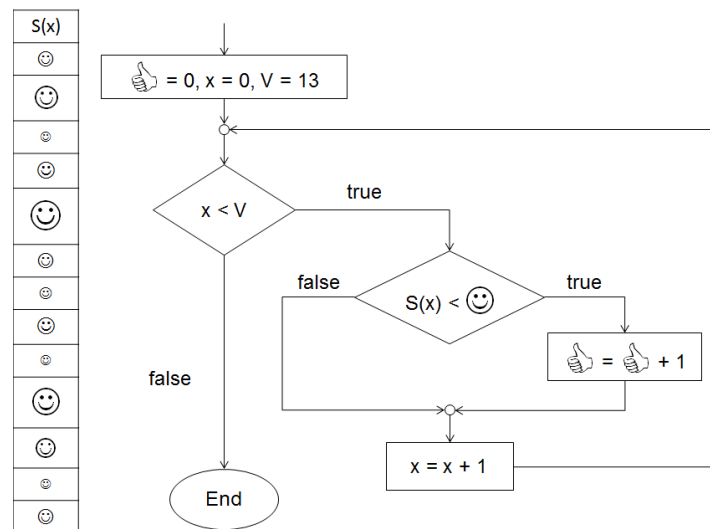


Figure 2. Task P3.

The test was carried out in the university's e-learning system. The explanations were open-ended questions, while the values of the variables were stored as integers.

2.3. The evaluation of the answers

Due to the two different answer types, a triangulation method was used to evaluate the students' answers. The SOLO categories of understanding were assigned to the students' answers based on previously published results (Biggs et al. 1982a, 1982b, Bruner 1990, Csernoch et al. 2015). Two of

the members of our research group carried out the categorization. The SOLO categories are the following:

- Ignore: 0
- Prestructural: 1
- Unistructural: 2
- Multistructural: 3
- Relational: 4

The Extended Abstract category was not available due to the characteristics of the tasks.

The integer values were evaluated automatically. The results were set up by combining qualitative and quantitative data.

2.4. Research question

The test aims to reveal whether students can recognize fundamental algorithms, and this knowledge is enough to build on further studies. If not, how can students be prepared for their tertiary CS studies?

Our further question was whether any connection between the students' maturation exam results in Informatics and their test results can be found. How reliable are the maturation exam results in tertiary CS studies?

3. Results

The test results of the three conditional calculations and the maximum selection were compared to each other (P2_1, P2_2, P2_3, and P3) and to the results in the maturation exams in Informatics. It was found that the mean of the students' results on the test was 58.03. Considering the level of tasks – originally prepared for Grades 5–8 students (ELTE 2008) – we can conclude that students starting their tertiary studies in CS are at the elementary school level on average.

3.1. Explanation of pseudo-codes vs. values

In the first step of the detailed analysis, the comparison of the explanations of the pseudo-codes and the values of the given variables at the end of the algorithm was carried out in Task P2. The results revealed that there is a significant difference in Task P2_1 between the explanation and the value of DB ($p = 0.020$), while there is no significant difference in Tasks P2_2 ($p = 0.387$) and P2_3 ($p = 0.456$). It was also tested whether any difference can be revealed when the presentation mode of an algorithm is changed. To this comparison, Tasks P2_1 and P3 were compared. It was found that students can recognize the algorithm in a text-based form more easily than in a graphical form. This implies that schools primarily focus on text-based presentation, and students cannot transfer this knowledge to other environments (Figure 3).

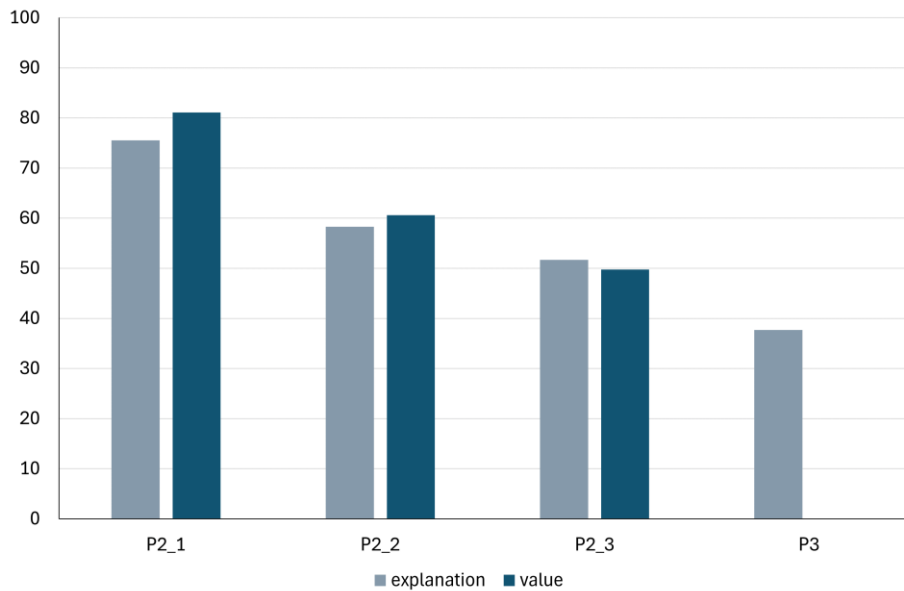


Figure 3. The comparison of the explanation of the pseudo-codes and the values of the variables at the end of the algorithm.

3.2. The distribution of students' results

The second phase of the analysis compared the students' results in the presented tasks. The highest point is 22. Figure presents the distribution of the points of the 193 students. The mode of the points is 12. The distribution of the collected points implies that students had problems solving these simple tasks prepared for Grades 5–8 students. We must also remember that the tested students were CS students starting their tertiary studies in a subject they are good at and interested in.

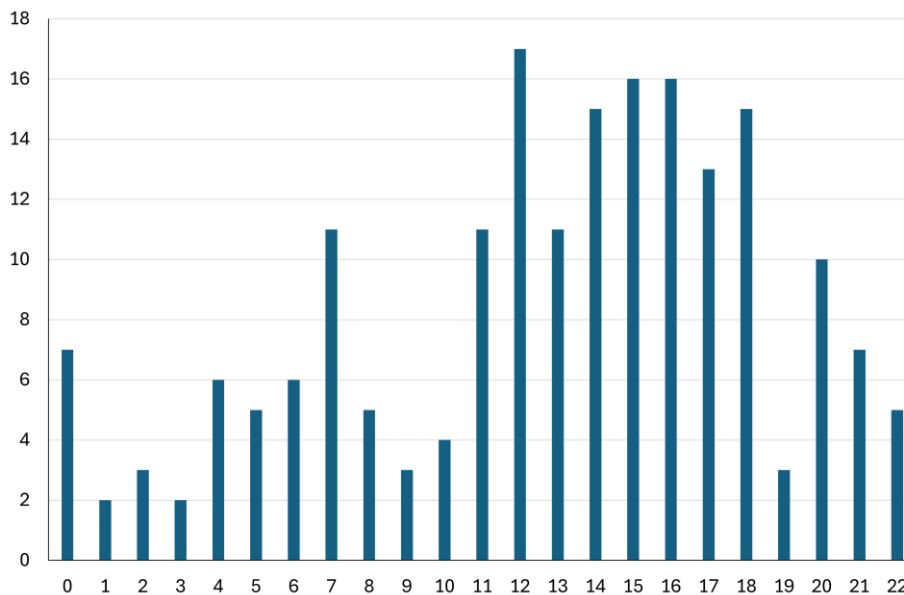


Figure 4. The distribution of the total points in Tasks P2 and P3.

In the following step, the SOLO categories of understanding were assigned to the performance of the students (Figure) (Biggs et al. 1982a, 1982b, Bruner 1990, Csernoch et al. 2015). Task P2_1 was the easiest among the four tasks, which is demonstrated by the high value of the Relational SOLO category. In this task, most students (54%) could formulate a short and correct expression describing

the algorithm. However, they could not recognize the same algorithm in Task P3. This result is an indication that students in their elementary and secondary education instead focused on coding rather than understanding and building algorithms, their level of computational thinking is relatively low (Denning 2013, Lodi & Martini 2021, Papert 1980, Wing 2006), and their problem-solving abilities do not allow them to find connection between similar problems (Polya 1945).

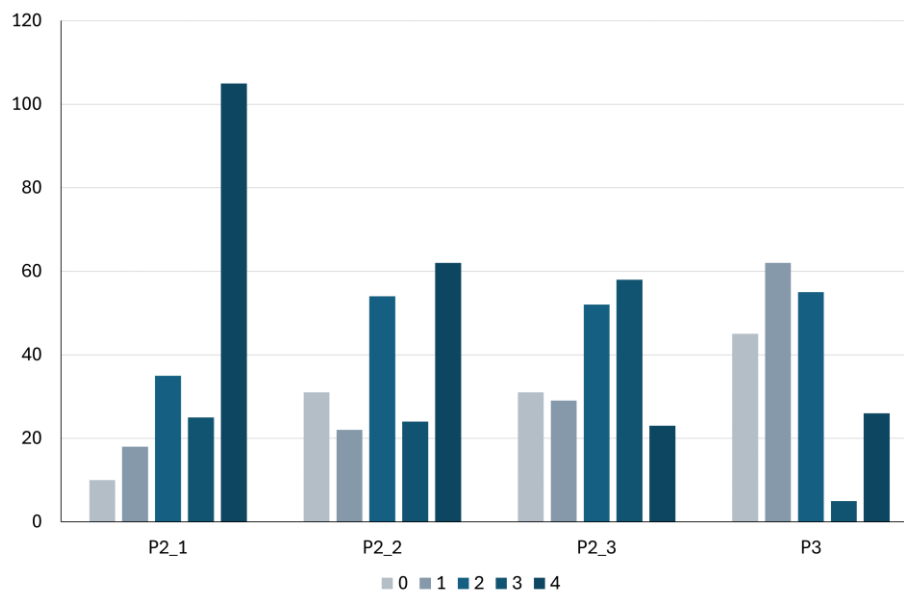


Figure 5. The distribution of the SOLO categories by tasks.

3.3. The effect of the maturation exam

The students' test results were compared to their maturation exam results in Informatics. First, it was checked whether there were any differences between those who did or did not take the maturation exams or did not provide data. It was found that the mean of those who did not take the maturation exams is less (51.4) than those who did (60.1) (Figure). However, the standard deviation is larger in the group who did not take the exam (28.6 vs. 24.1), which might be explained by the fact that some students did not provide data. Considering the differences between the two groups, it is on the boundaries of significance. The parametric t-test shows significance ($p = 0.043$), while the non-parametric Mann-Whitney test is marginally non-significant ($p = 0.089$). The visualizations show that while both groups have similar distributions, the group with maturation exams has a slightly higher central tendency and less variability in the lower score ranges (Figure).

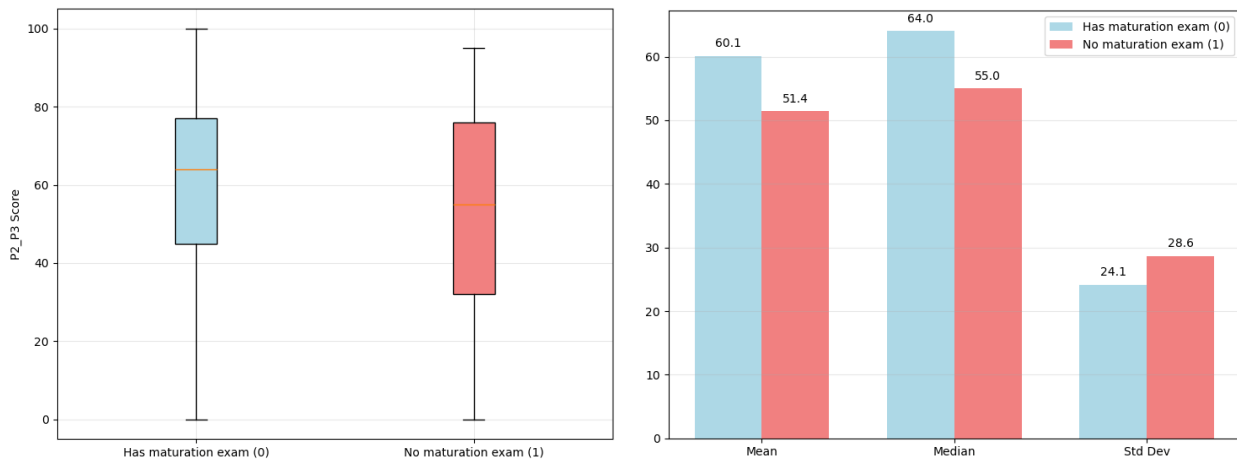


Figure 6. The comparison of the test results of those who did or did not take the maturation exams in Informatics (julius.ai was used to create the figure).

In the following step, the test results were compared to the level of maturation exam in Informatics (Figure and Figure). The mean differences are -18.86 and -4.27 when the test results were compared to the middle ($p < 0.001$) and upper-level ($p = 0.036$) maturation exam results. There were significant differences in both cases, but the upper-level exam is closer to the test results. However, we must keep in mind that the tasks of the test were initially prepared for Grades 5–8 students (ELTE 2008).

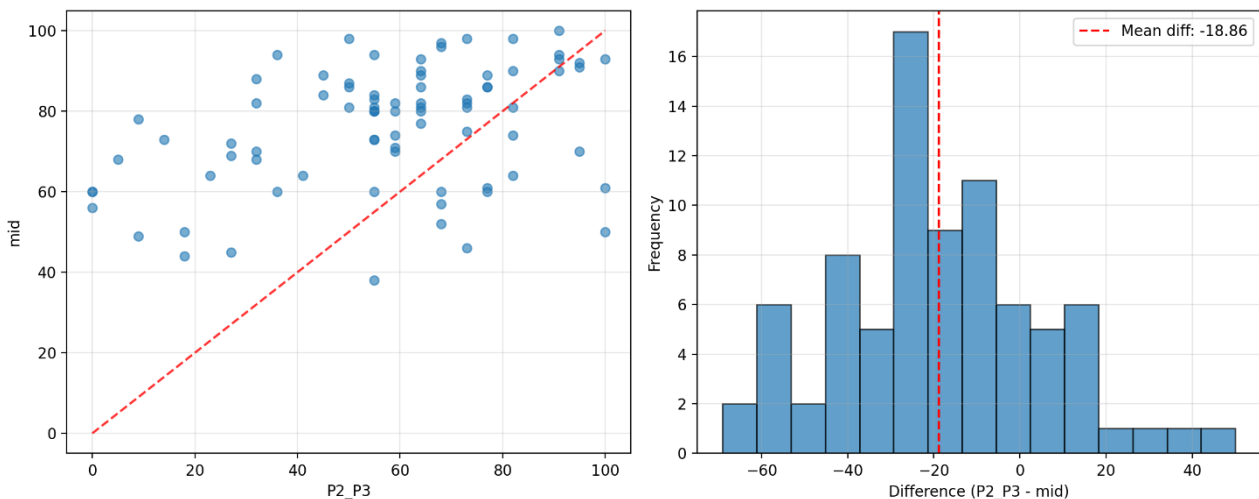


Figure 7. The comparison of the test results of those who took the middle-level maturation exam in Informatics (julius.ai was used to create the figure).

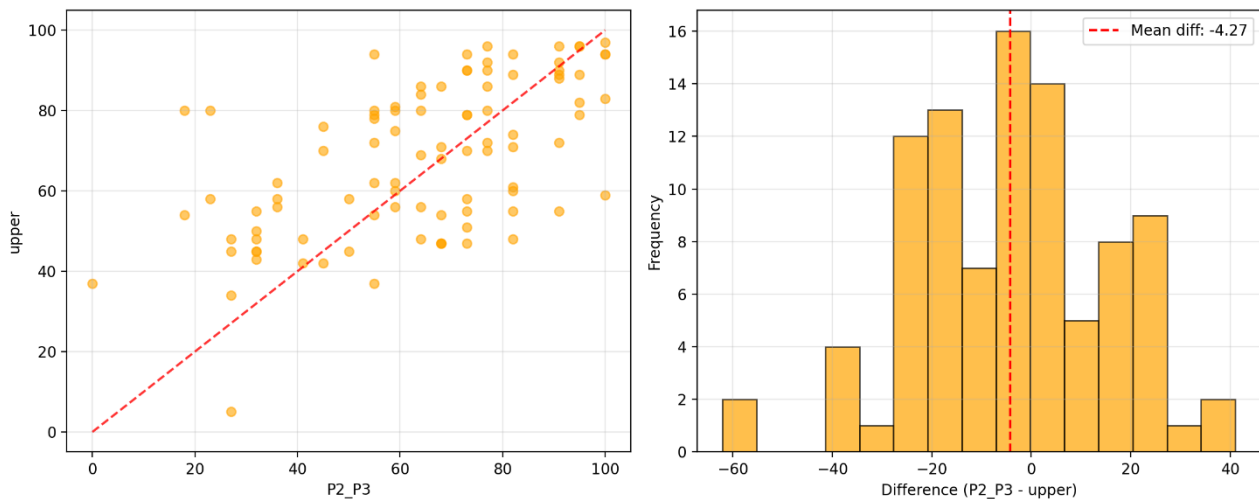


Figure 8. The comparison of the test results of those who took the upper-level maturation exam in Informatics (julius.ai was used to create the figure).

The comparison of similar tasks, the students' points in the test, and the SOLO categories assigned to students' answers revealed that students do not have firm schemata stored in long-term memory (Sweller et al. 2011, Kahneman 2011). This implies that the cognitive load on the working memory is high, and problem-solving is rather error-prone. The analysis of the National Curriculum (OFI 2012) and adjacent frame curricula (OFI 2020a, 2020b, 2020c) has proven that learning-teaching approaches instead focus on tools instead of developing students' problem-solving skills (Polya 1945, Kirschner & De Bruyckere 2017, Kirschner et al. 2006, Sweller et al. 2007, 2011).

4. Conclusions

Within the framework of the TAaAS project, a test was conducted on a group of first-year Computer Science students in their first week of tertiary education. The present paper focuses on the algorithms of conditional calculation and the selection of the maximum value – originally prepared for Grades 5–8 students – and the comparison of the test and the maturation exam results in Informatics. The primary question of the test was whether students, after studying informatics for nine years in elementary and secondary education, arrived well-prepared for their studies in CS.

The results show that the tested students are at the elementary school level on average, which finding implies that they do not have the required level of computational and algorithmic skills to start their CS studies. Only 11.4% of the students scored at least 90%. The comparison of the test results and the maturation exams in Informatics demonstrated that the maturation exams build up a false view of the students' skills and competencies considering their knowledge of programming and algorithms. This negative result is rather connected to the middle-level maturation exam; despite that, it also has a section with programming tasks.

We can conclude that students start their tertiary CS studies with a low level of programming skills and competence, and these results should be taken into consideration in tertiary education when CS curriculum and learning-teaching materials are prepared.

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Piroska Biró

Department of Economic Sciences, Faculty of Economics, Socio-Human Sciences and Engineering, Sapientia Hungarian University of Transylvania, Miercurea-Ciuc, Romania

Department of Information Technology, Faculty of Informatics, University of Debrecen, Debrecen

e-mail: biropiroska@uni.sapientia.ro, biro.piroska@inf.unideb.hu

Zsuzsanna Timea Nagy

Department of Mathematics-Informatics, Faculty of Technical and Human Sciences, Sapientia Hungarian University of Transylvania, Târgu Mureș, Romania

e-mail: nagy.zsuzsa@ms.sapientia.ro

Mária Csernoch

Department of Computer Science, Faculty of Informatics, University of Debrecen, Debrecen, Hungary

e-mail: csernoch.maria@inf.unideb.hu

PERFORMANCE ANALYSIS OF HUNGARIAN FOOD INDUSTRY COMPANIES USING THE DEA METHOD

ANITA KISS - ÉVA DARABOS - TÜNDE ORSOLYA NAGY

Abstract

This study aims to evaluate the performance of Hungarian food industry companies using the DEA (Data Envelopment Analysis) method. The relevance of the research lies in the increasing importance of monitoring operational efficiency and economic viability in a continuously evolving economic environment. The primary objective is to explore how performance measurement and comparative analysis can support strategic decision-making and corporate development within the sector. The research follows an empirical, quantitative approach based on secondary data drawn from the EMIS database, covering 702 food industry enterprises over the financial years 2018 to 2021.

Keywords: food industry, corporate performance, efficiency, DEA method

1. Introduction

Due to the rapid changes in the economic environment, increasing emphasis is being placed on the continuous monitoring of corporate operational efficiency and performance—particularly in strategically important sectors such as the food industry. In order to maintain competitiveness and achieve long-term sustainable growth, the use of objective and reliable performance indicators that support informed decision-making has become essential. One of the most advanced and widely used tools in this field is the DEA (Data Envelopment Analysis) method, which enables the comparative assessment of the relative efficiency of organizations utilizing similar inputs.

The aim of this study is to examine the efficiency of Hungarian food industry companies through an empirical and quantitative approach using the DEA methodology. Special attention is given to differences based on regional location, sub-sector classification, company size, and operational age. The analysis is based on secondary data derived from the EMIS database, which contains financial reports of 702 Hungarian food industry companies for the financial years 2018 to 2021. The objective of the research is not only to map current efficiency levels but also to identify benchmarking-based indicators and performance-determining factors that can serve as a foundation for strategic development at both the corporate and sectoral levels.

2. Theoretical Overview

2.1. Interpretation and Dimensions of Corporate Performance

Defining and evaluating corporate performance is a complex issue that has led to diverse approaches across several fields related to management science - such as economics, controlling, and organizational theory. In the academic literature, two key factors traditionally stand out: effectiveness and efficiency, which, according to Dobák et al. (1996), constitute the foundation of performance management. Although these dimensions can be separated in theory, they are interdependent in practice, as efficiency holds real significance only when it translates into tangible outcomes.

In recent years, research has significantly broadened the conceptual framework of corporate performance. Beyond traditional financial indicators, increasing emphasis is placed on factors such as product quality, innovation capacity, employee knowledge, and sustainability. These attributes not only reflect the internal operational efficiency of a company but also its ability to adapt to environmental changes - an ability that is crucial for long-term competitiveness. Wimmer (2004) does

not treat profitability as an isolated dimension but as the result of the combined effects of several performance elements, including effectiveness, efficiency, productivity, and innovation.

There are strong interdependencies among performance dimensions. For example, improved quality can enhance customer satisfaction and revenue growth, which in turn leads to better efficiency indicators using the same resources. Conversely, innovation may increase costs in the short term, thereby temporarily reducing efficiency. This highlights that performance must always be interpreted in light of the specific time horizon and external environment (Kaplan & Norton, 1992; Neely et al., 2005).

In modern performance measurement, scholars such as Bititci et al. (1997) and Otley (1999) argue that reliance solely on financial indicators is insufficient. They advocate for the inclusion of indirect, non-financial elements such as employee satisfaction, utilization of technical capacity, customer feedback, and market positioning.

The specific characteristics of the food industry - including seasonal demand fluctuations, strict regulations, and short production cycles - make a multi-dimensional approach particularly justified. In this context, the DEA method provides an opportunity to assess various input and output factors simultaneously. Utilizing this methodology, the present research not only explores the relationship between efficiency and effectiveness but also identifies regional, structural, and temporal differences among Hungarian food industry enterprises.

2.2. Theoretical Background of the DEA Method

The Data Envelopment Analysis (DEA) is one of the most widely applied non-parametric methods for measuring production efficiency. It is used to evaluate the relative performance of decision-making units (DMUs) that utilize similar resources. Rooted in the principles of linear programming, the method seeks to construct an efficiency frontier against which the position of each unit can be assessed. The original concept of DEA was developed by Charnes et al. (1978), and while the initial CCR model - based on the assumption of constant returns to scale (CRS) - was predominant, the later BCC model introduced by Banker et al. (1984) allowed for the consideration of variable returns to scale (VRS). The choice of model becomes particularly relevant when analyzing organizations of varying sizes.

One of the primary advantages of DEA is that it does not require any prior assumptions regarding the functional form of the production process. Moreover, it is capable of handling multiple input and output variables simultaneously, making it especially suitable for complex performance assessments. Emrouznejad and Yang (2018) emphasize that DEA's popularity stems from its flexibility and wide applicability across various industries, including healthcare, public services, and the agri-food sector. Nonetheless, critical perspectives have also emerged. Luo et al. (2012) caution that DEA can be sensitive to the size of the dataset and the ratio of input to output variables. If too many variables are used in a small sample, the model's discriminating power may diminish, potentially leading to inaccurate efficiency scores.

DEA is frequently compared to the Stochastic Frontier Analysis (SFA) method. While DEA adopts a deterministic, non-parametric approach, SFA is a parametric model that incorporates statistical error into the evaluation. According to Zhu (2014), a key strength of DEA is its freedom from distortions caused by prior assumptions. However, a major limitation is its inability to account for random error, which makes it more susceptible to data noise.

In our view, the application of DEA in the food industry is particularly justified, as the sector is characterized by complex and heterogeneous production processes, with companies varying significantly in size. According to the comprehensive literature review by Dutta et al. (2022), DEA has served as a frequent empirical basis for evaluating the efficiency of food industry suppliers and producers over the past two decades - especially in studies disaggregated by size or region.

3. Materials and Methods

3.1. Data Source and Variables Examined

The reliability of DEA analysis is strongly influenced by the selection of input and output variables, as well as the quality of the underlying dataset. This study is based on the financial statement data of 702 Hungarian food industry companies for the period 2018-2021, extracted from the EMIS (Emerging Markets Information Service) database. The sample exclusively includes companies classified under NAICS code 311, which corresponds to food manufacturing.

The input variables reflect the firms' resource utilization and include tangible fixed assets, material-type expenditures, personnel-related expenses, other costs, and interest paid - this latter also serving as an indicator of the efficiency of the financial structure. The outputs are represented by total revenue and gross value added (GVA), both of which are widely accepted as reliable measures of corporate performance (Cook & Seiford, 2009; Zhu, 2014).

The selection of variables was guided not only by data availability but also by sector-specific characteristics - such as high material costs and labor intensity (Emrouznejad & Yang, 2018). The number of input and output dimensions was limited in accordance with the recommendations of Cooper et al. (2011) to ensure adequate discriminative power of the model.

3.2. Research Objectives and Analytical Dimensions

The primary objective of this research is to map the efficiency of Hungarian food industry companies using the DEA method and to enable comparability along structural dimensions. The analysis does not only provide aggregated efficiency scores but also identifies organizational and environmental factors that influence performance.

Due to its flexibility, DEA is well-suited for analyzing the multidimensional performance of the food industry (Cook & Seiford, 2009; Zhu, 2014). In this study, efficiency analysis was conducted along four key dimensions:

- regional location,
- industry sub-sector,
- company size (based on number of employees),
- firm age.

This structure aligns with the increasingly emphasized contextual frameworks in DEA applications (Färe et al., 2007; Emrouznejad & Yang, 2018). Analyzing regional differences is particularly relevant in light of Hungary's economic development goals (Lengyel & Rechnitzer, 2004). The breakdown by industry sub-sector reveals intra-vertical disparities, while company size allows for the investigation of scale efficiency effects (Banker et al., 1984). The analysis of firm age-based on the work of Rossi (2016) - is introduced as a novel perspective within DEA studies.

Thus, the research goes beyond the mere ranking of efficiency: it establishes a foundation for benchmarking and contributes to the identification of performance-determining factors, offering results that are both scientifically valuable and applicable to economic policy-making.

4. Results and Discussion

4.1. Distribution of the Examined Companies by NAICS Code, Region, and DEA Efficiency

The dataset analyzed contains data for 702 food industry companies over a four-year period, making it both temporally and structurally complex. Presenting the characteristics of the sample is essential for interpreting the DEA results, as efficiency scores can only be meaningfully understood in the context of the types of companies included in the analysis.

Figure 1 illustrates the industrial classification of the sample based on the NAICS system.

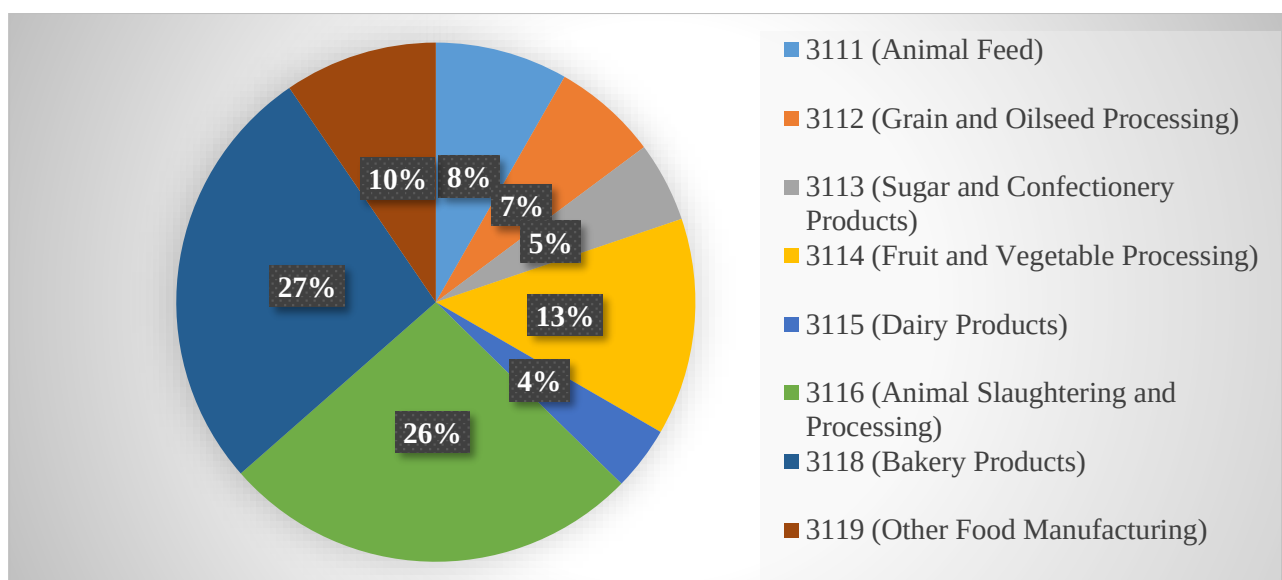


Figure 1: Industry Classification of the Sample Based on the NAICS System
Source: Own editing

The industry composition of the sample, comprising 702 companies, reveals a marked concentration in certain segments of the food industry. The largest share is represented by bakery product manufacturers (NAICS 3118), with 190 firms (27%), closely followed by companies engaged in animal slaughtering and processing (NAICS 3116), totaling 183 firms (26%). Together, these two sub-sectors account for more than half of the entire sample, indicating that they form the backbone of the Hungarian food industry, characterized by a large number of market participants and significant production volumes.

Moderate representation is observed among fruit and vegetable processing companies (NAICS 3114) at 13%, feed manufacturers (NAICS 3111) at 8%, and food manufacturers classified under “other” (NAICS 3119) at 10%. These sub-sectors reflect the diversity of domestic agricultural product processing and contribute to the complexity of the food industry value chain.

The lowest shares are recorded for grain and oilseed processing (NAICS 3112 – 7%), sugar and confectionery product manufacturing (NAICS 3113 – 5%), and dairy product manufacturing (NAICS 3115 – 4%). These industries are likely composed of fewer but larger-scale enterprises, which may explain their lower representation in the sample.

Overall, the sectoral structure of the corporate sample reflects the composition of the domestic food industry. However, the strong dominance of two sub-sectors may introduce a degree of bias in the aggregated efficiency indicators, which must be carefully considered in the subsequent analyses.

Figure 2 presents the regional distribution of the corporate sample.

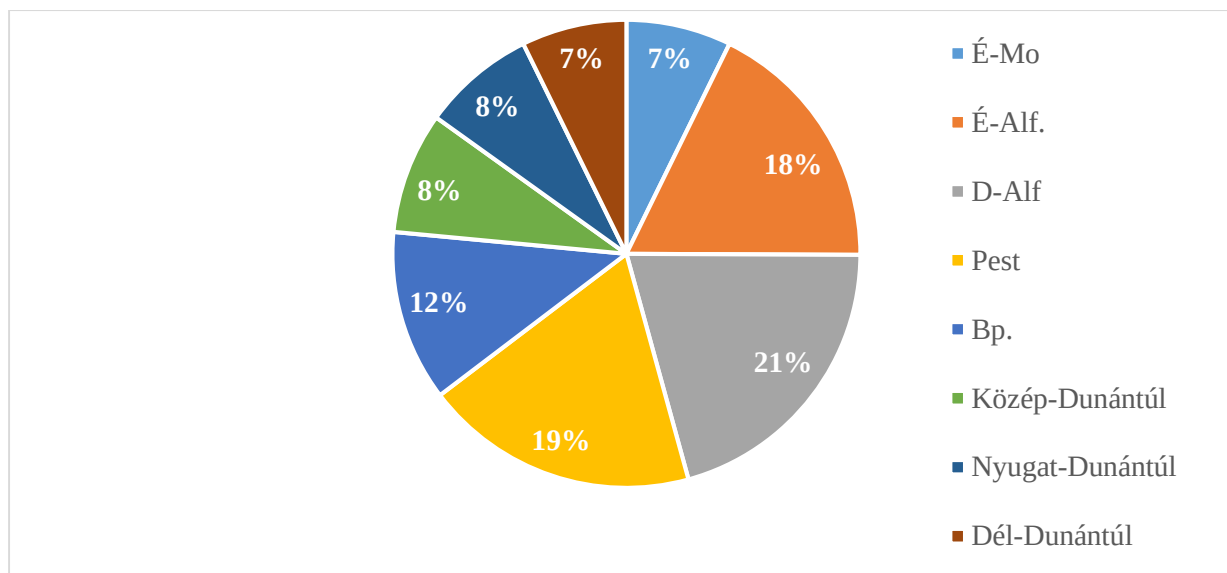


Figure 2: Regional Distribution of the Sample
Source: Own editing

The regional distribution of the 702 food industry companies in the sample clearly shows that Dél-Alföld (21%; 147 companies), Pest megye (19%; 133 companies), and Észak-Alföld (18%; 126 companies) play a prominent role, together accounting for more than half of the total sample. This indicates a significant concentration of food industry activity in these regions, likely due to favorable agricultural conditions as well as well-developed logistics and industrial infrastructure.

Budapest alone accounts for a substantial share of 12% (84 companies), which can be attributed to its administrative centrality and the presence of service-oriented food industry operations. The mid-range includes Közép-Dunántúl, Nyugat-Dunántúl, and Észak-Magyarország, each representing 7–8% of the sample (49-56 companies), while Dél-Dunántúl is also represented with 7% (49 companies).

These figures suggest that although food industry companies are present across the entire country, the northern and Transdanubian regions have a smaller share, which may reflect regional disparities in food industry infrastructure and investment activity. The geographical distribution of the sample thus reflects the economic significance of traditional agricultural centers, industrial clusters, and the central region within the sector.

Table 1: Distribution of the Examined Companies by DEA Efficiency Scores (2018-2021)

Efficiency Score Intervals		2018		2019		2020		2021	
		No.	%	No.	%	No.	%	No.	%
	=1.0	88	12,54%	78	11,11%	80	11,40%	76	10,83%
>= 0.9	< 1.0	30	4,27%	17	2,42%	22	3,13%	29	4,13%
>= 0.8	< 0.9	45	6,41%	18	2,56%	29	4,13%	30	4,27%
>= 0.7	< 0.8	49	6,98%	42	5,98%	50	7,12%	63	8,97%
>= 0.6	< 0.7	96	13,68%	62	8,83%	58	8,26%	67	9,54%
>= 0.5	< 0.6	115	16,38%	95	13,53%	101	14,39%	92	13,11%
>= 0.4	< 0.5	128	18,23%	133	18,95%	127	18,09%	90	12,82%
>= 0.3	< 0.4	85	12,11%	115	16,38%	102	14,53%	89	12,68%
>= 0.2	< 0.3	48	6,84%	88	12,54%	81	11,54%	88	12,54%
>= 0.1	< 0.2	18	2,56%	53	7,55%	47	6,70%	64	9,12%

≥ 0.0	< 0.1	0	0,00%	1	0,14%	5	0,71%	14	1,99%
Average DEA		0,5979		0,5185		0,5383		0,5328	
Total (No.)		702		702		702		702	

Source: Own editing

Table 1 presents the distribution of DEA efficiency scores for the 702 food industry companies examined over four consecutive years (2018-2021), broken down into efficiency intervals ranging from 0 to 1. The proportion of firms achieving full efficiency (DEA = 1.00) remained relatively stable throughout the period: 12.54% in 2018, 11.11% in 2019, 11.40% in 2020, and a slight decline to 10.83% in 2021.

Each year, the majority of firms were concentrated in the mid-efficiency ranges. In 2018, the largest groups fell within the 0.4-0.5 (18.23%) and 0.5-0.6 (16.38%) intervals. A similar pattern was observed in 2019, with the highest concentrations in the 0.4-0.5 (18.95%) and 0.3-0.4 (16.38%) ranges. This trend continued in 2020 (0.4-0.5: 12.78%; 0.3-0.4: 14.53%) and shifted slightly in 2021, with the majority of companies falling into the 0.3-0.4 (12.68%) and 0.4-0.5 (12.82%) intervals.

The lowest efficiency category (0.0-0.1) was scarcely represented - there were no firms in this range in 2018, only 1 in 2019, 5 in 2020, and 14 in 2021 - indicating that extremely low-efficiency operations were rare in the sample. However, the 0.1-0.3 range showed a relatively high proportion of firms, particularly in 2019 and 2021, where they together accounted for over 20% of the sample.

Average DEA scores showed a slight but consistent decline over the four-year period: from 0.5979 in 2018 to 0.5328 in 2021. This downward trend suggests an overall deterioration in corporate efficiency during the observed timeframe, likely influenced by external economic pressures such as inflation, rising input costs, and market uncertainty - especially after 2020.

4.2. Statistical Characteristics of DEA Scores

The following table presents the key statistical indicators of efficiency (DEA scores) for the examined food industry companies over the period 2018 to 2021. The descriptive statistics for each year - including minimum, quartiles, median, mean, standard deviation, coefficient of variation, skewness, and kurtosis - provide a comprehensive overview of the distribution and dispersion of efficiency levels within the sample.

Table 2: Key Statistical Characteristics of Efficiency (DEA) Scores by Year, 2018–2021

	2018	2019	2020	2021
Minimum	0,1123	0,0857	0,0580	0,0229
Lower Quartile	0,4157	0,3294	0,3528	0,3148
Median	0,5695	0,4667	0,4904	0,5036
Upper Quartile	0,7739	0,6631	0,7144	0,7265
Maximum	1	1	1	1
Mean	0,5979	0,5185	0,5383	0,5328
Standard Deviation	0,2375	0,2497	0,2555	0,2702
Coefficient of Variation	39,74%	48,16%	47,48%	50,72%
Skewness	0,2839	0,6032	0,4259	0,2765
Kurtosis	-0,8984	-0,5841	-0,8066	-0,9688

Source: Own editing

Based on the statistical analysis of DEA scores, a consistent decline in average efficiency can be observed between 2018 and 2021, dropping from 0.5979 in 2018 to 0.5328 by 2021. The minimum values decreased notably, especially in 2021 (0.0229), indicating that some firms operated with extremely low efficiency that year. The lower quartile values followed a similar trend, falling from

0.4157 in 2018 to 0.3148 in 2021, suggesting a significant deterioration in the performance of the bottom 25% of companies.

In contrast, the median value slightly increased in 2021 (0.5036) compared to 2020 (0.4904), indicating a modest improvement in the mid-performing group. The upper quartile rose to 0.7265 in 2021, demonstrating that the top 25% of firms maintained strong efficiency levels. Both the standard deviation and the coefficient of variation increased steadily over the years, peaking in 2021 (coefficient of variation: 50.72%), which signals growing disparities in efficiency levels across firms. Skewness values remained positive throughout the period but gradually declined, meaning that while the distribution remained right-skewed - indicating a concentration of firms with lower efficiency - the decreasing skewness suggests a slight reduction in extreme values. The negative kurtosis values observed each year reflect a flatter, less concentrated distribution compared to a normal distribution. Overall, the findings indicate a decline in average efficiency and an increase in performance dispersion during the study period. This trend suggests that the economic environment had increasingly differentiated impacts on firms' efficiency - particularly between 2020 and 2021, amid the COVID-19 pandemic and rising inflationary pressures.

4.3. Regional Efficiency Ranking Based on DEA Scores

Table 3 presents the ranking of Hungarian regions according to efficiency, as measured by the DEA method. The comparison is based on the average corporate performance for the period 2018 to 2021, aiming to identify which regions host more efficient food industry companies. The ranking provides a comprehensive overview of regional disparities in terms of operational efficiency.

Table 3: Regional Efficiency Ranking Based on DEA Scores

Region	2018	2019	2020	2021	Average	Rank
Észak-Magyarország	0,544	0,473	0,524	0,499	0,5102	7
Észak-Alföld	0,592	0,519	0,517	0,494	0,5302	5
Dél-Alföld	0,636	0,549	0,566	0,567	0,5795	2
Pest	0,56	0,473	0,493	0,501	0,5068	8
Budapest	0,621	0,568	0,591	0,601	0,5954	1
Közép-Dunántúl	0,624	0,53	0,56	0,53	0,5612	4
Nyugat-Dunántúl	0,608	0,533	0,565	0,553	0,5646	3
Dél-Dunántúl	0,578	0,486	0,504	0,52	0,5219	6

Source: Own editing

The table clearly shows that Budapest achieved the highest average DEA score (0.5954), indicating that food industry companies in the capital operated with outstanding efficiency during the observed period. The Dél-Alföld region ranks second (0.5795), consistently demonstrating relatively high and balanced efficiency scores across all years, especially in 2018 (0.636). In third place is Nyugat-Dunántúl (0.5645), which also showed stable performance, although a slight decline in 2021 (0.546) lowered its overall average.

The middle tier includes Közép-Dunántúl (0.5612) and Észak-Alföld (0.5302); the latter exhibited a gradual decline in efficiency from a relatively high initial value in 2018, suggesting a weakening trend in regional performance. Dél-Dunántúl (0.5219) and Észak-Magyarország (0.5102) are also positioned in the lower half of the ranking.

The lowest average efficiency was recorded in Pest megye (0.5068), despite its classification as an economically developed area. In Pest, DEA scores remained below 0.56 throughout the entire period, indicating persistently low performance.

4.4. Industry Efficiency Ranking Based on DEA Scores

Table 4 presents the efficiency ranking of various food industry sub-sectors based on their average DEA scores for the period 2018 to 2021. The aim of the analysis is to assess how effectively each sub-sector utilizes its resources, thereby enabling the identification of relative performance differences and allowing for a comparison of competitiveness levels across the industry.

Table 4: Efficiency Ranking of Food Industry Sub-sectors Based on DEA Scores

NAICS Code	2018	2019	2020	2021	Average	Rank
3111 (Animal Feed)	0,6732	0,6025	0,6054	0,5971	0,6195	2
3112 (Grain and Oilseed Processing)	0,5707	0,5215	0,5622	0,6063	0,5652	4
3113 (Sugar and Confectionery Products)	0,5225	0,4167	0,4159	0,3732	0,4321	8
3114 (Fruit and Vegetable Processing)	0,5660	0,4943	0,5086	0,5079	0,5192	6
3115 (Dairy Products)	0,6969	0,6392	0,6565	0,6880	0,6702	1
3116 (Animal Slaughtering and Processing)	0,6399	0,5691	0,5707	0,5819	0,5904	3
3118 (Bakery Products)	0,5650	0,4701	0,4973	0,4545	0,4967	7
3119 (Other Food Manufacturing)	0,5725	0,4790	0,5477	0,5672	0,5416	5

Source: Own editing

Based on the data, companies engaged in animal slaughtering and processing (3116) achieved the highest average efficiency score (0.6295), indicating that this sub-sector utilizes its production resources most effectively. Closely following is the animal feed manufacturing sector (3111), with a stable and consistently high average of 0.6195 across all years. Dairy product manufacturing (3115) ranks third with an average score of 0.6020, supported by balanced performance and a notably high score in 2021 (0.688).

The grain and oilseed processing industry (3112) and the “other food manufacturing” category (3119) fall into the mid-range, with averages of 0.5564 and 0.5146, respectively, reflecting moderate efficiency levels. Fruit and vegetable processing (3114) also demonstrated average performance (0.5192), although the year-to-year fluctuations suggest less stability in this sub-sector.

The bottom two positions are occupied by bakery products (3118) and sugar and confectionery manufacturing (3113), with average DEA scores of 0.4967 and 0.4321, respectively. These results indicate substantial potential for improvement in resource utilization, particularly in the sugar and confectionery industry, where the 2021 efficiency score (0.3732) ranks among the lowest in the entire period.

4.5. Efficiency Ranking by Company Size

Table 5 presents the efficiency ranking of the examined companies categorized by the number of employees. The aim of this analysis is to explore the relationship between company size - specifically the number of employees - and relative resource efficiency, as measured by the DEA method.

Table 5: Efficiency Ranking of Companies by Number of Employees

Employee Size Category	2018	2019	2020	2021	Average	Rank
1. <5	0,6576	0,5719	0,5870	0,5923	0,6022	3
2. 5-10	0,5210	0,4530	0,5103	0,4834	0,4919	5
3. 11-20	0,5241	0,4481	0,4590	0,4644	0,4739	7
4. 21-50	0,5705	0,4459	0,4720	0,4592	0,4869	6

5. 51-100	0,5773	0,4833	0,4877	0,4838	0,5080	4
6. 101-250	0,6729	0,6751	0,6876	0,6908	0,6816	2
7. >250	0,8496	0,8424	0,8797	0,8655	0,8593	1

Source: Own editing

The results clearly indicate that large enterprises with more than 250 employees achieved by far the highest average efficiency score (0.8593), consistently demonstrating outstanding performance across all years, particularly in 2021 (0.8655). Medium-sized companies with 101-250 employees also exhibited a strong efficiency level (0.6816), placing them in second position.

Surprisingly, microenterprises with fewer than 10 employees ranked third with an average score of 0.6022, suggesting that despite their small size, they are relatively effective in utilizing their resources. Firms employing 26-50 people (average: 0.4869) and those with 51-100 employees (0.4986) achieved moderate results and fall into the lower half of the ranking. Companies with 5-10 employees displayed somewhat lower efficiency (average: 0.4919), while firms with 11-20 employees recorded the weakest performance (average: 0.4739), reflecting consistently poor outcomes - especially in 2019 and 2020, when their scores fell below 0.45.

Overall, a U-shaped relationship can be observed between company size and efficiency: the smallest and largest companies tend to operate more efficiently, while mid-sized firms - particularly those in the 11-50 employee range - show lower levels of efficiency. This pattern may point to structural challenges, resource constraints, or less effective management practices within mid-sized enterprises. Thus, the ranking offers important insights into the relationship between firm size and operational efficiency and provides a useful basis for designing targeted development interventions.

4.6. Efficiency Ranking by Company Age

Table 6 presents the efficiency ranking of the examined companies grouped by age categories, based on their DEA scores. Although company age is a less frequently analyzed factor in efficiency assessments, it may offer relevant insights: older firms often benefit from more stable operations, mature processes, and accumulated resources, whereas younger companies may stand out through greater dynamism, adaptability, and openness to innovation.

The purpose of this table is to explore whether there is a significant relationship between company age and relative efficiency, and to determine the direction and magnitude of this relationship.

Table 6: Efficiency Ranking of Companies by Age

Age Category	2018	2019	2020	2021	Average	Rank
1. 0-5 years	0,6604	0,5764	0,5803	0,5870	0,6108	2
2. 5-10 years	0,5739	0,4799	0,5413	0,5569	0,5371	4
3. 10-20 years	0,5732	0,5035	0,5382	0,5237	0,5356	5
4. 20-50 years	0,6108	0,5240	0,5309	0,5291	0,5463	3
5. over 50 years	0,6297	0,7085	0,6470	0,5750	0,6401	1

Source: Own editing

Table 6 presents the evolution of company efficiency across different age categories, based on the average DEA scores for the period 2018 to 2021. The results clearly show that the most efficient companies are those over 50 years old, which ranked first with an average DEA score of 0.6401. These firms consistently demonstrated high efficiency throughout the period, with an especially outstanding performance in 2019 (0.7805), indicating exceptional operational effectiveness.

Interestingly, the youngest companies - those aged 0 to 5 years - also achieved strong results, with an average score of 0.6108, placing them in second position. This suggests that the flexibility and

innovative capacity of young firms may contribute to efficient operations, particularly in their early stages. Companies aged 20 to 50 years occupy the middle range of the ranking, with a moderate but stable average of 0.5463.

By contrast, firms aged 10 to 20 years showed lower efficiency, averaging 0.5356, largely due to weaker performance in 2019 and 2020. The lowest efficiency scores were recorded among companies aged 5 to 10 years (average: 0.5371), which consistently ranked in the lower-middle segment across all years.

The ranking suggests a U-shaped relationship: the youngest and oldest companies tend to operate more efficiently, while mid-aged firms - particularly those in the 5-20-year range - exhibit lower efficiency. This may be partly explained by the fact that such firms are often in phases of growth or structural transition, which can temporarily reduce operational efficiency.

Overall, the analysis highlights that company age does not influence efficiency in a linear way, and that taking this factor into account can provide valuable insights for corporate development strategies and policy-making in the field of business support.

5. Conclusions

The primary objective of this study was to provide a comprehensive evaluation of the efficiency of Hungarian food industry companies using the DEA method over the period 2018-2021. The analysis began by describing the composition of the sample in terms of industry and region: the most represented sectors were bakery products and animal slaughtering and processing, while regionally, Dél-Alföld, Pest megye, and Észak-Alföld dominated the sample.

The annual distribution of efficiency revealed that most companies operated within mid-efficiency ranges, while the proportion of fully efficient firms (DEA = 1.00) remained relatively stable, ranging between 10% and 12%. However, the average DEA scores showed a declining trend, likely reflecting the adverse effects of macroeconomic changes such as the COVID-19 pandemic and inflationary pressures. Descriptive statistics - such as standard deviation, skewness, and kurtosis - indicated increasing disparities among companies, suggesting a growing polarization in efficiency performance.

According to the regional ranking, Budapest achieved the highest average efficiency, while Pest megye - contrary to expectations - ranked last, indicating that economically developed regions do not necessarily provide more efficient operational environments. At the sectoral level, dairy manufacturing, animal feed production, and meat processing stood out with the highest efficiency scores, while the sugar and confectionery industry and the bakery sector recorded the lowest scores, pointing to the presence of internal efficiency reserves in these areas.

The analysis by company size clearly showed that the largest (>250 employees) and the smallest (<5 employees) firms operated most efficiently, while medium-sized enterprises - particularly those employing 11-50 people - demonstrated weaker performance. This suggests a potential U-shaped relationship between firm size and efficiency. A similar U-shaped pattern was observed in relation to company age: the youngest (0-5 years) and oldest (>50 years) firms achieved the highest average DEA scores, while those in the 5-20-year range showed the lowest efficiency, likely due to the internal pressures associated with growth and structural transformation.

In summary, the study not only uncovered differences in efficiency levels, but also highlighted the structural factors - such as regional disparities, sectoral characteristics, firm size, and age - that strategically influence corporate performance. As such, the findings offer valuable insights for the design of future development policies and strategic management decisions.

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Anita Kiss

Institute of Accounting and Finance, Faculty of Economics and Business, University of Debrecen
Debrecen, Hungary

e-mail: kiss.anita@econ.unideb.hu

Éva Darabos

Institute of Accounting and Finance, Faculty of Economics and Business, University of Debrecen
Debrecen, Hungary

e-mail: eva.darabos@econ.unideb.hu

Tünde Orsolya Nagy

Institute of Accounting and Finance, Faculty of Economics and Business, University of Debrecen
Debrecen, Hungary

e-mail: nagy.tunde@econ.unideb.hu

APPLICATION OF CONSTRAINED OPTIMIZATION IN INDEX TRACKING PORTFOLIO CONSTRUCTION

CSONGOR KRISTÓ - LÁSZLÓ PÁL

Abstract

Index tracking aims to replicate benchmark returns at minimal cost, a core strategy in passive investing. Constrained optimization incorporates real-world limits like sector exposure and turnover, generating near-optimal portfolios using solvers like Gurobi. Our research evaluates how constraints impact tracking accuracy and risk. We expect that expanding portfolio size (e.g., 10-20 stocks) enhances performance, while rolling-window methodology provides stability across different periods.

Keywords: index tracking, mixed integer programming, Gurobi solver

1. Introduction

In modern financial markets, index tracking is a cornerstone of passive investing, aiming to replicate a benchmark index's performance while minimizing tracking error. The growth of index-based products like ETFs and index funds reflects the recognition that actively managed funds rarely outperform market indices long-term (Rubio-García et al. 2024). This has driven significant expansion in passive investment strategies in recent decades.

Index tracking aims to minimize tracking error while keeping costs manageable. Perfect replication is often impractical due to transaction costs, liquidity constraints, and administrative hurdles, especially for large indices (Benidis et al. 2018). As a result, methods using only a subset of components have been developed to achieve efficient tracking.

Index tracking is modeled as an optimization problem, often framed as mixed integer programming (MIP) due to discrete portfolio decisions (Beasley et al. 2003). The cardinality constraint introduces NP-hard complexity (Rubio-García et al. 2024), leading researchers to develop both exact and heuristic solution methods.

Early researches focused mainly on minimizing tracking error without considering additional limitations. Beasley et al. (2003) proposed an evolutionary algorithm to address the index tracking problem with stock number constraints, which became a pioneering approach to the subject. Dose and Cincotti (2005) introduced a clustering-based method in which they reduced the dimension of the problem by grouping assets with similar yield profiles. Canakgoz and Beasley (2009) have further developed this research and developed mixed integer programming models for both index tracking and *enhanced index tracking*, which aims to outperform the index while maintaining low tracking error. The impact of various constraints on index tracking performance has been investigated in a variety of contexts. Scozzari et al. (2013) analysed the impact of regulatory constraints on index tracking, highlighting how legal restrictions affect optimal portfolio composition. Fastrich et al. (2012) compared share number restrictions with Q-norm restrictions, highlighting their different effects on tracking accuracy. Sant'Anna et al. (2017) incorporated sector constraints into index tracking using hybrid heuristics, emphasizing the importance of sectoral diversification. Xu et al. (2018) examined *chance constraints* under cardinality constraints, showing that probability constraints can improve the robustness of tracking performance. More recently, Sant'Anna et al. (2022) incorporated risk indicators into index tracking models, while Kobayashi et al. (2023) applied a distribution-robust optimization approach to portfolios with cardinality constraints.

The toolkit for solving index tracking problems with restrictions has recently expanded significantly. García et al. (2018) compared genetic algorithms with taboo search heuristics for portfolios with cardinality constraints. Moeini (2022) developed a continuous optimization approach to improve computational efficiency. Anis and Kwon (2025) proposed a comprehensive, decision-based

framework for portfolio optimization with a limited number of shares. Rubio-García et al. (2024) demonstrated a hybrid simulated cooling algorithm for large-scale index tracking problems, while Dai and Li (2024) used deep learning techniques for advanced index tracking.

Despite these findings, few studies systematically analyse the combined impact of practical constraints—such as sector weights, turnover limits, and beta restrictions—on index tracking performance within a fixed equity set. Existing research often examines constraints in isolation or prioritizes methodological advances over comprehensive assessments. Additionally, while transaction costs are widely recognized as crucial for realistic evaluation, many constraint-focused studies overlook them.

In this research, we use a mixed integer quadratic programming (MIQP) model, which systematically examines the effect of different constraint combinations on index tracking performance. To examine the MIQP problem, we use a framework called Gurobi (Gurobi Optimization, LLC, 2024) and its *solution pool* function.

The key contribution of our research is a thorough analysis of how different constraint combinations impact index tracking performance, portfolio stability, and risk metrics using a fixed stock number. By evaluating near-optimal solutions, we reveal the trade-offs inherent in each constraint scenario. Our rolling-window approach incorporates both in-sample optimization and out-of-sample testing, enabling us to assess performance across varying market conditions and develop more robust tracking strategies.

2. Material and Methods

2.1 The optimization model

We modeled the index tracking problem at two levels to analyse the impact of different constraints. The central element of the models is *the minimization of the squared tracking error*, which has been supplemented with constraints for practical feasibility.

2.1.1 Basic constrained model

The basic index-tracking optimization model minimizes the squared tracking error between the portfolio and the benchmark index returns with cardinality constraints:

$$\min_w \sum_{t=1}^T \left(\sum_{i=1}^n w_i r_{i,t} - r_{m,t} \right)^2 \quad (1)$$

Subject to the following constraints:

$$\begin{aligned} \sum_{i=1}^n w_i &= 1 \\ \sum_{i=1}^n z_i &= K \\ w_i &\leq 0.2 \cdot z_i, \forall i = 1, \dots, n \\ w_i &\geq 0, \forall i = 1, \dots, n \\ z_i &\in \{0,1\}, \forall i = 1, \dots, n \end{aligned}$$

Where:

- w_i - weight of component i in the portfolio
- z_i - a binary variable that indicates whether component i is (1) or not (0) in the portfolio
- $r_{i,t}$ - return of component i at time t
- $r_{m,t}$ - return of market index at time t
- K - maximum number of components allowed in the portfolio

- T - number of periods in the sample
- n - total number of available components

2.1.2 Expanded model with sector, beta and turnover constraints

The key challenge in index tracking is replicating a reference index with minimal tracking error while considering practical constraints. Beyond limiting the number of shares, additional restrictions can optimize portfolio risk and behaviour while enhancing feasibility.

Sector restrictions maintain the portfolio's sector weights close to the benchmark, providing multiple benefits. They promote diversification by avoiding overexposure to any single sector, reducing vulnerability to sector-specific shocks. Additionally, they enhance risk management since different sectors respond uniquely to macroeconomic shifts, allowing better control over portfolio behaviour. Finally, they structurally lower tracking error because stocks within sectors tend to be highly correlated, making sector-aligned portfolios more accurately track the index. Beta restrictions maintain the portfolio's market sensitivity in line with the benchmark, preventing excessive aggressiveness ($\beta > 1$) or defensiveness ($\beta < 1$). This alignment ensures the portfolio responds similarly to market stress periods, matching investors' risk expectations. Limiting portfolio turnover is crucial for maintaining cost-efficiency and stability. By reducing frequent rebalancing, transaction costs are minimized and performance drag is avoided. Portfolios with lower turnover are also less vulnerable to short-term market volatility, delivering more consistent results. The extended index tracking model includes additional limits to regulate sector exposure, portfolio beta and turnover:

$$\min_w \sum_{t=1}^T \left(\sum_{i=1}^n w_i r_{i,t} - r_{m,t} \right)^2 \quad (2)$$

Subject to the following limitations:

$$\begin{aligned} \sum_{i=1}^n w_i &= 1 \\ \sum_{i=1}^n z_i &= K \\ w_i &\leq 0.2 \cdot z_i, \forall i = 1, \dots, n \\ t_s - \delta &\leq \sum_{i \in S_s} w_i \leq t_s + \delta, \forall s \in \text{Sectors} \\ \beta_{min} &\leq \sum_{i=1}^n w_i \beta_i \leq \beta_{max} \\ \sum_{i=1}^n (w_i^+ + w_i^-) &\leq 2 \cdot \tau_{max} \\ w_i - w_{i,prev} &= w_i^+ - w_i^-, \forall i = 1, \dots, n \\ w_i^+ &\geq 0, w_i^- \geq 0, \forall i = 1, \dots, n \\ w_i &\geq 0, \forall i = 1, \dots, n \\ z_i &\in \{0,1\}, \forall i = 1, \dots, n \end{aligned}$$

Additional definitions:

- t_s - target weight of sector s
- S_s - components belonging to sector S
- δ - Maximum deviation from the target sector weights
- β_i - beta of component i

- β_{min}, β_{max} - Minimum and maximum portfolio beta allowed
- $w_{i,prev}$ - weight of component i in the previous portfolio
- w_i^+, w_i^- - auxiliary variables for weight adjustments of component i
- τ_{max} - the maximum allowable portfolio turnover

2.2 Gurobi framework and solution pool

The choice of Gurobi software (Gurobi Optimization, LLC, 2024) was justified by the fact that it was specifically developed to solve mixed integer quadratic programming (MIQP) problems efficiently and offers the current *state of the art* algorithms in this field. The suite stands out for providing fast and accurate solutions, thanks to the combination of *Branch-and-Bound* algorithms and heuristics that allow for rapid convergence in complex problems.

There can be multiple solutions to the mathematical model of the index tracking problem with a target function of the same value. The mechanism of the Gurobi *solution pool* gives us the opportunity to record a certain number of solution sets during optimization. These solutions have the same target function value as the "optimal solution" or close to it. The solution set provides an opportunity to filter nearly identical solutions based on indicators such as risk, return or sector deviation.

2.3 Rolling-window optimization methodology

The purpose of the *rolling-window optimization methodology* is to examine the stability and adaptability of portfolio optimization models over time in changing market conditions. The method basically divides the data series into two time intervals: *in-sample* (optimization) and *out-of-sample* (validation) periods. The portfolio is constructed in the in-sample period, while the out-of-sample period is used to evaluate the performance of the model in practice. The process repeats cyclically as the windows advance along the timeline, allowing for continuous updating and validation.

The window structure follows a rolling approach: it begins with an initial in-sample period (e.g., 250 days) used for portfolio optimization. This is followed by a shorter out-of-sample validation period (e.g., 60 days) to test the model's performance under realistic market conditions. After each validation cycle, the window slides forward by the validation period length. If the validation period is shorter than the in-sample window, the new in-sample data partially overlaps with the previous window, ensuring smoother model updates and minimizing data loss. Otherwise, the windows advance sequentially without overlap. This approach balances continuity with adaptability in portfolio adjustments.

The primary advantage of the method is that it re-optimizes the portfolio in each window based on the latest market data. This allows the model to dynamically adapt to market trends, structural changes or crisis situations. Continuous updating is particularly important due to the variability over time that characterizes financial markets, where past patterns do not necessarily predict future behaviour. Figure 1 shows the method of rolling-window optimization visually.

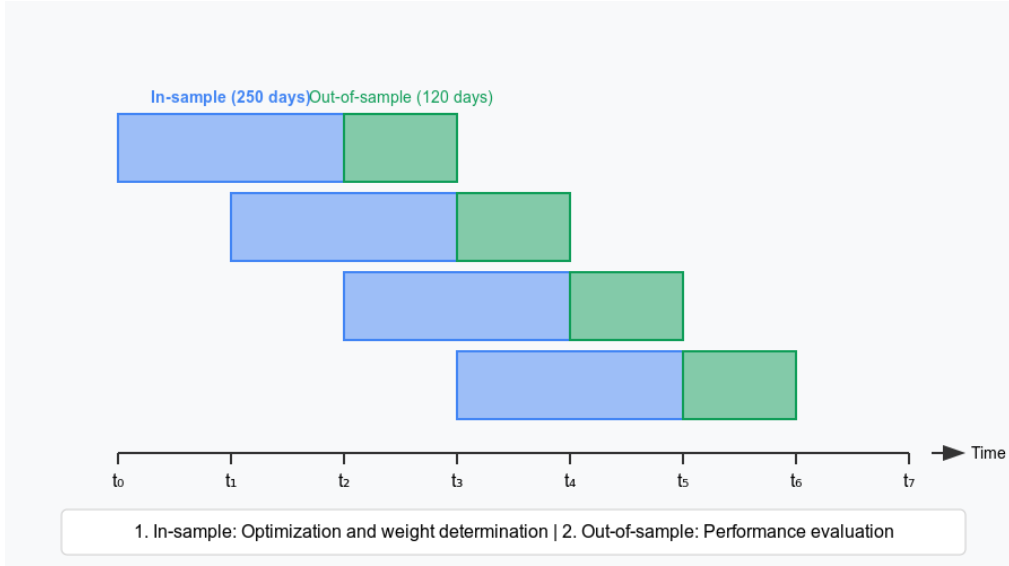


Figure 1. Rolling-window optimization.

By evaluating performance across changing market conditions, the rolling-window methodology reveals the model's stability while preventing overfitting to specific market phases. The approach realistically incorporates transaction costs during each rebalancing, providing more accurate performance estimates. As windows progress, the model maintains relevance while compiling out-of-sample results over time - offering a comprehensive, real-world assessment of strategy effectiveness rather than a single-period snapshot. These features make the approach particularly valuable for practical implementation. The method extensively addresses practical constraints (e.g., sector weights, beta ranges, turnover) in each window. During optimization, weights from the previous portfolio can be used as an initial value (*warm start*), which improves the speed of convergence and reduces the computational load. In addition, the analysis of the *solution pool* allows the comparison of alternative portfolios, so the final choice is based not only on optimality criteria, but also on stability indicators.

2.4 Performance metrics

The performance of index-tracking portfolios is assessed using the following metrics:

- Tracking error, TE

$$TE = \sqrt{\frac{1}{T} \sum_{t=1}^T (r_{p,t} - r_{m,t})^2} \quad (3)$$

- Mean excess return, MER

$$MER = \frac{1}{T} \sum_{t=1}^T (r_{p,t} - r_{m,t}) \quad (4)$$

- Information ratio, IR

$$IR = \frac{MER}{\sigma(r_{p,t} - r_{m,t})} \quad (5)$$

- Sharpe rate, SR

$$SR = \frac{r_p - r_f}{\sigma_p} \quad (6)$$

- Maximum dropdown, MDD

$$MDD = \min_t \left(\frac{V_t}{\max_{s \leq t} V_s} - 1 \right), \quad (7)$$

where the definition of cumulative value is:

$$V_t = \prod_{i=1}^t (1 + r_{p,i}) \quad (8)$$

- Turnover

$$Turnover = \frac{1}{2} \sum_{i=1}^n |w_i - w_{i,prev}| \quad (9)$$

Further definitions of performance indicators:

- $r_{p,t}$ - portfolio return at time t
- r_p - average portfolio return
- r_f - the risk-free interest rate
- σ_p - portfolio return deviation
- $\sigma(r_{p,t} - r_{m,t})$ - deviation of return differences
- V_t - The cumulative portfolio value at time t

2.5 Exploratory data analysis

Our dataset contains information about the *S&P 100* index, which we download from *Yahoo Finance*. The period of the analysis covers the period between 2019 and 2025, and we analyse the structure of the index, its exchange rate dynamics and the sectoral trends through the figures below.



Figure 2. Index prices in significant crisis situations.

Figure 2 shows the price changes of the index, where crisis periods are highlighted separately: the COVID-19 pandemic in 2020 and the war in Ukraine in 2022, with periods of sharp price falls.

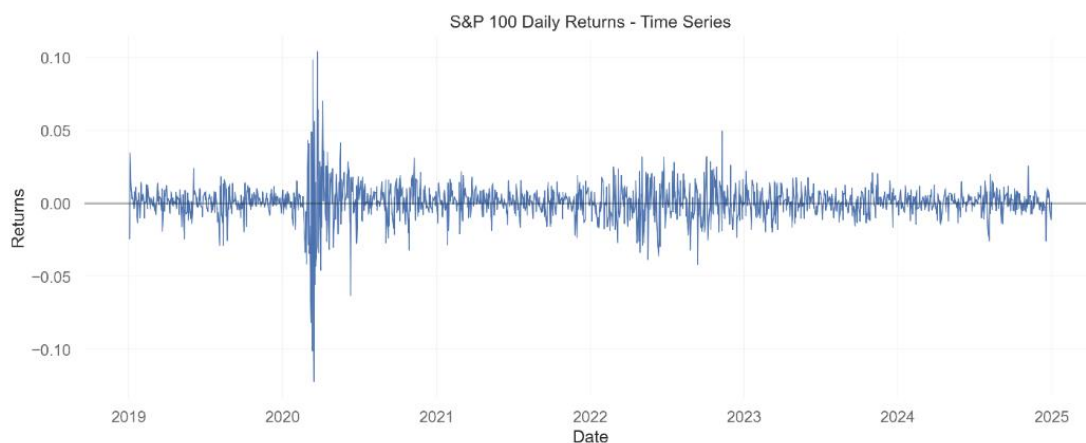


Figure 3. Daily returns - time series.

Figure 3 shows the time series of daily returns, showing that the peaks of volatility and fluctuations coincide with the mentioned global crises, while in more stable periods, such as 2021 or 2024, yields moved in a narrower, more stable range.

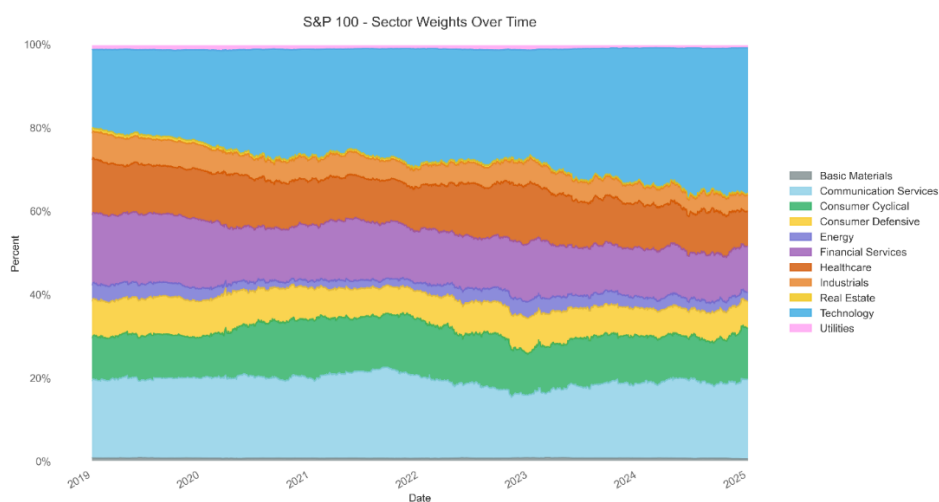


Figure 4. Changes in sector weights over time.

Figure 4 shows the development of the weights of the sectors included in the index over time, for sectors such as technology, healthcare, financial services, etc. In the period under review, the increase in the dominance of the technology sector can be highlighted.

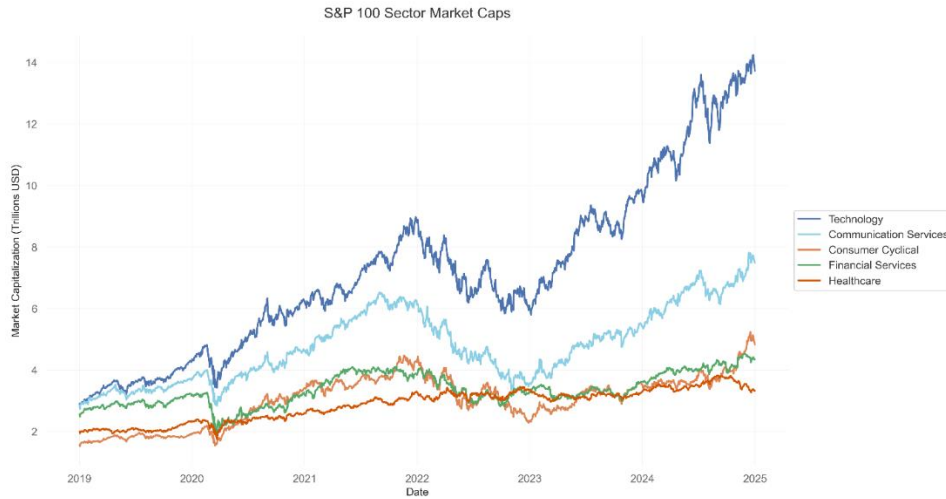


Figure 5. Market capitalization of sectors.

Figure 5 shows the development of the market capitalization of the top 5 sectors, which points out the changes in market dominance. It can be seen that the technology sector has been growing steadily and has a clear dominance, while in the case of the healthcare sector, for example, stagnation was typical of the entire analysis interval in this criterion.

In the course of data analysis, we can point out that the S&P 100 is heavily dependent on the technology sector, and it can be seen that the global crises (COVID-19, the war in Ukraine) have had a significant negative impact on exchange rates.

2.6 Experiment settings and analysis considerations

During the experiments, we will examine different versions of the optimization model with sector, beta and turnover constraints. Taking into account all combinations, we distinguish 8 strategies (No Constraints, Sector Only, Beta Only, Turnover Only, Sector + Beta, Sector + Turnover, Beta + Turnover, All Constraints).

2.6.1 Parameter bounds

For modeling, two periods were defined: the in-sample period (250 days, or 1 year) and the out-of-sample period (120 days). The 250-day in-sample period is widely accepted in financial modeling, as recent data better reflect current market dynamics. The 120-day out-of-sample period balances short-term fluctuations (e.g., crises like COVID-19 or the war in Ukraine) with longer-term trends, reducing excessive volatility while maintaining model resilience. This window also allows for a more comprehensive analysis of medium-term effects during crises, while the 250-day in-sample data provide a stable basis for initial parameters.

For the beta constraint, we used a range of 0.98 to 1.02 ($\pm 2\%$), ensuring the portfolio's risk closely tracks the benchmark. This 2% limit balances strict risk matching with flexibility, allowing market responsiveness while maintaining index alignment.

The sector deviation was set to 3%, allowing sector weights to vary by up to 3% from the reference. This tolerance ensures structural balance while avoiding excessive rigidity. The 3% limit enables flexible sector allocation, improving diversification and market adaptability, while also easing the Gurobi solver's optimization process and reducing convergence risks.

The *maximum number of shares* (*max_assets*) parameter was tested with *values of 10 and 20*. This is due to cost-effectiveness and manageability: portfolios of 10 to 20 stocks significantly reduce transaction costs, while tracking error still remains at an acceptable level.

The *transaction cost rate* is set at 0.001 (i.e. 0.1% or 10 basis points), reflecting the realistic cost level applied in practice during portfolio optimization. This low but not negligible transaction cost strikes

a balance between the cost-effectiveness of frequent portfolio rebalancing and the risk of excessive trading activity. The 10 basis point rate allows the model to flexibly adapt to market changes without transaction costs significantly reducing net returns.

The value of the *turnover constraint* has been set to 10%, which means that the total change in portfolio weights during optimization cannot exceed 10% compared to the previous period. This limit effectively regulates that the system can "reweight" a maximum of 10% of the portfolio in a given period. The 10% value is intended to control transaction costs and reduce the risk of excessive trading activity, while allowing for moderate adaptation to market changes.

The *risk-free rate* is set at 2%, which is the basis for calculating the Sharpe rate for the portfolio's performance evaluation. This value represents a reference point accepted in practice that is close to the long-term average risk-free yields (e.g. yields on government bonds) in a stable economic environment. The 2% rate allows the Sharpe rate to realistically measure the risk-adjusted return of the portfolio.

2.6.2 Solution filter criteria

For the analysis of the Gurobi solution pool, only the sectoral deviation was used as a screening criterion to keep the structural balance of the portfolios close to the benchmark index. The size of the solution set has been limited to a maximum of 10 portfolios, which ensures computational efficiency and practical manageability. The 3% sectoral deviation limit allows for flexible weight distribution without compromising diversification or adaptation to market dynamics.

The number of solutions generated by the Gurobi solver depends on the tightness of the model's constraints and the market environment. Sometimes there are fewer than 10 solutions available, most often when the optimal solution has been found.

During the Gurobi optimization process, we set a 10-minute timeout to limit compute time. This practical consideration was made in the knowledge that mixed integer programming (MIP) problems are NP-hard in nature and that finding a global optimum can take exponential time. By introducing the limit, we avoid costly long runs that bring minimal improvement. The 10-minute time frame represents an empirically defined trade-off between computational accuracy and practical feasibility.

2.7 Environment

The development environment leveraged Python's data science ecosystem, with core libraries like numpy and pandas handling data manipulation and analysis. Jupyter Notebook provided an interactive workspace for testing, and visualizing results throughout the development process.

3. Results and discussion

Comparing different constraint strategies gives us the opportunity to gain a deeper understanding of the impact of the optimization parameters of index-tracking portfolios. Below, we analyse in detail the performance of portfolios of 10 and 20 stocks, with a particular focus on tracking accuracy, returns, and risk profile. When evaluating the results, we also take into account various characteristics of the portfolios, such as turnover rate, transaction costs and stability.

3.1 Evaluation of results for 10 stocks

Table 1 contains the most important indicators of the portfolio of 10 stocks, and Table 2 contains the characteristics of the portfolio. In the next section, we evaluate the content of these tables and illustrate further characteristics through two figures (4.1 and 4.2).

In terms of cumulative returns, the *Beta + Turnover* (90.16%) and *Beta Only* (90.61%) strategies are the closest to the S&P 100 index's 90.56% performance. This indicates that the beta restriction is

effective in helping the portfolio return to stay close to the index it is tracking. However, both strategies produced the highest maximum dropdown (-33.87%), which is less favourable than the index's value of -31.53%. This suggests that while tracking returns is successful, these strategies suffer greater losses during market stress periods.

The *All Constraints* strategy shows particularly interesting results. Although its cumulative return (93.86%) is slightly above that of the index, its volatility (22.57%) is the lowest among the strategies and is close to the index's 21.97%. Its Sharpe rate (0.641) is also very close to the index's 0.636, indicating a performance adjusted for good risk. In addition, its maximum dropdown (-33.03%) is more favorable than that of beta-based strategies. However, in terms of tracking error (5.11%), it lags behind purely sectoral strategies, as applying the three constraints at the same time reduces optimization flexibility.

In terms of tracking error, the *Sector Only* and *Sector + Beta* strategies performed best (4.68%), but their returns (83.68% and 84.08%, respectively) were significantly lower than those of the index. This indicates the trade-off between accurate tracking and return.

The *No Constraints* strategy shows the highest cumulative return (113.72%), which significantly outperforms the index, however, it comes at the cost of a higher tracking error (4.73%).

Table 1. Performance metrics comparison for different constraint combinations (10 stocks).

Strategy	Net. Return	Cum. Return	Volatility	Sharpe Ratio	MDD	TE	MER	IR
<i>No Constraints</i>	18.47%	113.72%	22.38%	0.736	33.87%	4.73%	2.50%	0.511
<i>Sector Only</i>	15.36%	83.68%	22.73%	0.588	33.03%	4.68%	0.60%	0.126
<i>Beta Only</i>	16.14%	90.61%	22.71%	0.623	33.87%	4.86%	0.17%	0.034
<i>Turnover Only</i>	15.88%	88.41%	22.66%	0.613	33.87%	5.01%	0.08%	0.016
<i>Sector+Beta</i>	15.41%	84.08%	22.73%	0.590	33.03%	4.68%	0.56%	0.116
<i>Sector+Turnover</i>	15.47%	84.83%	22.63%	0.595	33.03%	5.13%	0.50%	0.095
<i>Beta+Turnover</i>	16.09%	90.16%	22.71%	0.620	33.87%	5.04%	0.12%	0.023
<i>All Constraints</i>	16.46%	93.86%	22.57%	0.641	33.03%	5.11%	0.49%	0.095
<i>S&P 100</i>	15.97%	90.56%	21.97%	0.636	31.53%	N/A	N/A	N/A

Figure 6 displays cumulative returns over the period. The *No Constraints* strategy consistently outperforms the index and other strategies, particularly since early 2022. The *Beta + Turnover*, *Beta Only*, and *All Constraints* strategies track closest to the S&P 100. Meanwhile, the *Sector Only* and *Sector + Beta* strategies underperform steadily since late 2022, while *Sector + Turnover* lags slightly behind the index from early 2024 onward.



Figure 6. Comparison of cumulative returns (10 stocks).

Table 2 reveals key portfolio characteristics across strategies. Turnover-limited strategies demonstrate substantially lower average turnover (9.0%) and transaction costs (0.1%) versus 37.9%-53.5% for others, confirming the effectiveness of turnover constraints. These strategies also show greater portfolio stability (0.78-0.84), indicating more consistent holdings between rebalances. Strategies with sector constraints maintain closer index alignment, with lower sector deviations (2.9%-3.0%). Turnover-limited portfolios hold fewer stocks (17-21) but feature more durable positions (5-6), reflecting a more concentrated investment approach.

Table 2. Portfolio characteristics comparison for different constraint combinations (10 stocks).

Strategy	Avg. Turnover	Total Trans. Costs	Avg. Sector Dev	Avg. Beta	Portfolio Stability	Unique Stocks	Persistent Stocks
<i>No Constraints</i>	44.9%	0.4%	13.5%	1.00	0.36	36	3
<i>Sector Only</i>	53.5%	0.5%	3.0%	1.00	0.27	39	3
<i>Beta Only</i>	47.6%	0.5%	14.3%	1.00	0.31	40	3
<i>Turnover Only</i>	9.0%	0.1%	12.1%	1.00	0.84	17	5
<i>Sector+Beta</i>	52.4%	0.5%	3.0%	1.00	0.28	39	3
<i>Sector+Turnover</i>	9.0%	0.1%	2.9%	1.00	0.80	20	6
<i>Beta+Turnover</i>	9.0%	0.1%	12.1%	1.00	0.84	17	5
<i>All Constraints</i>	9.0%	0.1%	2.9%	1.00	0.78	21	6

Figure 7 illustrates the change in the portfolio composition of four selected strategies. The significantly more stable composition of the *Turnover Only* and *All Constraints* strategies is striking, especially the significant and relatively stable positions in larger stocks (MSFT, AAPL). In contrast, the *Sector Only* and *Beta Only* strategies show more frequent and larger redeployments, which is consistent with their higher portfolio turnover.

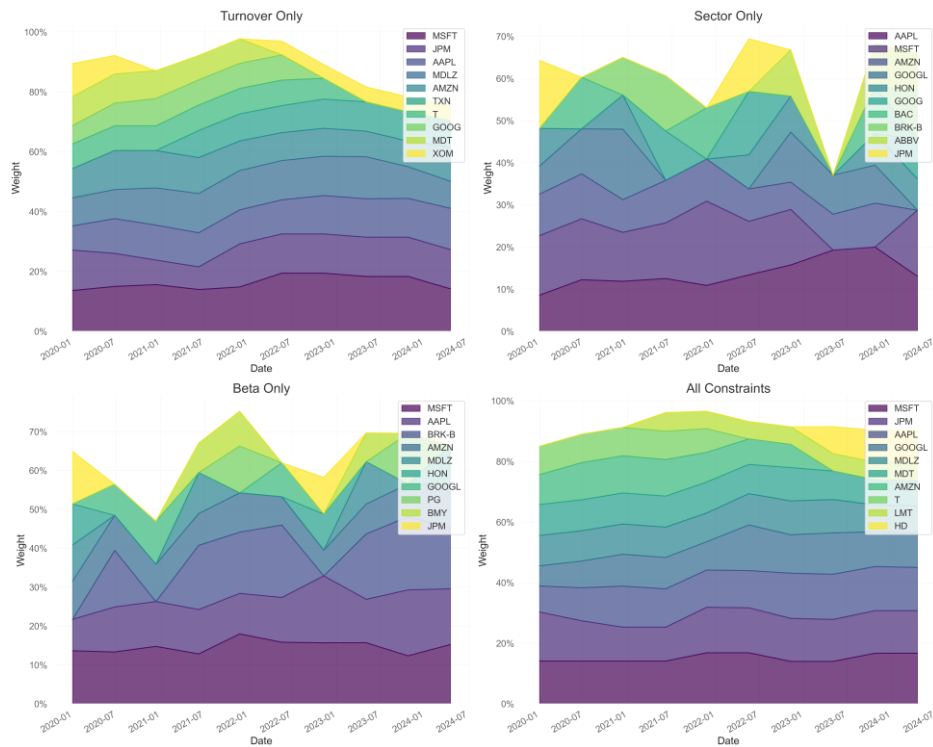


Figure 7. Change in portfolio composition for four strategies (10 stocks).

Overall, for a portfolio of 10 stocks, the *All Constraints* strategy seems to be the most balanced, as it provides a moderate excess return compared to the index, while its risk profile is close to the index and its management costs are low. If accurate index tracking is the top priority, Beta + *Turnover* or Beta *Only* strategies may be more suitable, but with a beta strategy with no turnover limit, higher management costs should be expected. An analysis of portfolio characteristics clearly points to the significant practical benefits of a turnover constraint in terms of cost and stability, while sectoral constraints may be important in aligning the composition of the portfolio sector with the index.

3.2 Evaluation of results for 20 stocks

Table 3 presents key portfolio metrics for 20-stock strategies. Analysis reveals that 20-stock portfolios achieve significantly lower tracking errors than their 10-stock counterparts. The Beta Only strategy delivers the best tracking performance (3.11%), followed closely by Sector + Beta (3.12%) and All Constraints (3.15%). This demonstrates that expanding the portfolio from 10 to 20 stocks substantially improves index-tracking precision, as the best 10-stock strategy had a 4.68% tracking error. The *All Constraints* strategy shows particularly remarkable results in terms of risk indicators. Its risk (22.02%) is the lowest among the strategies, and its value is close to the index's 21.97% risk. Its Sharpe rate (0.652) is also very close to the index's 0.636, which indicates that this strategy reproduces the index well not only in tracking accuracy, but also in terms of risk profile. Its maximum dropdown (-32.24%) is also among the most favourable, which is a particularly valuable feature in times of crisis. This balanced performance is due to the fact that the *All Constraints* strategy takes into account beta, sector and turnover constraints at the same time, which provides comprehensive control over the risk characteristics of the portfolio.

The Beta Only strategy generates remarkable cumulative returns of 124.10%, significantly outperforming both the S&P 100 (90.56%) and all other strategies. This superior performance stems from its balanced approach: while the beta constraint maintains market-aligned systemic risk, it permits strategic stock selection and sector allocation flexibility within its 20-stock universe. The

strategy's industry-leading Sharpe ratio of 0.786 further validates that these excess returns were achieved without disproportionate risk-taking.

Table 3. Performance metrics comparison for different constraint combinations (20 stocks).

Strategy	Net. Return	Cum. Return	Volatility	Sharpe Ratio	MDD	TE	MER	IR
<i>No Constraints</i>	18.56%	115.02%	22.23%	0.745	- 32.86%	3.16%	2.59%	0.794
<i>Sector Only</i>	18.35%	112.61%	22.34%	0.732	- 33.44%	3.18%	2.38%	0.721
<i>Beta Only</i>	19.41%	124.10%	22.14%	0.786	- 32.86%	3.11%	3.44%	1.070
<i>Turnover Only</i>	17.73%	107.04%	22.07%	0.713	- 32.86%	3.22%	1.76%	0.529
<i>Sector+Beta</i>	18.40%	113.58%	22.14%	0.741	32.24%	3.12%	2.43%	0.760
<i>Sector+Turnover</i>	17.16%	101.22%	22.23%	0.682	- 33.44%	3.34%	1.20%	0.347
<i>Beta+Turnover</i>	17.73%	107.04%	22.07%	0.713	- 32.86%	3.22%	1.76%	0.529
<i>All Constraints</i>	16.37%	94.14%	22.02%	0.652	32.24%	3.15%	0.40%	0.124
<i>S&P 100</i>	15.97%	90.56%	21.97%	0.636	- 31.53%	N/A	N/A	N/A

Figure 8 demonstrates that all strategies except All Constraints consistently outperformed the S&P 100 since 2021, with widening margins from 2023 onward - particularly for No Constraints, Sector Only, and Sector + Beta. The Beta Only strategy's outperformance became especially pronounced in 2024. In contrast, the All Constraints strategy closely tracked the index while slightly exceeding it, fulfilling its core index-tracking objective.



Figure 8. Comparison of cumulative returns (20 stocks).

The portfolio characteristics in Table 4 provide further insight into the operation and practical applicability of the different strategies.

Table 4. Portfolio characteristics comparison for different constraint combinations (20 stocks).

Strategy	Avg. Turnover	Total Trans. Costs	Avg. Sector Dev.	Avg. Beta	Portfolio Stability	Unique Stocks	Persistent Stocks
<i>No Constraints</i>	37.9%	0.4%	7.2%	1.00	0.40	67	5
<i>Sector Only</i>	41.9%	0.4%	2.9%	1.00	0.35	69	5
<i>Beta Only</i>	38.0%	0.4%	7.5%	1.00	0.40	67	5
<i>Turnover Only</i>	9.0%	0.1%	8.6%	1.00	0.81	36	14
<i>Sector+Beta</i>	45.6%	0.5%	3.0%	1.00	0.32	64	4
<i>Sector+Turnover</i>	9.0%	0.1%	2.7%	1.00	0.80	36	12
<i>Beta+Turnover</i>	9.0%	0.1%	8.6%	1.00	0.81	36	14
<i>All Constraints</i>	9.0%	0.1%	2.8%	1.00	0.81	36	11

Strategies with a turnover constraint (*Turnover Only*, *Sector + Turnover*, *Beta + Turnover*, *All Constraints*) show significantly lower average turnover (9.0%) and transaction costs (0.1%). This cost-effectiveness can significantly improve the long-term performance of the portfolio, especially in the case of frequent rebalancing. Portfolio stability is also significantly higher for these strategies (0.80-0.81), which means a smaller change between reweights and thus allows for easier portfolio management.

The *All Constraints* strategy combines the advantages of various constraints: low transaction costs, excellent portfolio stability, good industry fit, while also being close to the index in terms of tracking error and risk indicators. Together, these features make it an ideal choice for those who value stable, cost-effective index tracking, and do not prioritize significantly overperforming the index.

Figure 9 illustrates the change in the portfolio composition of four selected strategies (*Turnover Only*, *All Constraints*, *Sector Only* and *Beta Only*). The significantly more stable composition of strategies with turnover constraints is striking, which is a particularly valuable feature in the case of a long-term investment strategy. For the *Turnover Only* and *All Constraints* strategies, positions held in larger stocks (e.g. AAPL, MSFT) remain relatively constant throughout the period, as opposed to the *Sector Only* and *Beta Only* strategies, which show significant rearrangements.

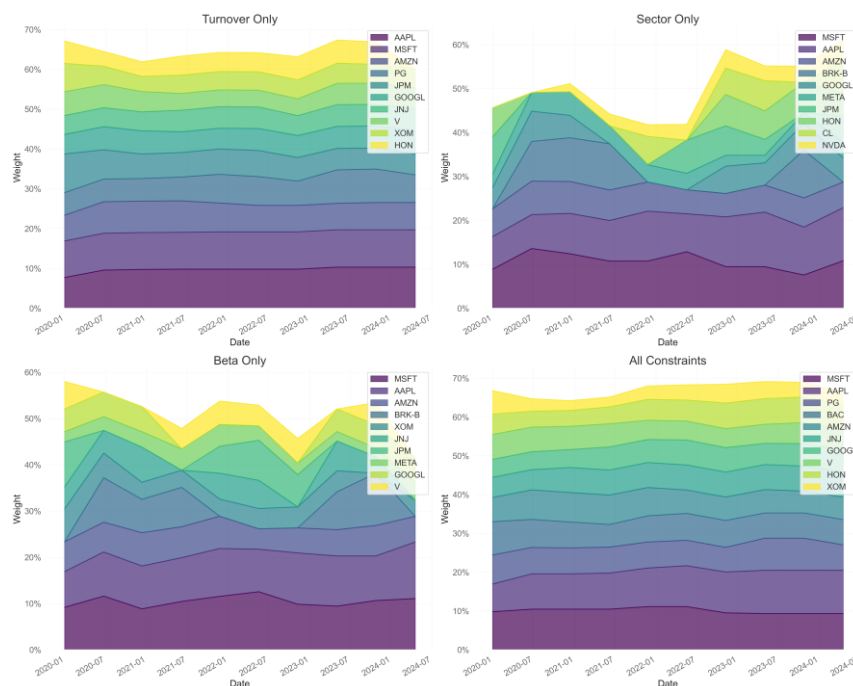


Figure 9. Change in portfolio composition for four strategies (20 stocks).

Overall, portfolios with 20 stocks allow for significantly more accurate index tracking than 10 shares. The values of the tracking errors are significantly lower for all strategies (in the range of 3.11%-3.34%), compared to values between 4.68%-5.13% for 10-stock portfolios. This clearly confirms the theoretical assumption that by including more components, the portfolio is better able to reproduce the behaviour of the index.

Particularly noteworthy is the *All Constraints* strategy, which consistently exhibits similar behaviour across both portfolio sizes. In both the case of 10 and 20 stocks, this strategy most closely follows the price movement of the index, while its risk profile is also close to the index. In the 20-stock version, the strategy's following error improved significantly (decreased from 5.11% to 3.15%) while maintaining low volatility (22.02%), a Sharpe rate close to the index (0.652), and a favourable maximum dropdown (-32.24%).

4. Conclusions

Based on the results, we can draw several important insights about the use of constrained optimization methods in the development of index-tracking portfolios. The analysis of the examined portfolios of 10 and 20 stocks clearly demonstrated the effectiveness and applicability of the different restriction strategies. We can conclude that increasing the size of the portfolio significantly improves the accuracy of index tracking. The tracking error for 20-stock portfolios was significantly lower for all strategies (in the range of 3.11%-3.34%) than the values for the 10-stock variants (4.68%-5.13%). This confirms the theoretical assumption that by involving more components, the portfolio is better able to reproduce the behaviour of the index.

Different constraint combinations offer different benefits according to portfolio management considerations. The *All Constraints* strategy has shown an outstandingly balanced performance across both portfolio sizes, combining the benefits of different types of constraints: low transaction costs, good portfolio stability, appropriate sector alignment and a risk profile close to the index. This approach may be ideal for more conservative, cost-sensitive investors for whom accurate index tracking is more important than potential additional returns. Turnover constraint strategies (*Turnover Only*, *Sector + Turnover*, *Beta + Turnover*, *All Constraints*) consistently showed lower average turnover (9.0%) and transaction costs (0.1%), as well as significantly higher portfolio stability (0.78-0.84), which is a significant advantage in practical portfolio management. These strategies used fewer individual stocks, but there was a higher number of durable stocks, indicating a more focused, stable approach to investing. Strategies that include sector restrictions have successfully kept the sectoral composition of the portfolio close to the index (with a difference of 2.7%-3.0%), which may be important in managing sectoral risks. At the same time, these strategies have generally resulted in lower returns, especially for portfolios of 10 shares. The results also show that the beta restriction alone is not always sufficient to properly regulate the risk profile of the portfolio, especially for a smaller number of shares. Beta-based strategies have often shown higher maximum dropdowns (MDD) during periods of market crisis. Overall, the study demonstrates that the mixed integer quadratic programming (MIQP) model and the solution set function of the Gurobi framework are effective methods for the design and evaluation of index-tracking portfolios.

In the future, it would be worthwhile to fine-tune various parameters of the model, such as more flexible adjustment of the turnover limit or widening of the sector deviation limits, in order to better understand their impact on portfolio performance. A particularly interesting research direction would be the development of "enhanced index tracking" strategies aimed at deliberately overperforming the index, which maintain the low tracking error but aim for higher returns.

As an alternative to the computationally intensive Gurobi framework, it would be worth exploring more efficient heuristic methods, such as hierarchical clustering or the use of genetic algorithms in portfolio selection. These techniques can provide an opportunity to process larger stock sets more efficiently and implement real-time optimization.

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Authors' addresses

Csongor Kristó

Sapientia Hungarian University of Transylvania, kristolcsongor@uni.sapientia.ro

László Pál

Sapientia Hungarian University of Transylvania, pallaszlo@uni.sapientia.ro

Abstract

The continuity axiom of decision theory states that for every prospect (lottery) there is a certain payoff equivalent to the prospect. This payoff is called the certainty equivalent (*CE*) value of the prospect. The certainty equivalent value is determined by experiments, but in practice experiments only lead to fuzzy value. From this point of view, we can say that the *CE* is a fuzzy quantity that can be well modelled by so-called intuitionistic fuzzy sets.

Many applications of prospect theory in risk management and multi-criteria decision making implicitly assume that the function of *CE* is homogeneous. The value functions for which the function of *CE* is homogeneous are called preference-homogeneous. The fundamental question is: what happens if the *CE* is modelled with intuitionistic fuzzy sets and what does the homogeneity condition mean in this case?

In this paper, we show how to determine the intuitionistic fuzzy equivalence of a prospect with a preference-homogeneous value function.

Keywords: prospect theory, certainty equivalent value, intuitionistic fuzzy set.

1. Introduction

Prospect theory is the result of several experiments by Kahneman and Tversky (1979) on human behaviour in uncertain situations. They retained the concept of lotteries, which were used to calculate expected utility functions. For every $x_1, x_2 \in \mathbb{R}$ and $p \in [0, 1]$, is denoted by $L = (x_1, p; x_2, 1 - p)$ the lottery (random variable) taking the x_1 and x_2 with probabilities p and $1 - p$.

Definition 1. Let $L = (x, p; 0, 1 - p)$ be a lottery, with $x > 0$. The value $r \geq 0$ for which the risk-free lottery $R = (r, 1)$ is equivalent to the lottery L is called the certainty equivalent value of the lottery L and is denoted by $CE_p(x)$.

The continuity axiom of Neumann Morgenstern's utility theory (1944) states that this value $r = CE(x)$ is uniquely determined. In prospect theory, Tversky and Kahneman (1992) provide a scaling of the value function. For prospect $L = (x, p; 0, 1 - p)$ the ratio of certainty equivalent $CE_p(x)$ and the value x remains constant for all $x > 0$. This property is called "preference homogeneity".

Many applications of prospect theory in fuzzy risk management and multi-criteria decision making (see for example: Hao and Xu, 2017; Kacprzyk, 2020) implicitly assume that the function of *CE* is homogeneous. The value functions for which the function of *CE* is homogeneous are called preference-homogeneous.

In practice, the value of $CE(x)$ can be estimated using queries in the following way.

Example 1. Consider a decision-making group of 10 people. We would like to estimate the certainty equivalence value of the group in the following random situation:

L: There is a box with 75 white balls and 25 black balls. If the designated person in the group draws a white ball, the group wins €10,000, if the designated person draws a black ball, the group wins €0. Formally, this can be described by the lottery $L = (10000, 0.75; 0, 0.25)$.

At the base of the continuity axiom, there is certainly a fixed value r for which the group's choice is indifferent, i.e. half of the group chooses the random event L and the other half chooses the fixed value r . This fixed amount will be the certainty equivalent of the lottery L , denoted by $r = CE(10000)$.

To estimate $CE(10000)$, we ask the following questions:

Question 1. Let me know if you're sure you would prefer 100 euros to the uncertain L . Answer: in the experiment, none of the members of the group is signalling. Therefore $CE(10000) \in (100, 10000)$.

Question 2. Let me know if you're sure you would prefer 9000 euros to the uncertain L . Answer: in the experiment, each member of the group signals. Therefore $CE(10000) \in (100, 9000)$.

Question 3. Let me know if you're sure you would prefer 1000 euros to the uncertain L . Answer: in the experiment, 1 member of the group signals. Therefore $CE(10000) \in (1000, 9000)$.

Question 4. Let me know if you're sure you would prefer 8000 euros to the uncertain L . Answer: in the experiment, each member of the group signals. Therefore $CE(10000) \in (1000, 8000)$.

Question 5. Let me know if you're sure you would prefer 4500 euros to the uncertain L . Answer: in the experiment, 7 members of the group signal. One is uncertain. Therefore $CE(10000) \in (1000, 4500)$.

Question 6. Let me know if you're sure you would prefer 2750 euros to the uncertain L . Answer: in the experiment, 3 members of the group signal. One is uncertain. Therefore $CE(10000) \in (2750, 4500)$.

Question 7. Let me know if you're sure you would prefer 3600 euros to the uncertain L . Answer: in the experiment, 4 members of the group signal. One is uncertain. Therefore $CE(10000) \in (3600, 4500)$.

Question 8. Let me know if you're sure you would prefer 4050 euros to the uncertain L . Answer: in the experiment, 5 members of the group signal. Therefore, the estimated value of $CE(10000)$ is 4050.

From a practical point of view, the $CE(10000)$ is a vague quantity. The series of questions is similar to the game of trying to find a hidden object while your peers help you with the cold, hot and lukewarm markers. When searching for a certainty equivalence, the cold indicator should be used when the group prefers the certainty, and the warm indicator when the majority of the group prefers the uncertainty. The lukewarm indicator indicates the proportion of undecideds. These indicators can be mathematically described by so-called intuitionistic fuzzy sets.

The cold membership function is $t_p: [0, 10000] \rightarrow [0, 1]$, which is an increasing function.

The warm membership function is $f_p: [0, 10000] \rightarrow [0, 1]$, which is a decreasing function.

The lukewarm (hesitation) membership function is $h_p: [0,10000] \rightarrow [0,1]$, where

$$h_p(r) = 1 - t_p(r) - f_p(r).$$

Based on the experiment:

$$\begin{aligned} t_p(0) &= 0, t_p(100) = 0, t_p(1000) = 1/10, t_p(2750) = 3/10, t_p(3600) = 4/10, \\ t_p(4050) &= 5/10, t_p(8000) = 10/10 = 1, t_p(9000) = 1, t_p(10000) = 1. \end{aligned} \quad (1)$$

$$\begin{aligned} f_p(0) &= 1, f_p(100) = 1, f_p(1000) = 9/10, f_p(2750) = 6/10, f_p(3600) = 5/10, \\ f_p(4050) &= 5/10, f_p(8000) = 0, f_p(9000) = 0, f_p(10000) = 0. \end{aligned} \quad (2)$$

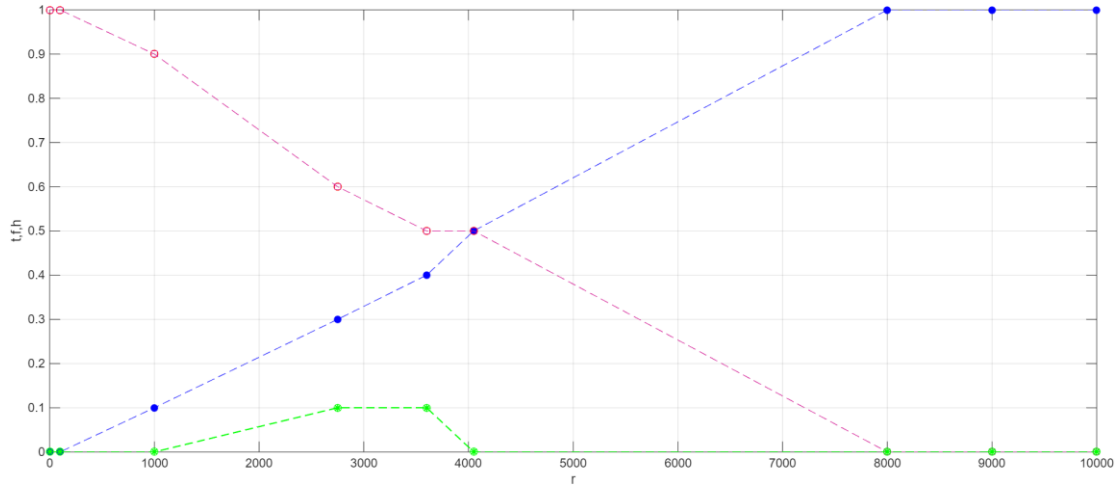


Fig. 1. The graph of experiment data: t_p (blue), f_p (red) and h_p (green).

Summary, the certainty equivalence can be viewed as an intuitionistic fuzzy set whose degree of membership is characterized by the functions t and whose degree of non-membership is characterized by the functions f , i.e.

$$\widetilde{CE} \left(L_p(x) \right) = \widetilde{CE}_p(x) = \langle r, t_{x,p}(r), f_{x,p}(r) \rangle,$$

where $t_{x,p}(r)$ indicates that the amount r is chosen with certainty by a fraction of the group over the lottery $L = (x, p; 0, 1 - p)$, and $f_{x,p}(r)$ indicates the fraction of the group that chooses L relative to the sum r .

We observe that the function $t: (0, +\infty) \times (0, x) \times (0, 1) \rightarrow [0, 1]$ with $t(x, r, p) = t_{x,p}(r)$ is increasing in variable r and decreasing in the variable x and p , and the function $f: (0, +\infty) \times (0, x) \times (0, 1) \rightarrow [0, 1]$ with $f(x, r, p) = f_{x,p}(r)$ is decreasing in variable r and increasing in the variable x and p .

The aim of this paper is to determine the general form of the membership function t and non-membership function f if the preference homogeneity condition is fulfilled for the decision environment.

2. Intuitionistic fuzzy sets

The intuitive fuzzy set (A-IFS) developed by Atanassov (1986, 1999), is an effective tool for dealing with fuzziness. In this section, we recall some basic concepts and results on intuitionistic fuzzy sets.

Definition 1. (Atanassov, 1986) *An intuitionistic fuzzy set on the nonempty universe of discourse X is given by $A = \{\langle r, t_A(r), f_A(r) \rangle : r \in X\}$, where $t_A: X \rightarrow [0,1]$, $f_A: X \rightarrow [0,1]$, with the condition $0 \leq t_A(r) + f_A(r) \leq 1$ for all $r \in X$, t_A and f_A denote a membership function and a non-membership function of r to A , respectively. For an intuitionistic fuzzy set A the $h_A: X \rightarrow [0,1]$ with $h_A(r) = 1 - t_A(r) - f_A(r)$ is the hesitant (indeterminacy) function of A .*

All intuitionistic fuzzy sets on the nonempty domains X will be denoted by $IFSs(X)$. Let $A, B \in IFSs(X)$. The order and operations between A and B will be defined as

- (1) $A \subseteq B$ iff $t_A(x) \leq t_B(x)$ and $f_A(x) \geq f_B(x)$, $\forall x \in X$.
- (2) $A = B$ iff $t_A(x) = t_B(x)$ and $f_A(x) = f_B(x)$, $\forall x \in X$.
- (3) $A \cap B = \{\langle x, \min\{t_A(x), t_B(x)\}, \max\{f_A(x), f_B(x)\} \rangle : x \in X\}$.
- (4) $A \cup B = \{\langle x, \max\{t_A(x), t_B(x)\}, \min\{f_A(x), f_B(x)\} \rangle : x \in X\}$.
- (5) $A^c = \{\langle x, f_A(x), t_A(x) \rangle : x \in X\}$.

Similarity measures and distance measures between intuitionistic fuzzy sets have received much attention in recent years (see for example Duan and Li, 2021).

Xu (2007) developed the concept of the intuitionistic fuzzy value (IFV), which can be treated as the basic element of the intuitionistic fuzzy set. A typical IFV α takes the form of $\alpha = (t_\alpha, f_\alpha) \in [0,1] \times [0,1]$ where $t_\alpha + f_\alpha \leq 1$.

Motivated by the operation laws for the IFSs, Xu (2007), presented the basic operation laws for the IFVs, defined as follows.

Definition 2. (Xu, 2007) *Let $\alpha = (t_\alpha, f_\alpha)$, $\beta = (t_\beta, f_\beta)$ and be the IFVs, then*

- (1) $\alpha \oplus \beta = (t_\alpha + t_\beta - t_\alpha \cdot t_\beta, f_\alpha \cdot f_\beta)$;
- (2) $\lambda \alpha = (1 - (1 - t_\alpha)^\lambda, f_\alpha^\lambda)$, $\lambda > 0$;
- (3) $\alpha^\lambda = (t_\alpha^\lambda, 1 - (1 - f_\alpha)^\lambda)$, $\lambda > 0$.

3. Relation between the preference-homogeneity condition and degree of membership

Tversky and Kahneman (1992) state, without proof, that if the “preference homogeneity” condition is satisfied, then the value function has the following form

$$v_0(x) = \begin{cases} x^\alpha & \text{if } x \geq 0, \\ -\rho(-x)^\beta & \text{if } x < 0, \end{cases} \quad (3)$$

where $\rho > 1$ is called the “loss-aversion” coefficient, and $\alpha, \beta > 0$ (usually $\alpha, \beta < 1$) describe the risk attitudes for gains and losses.

Nowaihi et al. (2008) proved that preference homogeneity is a necessary and sufficient condition to represent the value function as presented above. Wakker and Zank (2002) proved that the value

function of the form (3) is valid if and only if the preference relation satisfies the following conditions: weak ordering; stochastic dominance; simple continuity; tail independence and constant proportional risk aversion.

Someone is indifferent between winning an amount of money x with probability p or a certain value $CE_p(x)$. If his/her value function is preference-homogeneous with reference value zero, then the indifference can be described as:

$$v_0(CE_p(x)) = w(p)v_0(x) + (1 - w(p))v_0(0) = w(p)v_0(x).$$

We multiply the amount of money by $k > 0$, then

$$v_0(CE_p(kx)) = w(p)v_0(kx) + (1 - w(p))v_0(k \cdot 0) = w(p)v_0(kx).$$

By expressing $w(p)$ from these equations we obtain

$$CE_p(kx) = kCE_p(x). \quad (4)$$

Remark 1 The relation (4) also shows that certainty equivalence function CE_p for is first order positive homogeneous.

If we characterize the certainty equivalence by intuitionistic fuzzy sets, then the homogenization condition yields to the following property.

Theorem 2. If the decision maker is characterized by preference homogeneity, i.e.

$$\widetilde{CE}_p(kx) = k\widetilde{CE}_p(x),$$

with continuous differentiable membership functions t and f , then the intuitionistic fuzzy form of the certain equivalence is

$$\widetilde{CE}_p(x) = \langle r, 1 - e^{-C(r,p)x}, e^{-D(r,p)x} \rangle,$$

where C and D are positive, increasing function in the first argument, decreasing in the second argument with $C(r, p) \leq D(r, p)$ for all $r \in (0, x)$, $p \in [0, 1]$.

Proof. From $\widetilde{CE}_p(kx) = k\widetilde{CE}_p(x)$ we get

$$\begin{aligned} \langle r, t_p(r, kx), f_p(r, kx) \rangle &= k \langle r, t_p(r, x), f_p(r, x) \rangle \\ &= \langle r, 1 - (1 - t_p(r, x))^k, (f_p(r, x))^k \rangle. \end{aligned}$$

Thus

$$\begin{aligned} t_p(r, kx) &= 1 - (1 - t_p(r, x))^k, \\ f_p(r, kx) &= (f_p(r, x))^k. \end{aligned}$$

By calculated the logarithm on both sides of the equations, we get

$$\begin{aligned} \ln(1 - t_p(r, kx)) &= \ln(1 - t_p(r, x))^k, \\ \ln f_p(r, kx) &= \ln(f_p(r, x))^k \end{aligned}$$

$$\begin{aligned}\ln(1 - t_p(r, kx)) &= k \ln(1 - t_p(r, x)), \\ \ln f_p(r, kx) &= k \ln(f_p(r, x))\end{aligned}$$

Noted by

$$\begin{aligned}u_{r,p}(x) &= \ln(1 - t_p(r, kx)), \\ u_{r,p}(kx) &= k u_{r,p}(x).\end{aligned}$$

That is, the function $u_{r,p}$ is first-order homogeneous. From where it follows

$$u_{r,p}(x) = -C(r, p)x,$$

namely

$$t_p(r, x) = 1 - e^{-C(r, p)x}.$$

Similarly

$$f_p(r, x) = e^{-D(r, p)x}$$

Since

$$0 \leq t_p(r, x) \leq 1$$

we get

$$\begin{aligned}0 &\leq 1 - e^{-C(r, p)x} \leq 1, \\ 0 &\leq e^{-C(r, p)x} \leq 1, \\ C(r, p) &\geq 0.\end{aligned}$$

Similarly

$$D(r, p) \geq 0.$$

Since

$$0 \leq t_p(r, x) + f_p(r, x) \leq 1$$

We obtain

$$\begin{aligned}0 &\leq 1 - e^{-C(r, p)x} + e^{-D(r, p)x} \leq 1 \\ e^{-C(r, p)x} &\geq e^{-D(r, p)x} \\ C(r, p) &\leq D(r, p).\end{aligned}$$

Since the function $t_p(r, x)$ is increasing in the first argument, we get

$$\begin{aligned}\frac{\partial t_p(r, x)}{\partial r} &= 1 - e^{-C(r, p)x} = e^{-C(r, p)x} \frac{\partial C(r, p)}{\partial r} > 0, \\ \frac{\partial C(r, p)}{\partial r} &> 0.\end{aligned}$$

Since the function $t_p(r, x)$ is decreasing in the argument p , we obtain

$$\begin{aligned}\frac{\partial t_p(r, x)}{\partial p} &= 1 - e^{-C(r, p)x} = e^{-C(r, p)x} \frac{\partial C(r, p)}{\partial p} < 0, \\ \frac{\partial C(r, p)}{\partial p} &< 0.\end{aligned}$$

Since the function $f_p(r, x)$ is decreasing in the first argument, we obtain

$$\frac{\partial f_p(r, x)}{\partial r} = e^{-D(r, p)x} = -e^{-D(r, p)} \frac{\partial D(r, p)}{\partial r} < 0,$$

$$\frac{\partial D(r, p)}{\partial r} > 0.$$

Since the function $f_p(r, x)$ is increasing in the argument p , we obtain

$$\frac{\partial f(x, r, p)}{\partial r} = e^{-D(r, p)x} = -e^{-D(r, p)} \frac{\partial D(r, p)}{\partial p} > 0,$$

$$\frac{\partial D(r, p)}{\partial p} < 0.$$

For example, if C and D are following forms: $C(r, p) = \frac{1}{p} * \left(\frac{r}{k_1}\right)^{d_1}$, $D(r, p) = \frac{1}{p} * \left(\frac{r}{k_2}\right)^{d_2}$, then the best fit to the measured data in Example 1 is for $k_1 = 500045$, $k_2 = 686138$, $d_1 = 2.04$ and $d_2 = 1.88$. In the Fig. 2 we show that $C(r, 0.75) \leq D(r, 0.75)$, since the difference $D(r, 0.75) - C(r, 0.75)$ is positive.

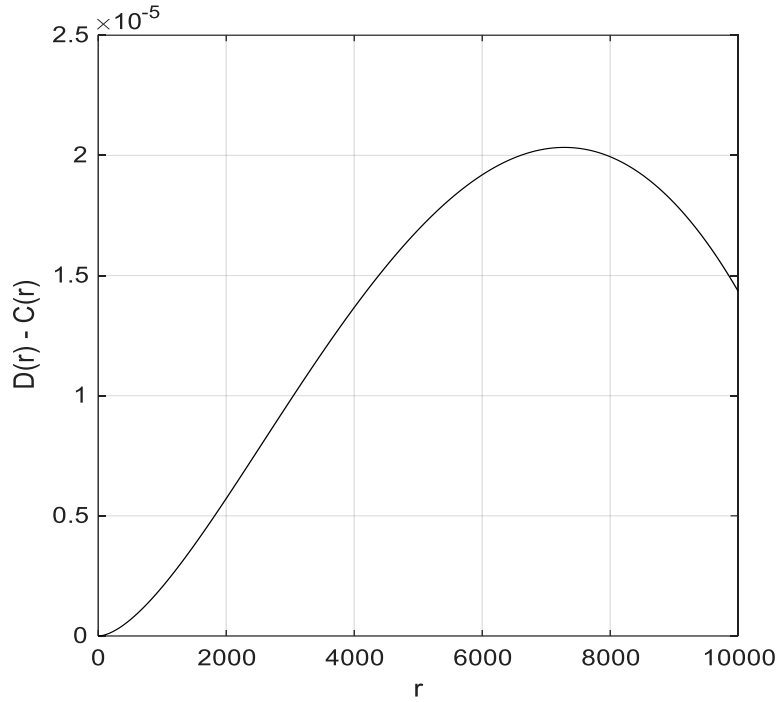


Fig. 2. The variation of difference $D(r, 0.75) - C(r, 0.75)$.

In the Fig. 3 we present the graph of the membership function t , non-membership function f and hesitant function h for $x = 10000$ and $p = 0.75$ in the Example 1. The small circles in the figure show the values of t (color blue) and f (color red) given in Example 1 by relations (1) and (2).

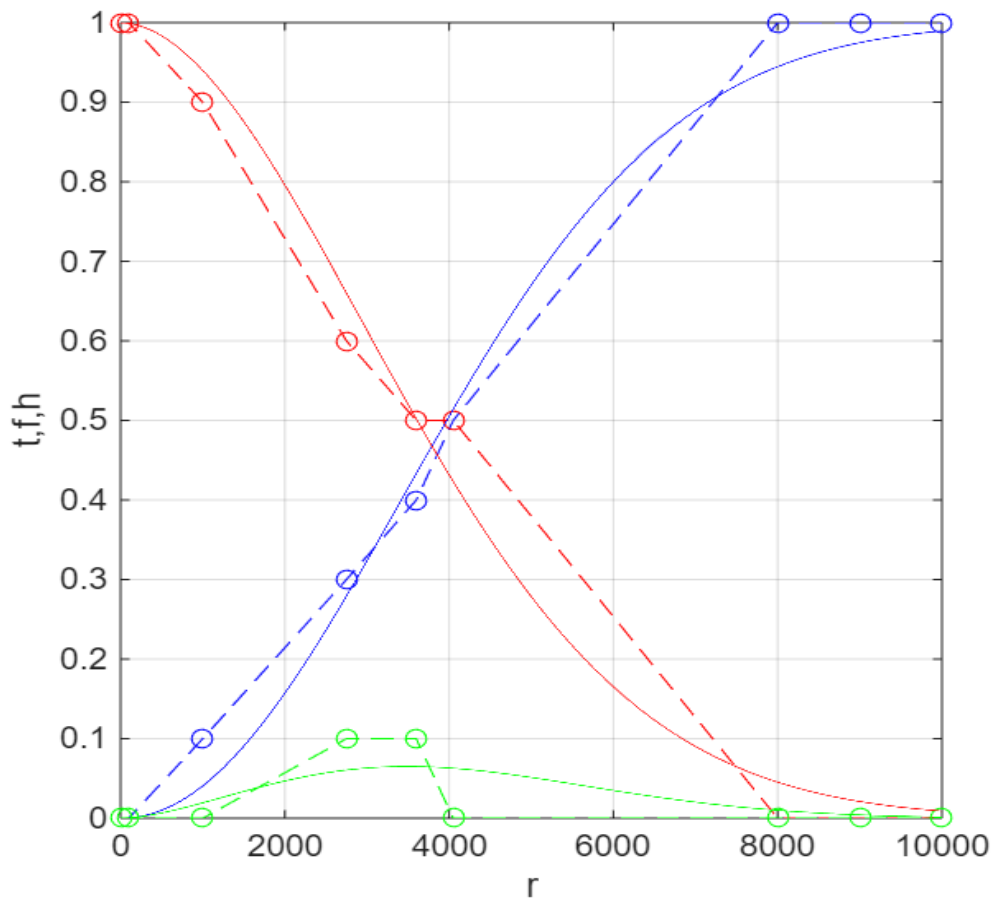


Fig. 3. The graph of membership function t (blue) non-membership function f (red) and hesitant function h (green) of the Example 1.

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Zoltán MAKÓ
Department of Economic Sciences,
Sapientia Hungarian University of Transylvania
Miercurea Ciuc, Romania
e-mail: makozoltan@uni.sapientia.ro

Júlia SALAMON,
Department of Economic Sciences,
Sapientia Hungarian University of Transylvania,
Miercurea Ciuc, Romania
e-mail: salamonjulia@uni.sapientia.ro

SEARCHING FOR CORRELATED EQUILIBRIUMS IN INTERVAL VALUED GAMES

JÚLIA SALAMON - ZOLTÁN MAKÓ

Abstract

In this paper we introduce the notions of correlated equilibrium for interval valued bimatrix games. In the particular case, when the incomplete preference preordering defined for intervals is the product preference relation, we study the existence of correlated equilibriums. An algorithm is suggested which can be used in real decision making situations. We show that there exist interval bimatrix games which have correlated equilibriums, but have no Nash equilibrium points.

Keywords: correlated equilibrium, Nash equilibrium, interval valued bimatrix games.

1. Introduction

In classical game theory it is assumed that all data of a game are known exactly by the players. The equilibrium concept of the classical games was introduced by Nash in (Nash 1951). He proved that if we allow mixed strategies, then every classical game with a finite number of strategies has at least one Nash equilibrium. The Nash equilibrium can be computed by solving a mixed binary linear programming problem (Audet et al. 2006).

External signal decision-making procedures lead to so-called correlated equilibrium and do not always tend to a Nash equilibrium point. The notion of correlated equilibrium was introduced by Aumann in 1987, which is a generalization of Nash equilibrium. The informal definition of correlated equilibrium is: *each player chooses his/her action according to his/her observation of the same public signal. A strategy assigns an action to every possible observation a player can make. If no player would want to deviate from the recommended strategy (assuming the others don't deviate), the distribution is called a correlated equilibrium.* The correlated equilibrium is consistent with the Bayesian rationality i.e. the equilibrium condition appears as a simple maximization of utility functions on the part of each player. The set of correlated equilibriums is a convex polytope, and it can be determined by linear programming methods (Forgo 2010, Hart – Schmeidler 1989, Lo 2002, Nau et al. 2003, Papadimitriu – Roughgarden 2008, Stein et al. 2011).

Often in practical problems the incomes cannot be precisely given only the approximate values of the incomes are known but generally we can estimate the lower and upper bounds of incomes. These games are called interval valued games. In order to study the equilibriums of interval valued game, it is necessary to define the basic operations on intervals and the ordering relation of intervals. By defining these concepts we get different game theory models (Jiang et al. 2015, Li 2011, Maeda 2015, Mako – Salamon 2020).

In classic games, the basic assumption is that the ordering relation is complete and satisfies the continuity and independence axioms of utility theory. Neumann and Morgenstern proved that the

players aim is to maximize the expected utilities if and only if these axioms are fulfilled. Aumann demonstrated that if the relation satisfies these axioms but is not complete, then the property holds only in one direction. Even in this case the goal of the players is to maximize the expected utilities, but here the function of the expected utility can be multi-dimensional.

The goal of this paper is to generalize the notion of correlated equilibrium to interval valued bimatrix games. The paper is organized as follows. In section 2 we recall the notions of the Nash and correlated equilibrium of the classical game. The basic operations and the ordering relation of intervals is also presented. The notion of correlated equilibrium for interval games is introduced in section 3. In particular case, when the incomplete preference preordering is the product preference relation we study the existence of Nash and correlated equilibriums for interval games. An algorithm is suggested which can be used in real decision making situations.

2. Preliminaries

Let $I = \{1, 2, \dots, m\}$ and $J = \{1, 2, \dots, n\}$ be the sets of all pure strategies available for players I and J , respectively. The sets of all mixed strategies for players I and J are denoted by

$$S_I = \left\{ (x_1, x_2, \dots, x_m) \in \mathbb{R}^m \mid x_i \geq 0, i \in I, \sum_{i=1}^m x_i = 1 \right\}$$

$$S_J = \left\{ (y_1, y_2, \dots, y_n) \in \mathbb{R}^n \mid y_j \geq 0, j \in J, \sum_{j=1}^n y_j = 1 \right\}$$

respectively, where $\mathbb{R}^m$ is the m -dimensional real vector space. The numbers $a_{ij} \in \mathbb{R}$ and $b_{ij} \in \mathbb{R}$ represent the incomes of players, when player I plays the pure strategy i and player J plays the pure strategy j . The payoff matrices are $A = (a_{ij})_{m \times n}$ and $B = (b_{ij})_{m \times n}$. We call this game a noncooperative bimatrix game and we denote it by $G = (I, J, S_I, S_J, A, B)$.

In the following we recall the definitions of Nash and correlated equilibriums.

Definition 1. A Nash-equilibrium (NE) of G is a pair $(x^*, y^*) \in S_I \times S_J$ such that

$$\sum_{i=1}^m \sum_{j=1}^n x_i a_{ij} y_j^* \leq \sum_{i=1}^m \sum_{j=1}^n x_i^* a_{ij} y_j^* \text{ and}$$

$$\sum_{i=1}^m \sum_{j=1}^n x_i^* b_{ij} y_j \leq \sum_{i=1}^m \sum_{j=1}^n x_i^* b_{ij} y_j^*,$$

for all $(x, y) \in S_I \times S_J$.

Definition 2. A correlated equilibrium (CE) of the game G is a joint distribution $P = (p_{ij})_{m \times n}$ (i.e. $p_{ij} \geq 0$ and $\sum_{i=1}^m \sum_{j=1}^n p_{ij} = 1$ for all $i \in I, j \in J$) such that

$$\sum_{j=1}^n p_{ij} a_{kj} \leq \sum_{j=1}^n p_{ij} a_{ij}, \text{ for all } i \in I \text{ and } k \in I \setminus \{i\},$$

$$\sum_{i=1}^m p_{ij} b_{il} \leq \sum_{i=1}^m p_{ij} b_{ij}, \text{ for all } j \in J \text{ and } l \in J \setminus \{j\}.$$

The relation between Nash and correlated equilibriums is given by the following theorem.

Theorem 3 (Aumann 1987). *In any bimatrix game, if (x, y) is a NE strategy, then the joint distribution P , where $p_{ij} = x_i y_j$ ($i \in I, j \in J$) is a CE.*

In any bimatrix game, if the joint distribution $\mathbf{P}$ is a CE and there exist marginal distributions $(\mathbf{x}, \mathbf{y})$ such that $\mathbf{p}_{ij} = \mathbf{x}_i \mathbf{y}_j$ for all $i \in I, j \in J$, then $(\mathbf{x}, \mathbf{y})$ is a NE strategy.

The basic notions of the interval based approach are stated as follows.

The set of closed intervals is denote by

$$\mathcal{N} = \{\mathbf{a}: \underline{a} \leq \bar{a}, \mathbf{a} = [\underline{a}, \bar{a}] \text{ is closed interval of } \mathbb{R}\}.$$

The sum and the product with scalar of intervals is given in the next definition.

Definition 4. *If $\mathbf{a} = [\underline{a}, \bar{a}]$, $\mathbf{b} = [\underline{b}, \bar{b}]$ are closed intervals and $\lambda \geq 0$ then $\mathbf{a} + \mathbf{b} = [\underline{a} + \underline{b}, \bar{a} + \bar{b}]$ and $\lambda \mathbf{a} = [\lambda \underline{a}, \lambda \bar{a}]$.*

To be able to introduce the notion of correlated equilibrium we need to specify the incomplete preference ordering relation defined on intervals. The theory of incomplete preferences is an important subfield of decision theory. The basis of this theory was laid by Hausner 1954 and Aumann 1962. Some significant papers in this field are the studies (Bade 2005, Dubra et al. 2004, Mako – Salamon 2023).

Definition 5. *Let $\preceq$ be a (binary) relation on $\mathcal{N}$*

i) Two closed intervals $\mathbf{a}$ and $\mathbf{b}$ are $\preceq$ -comparable if either $\mathbf{a} \preceq \mathbf{b}$ or $\mathbf{b} \preceq \mathbf{a}$ holds, otherwise we say that they are $\preceq$ -incomparable.

ii) The relation $\preceq$ is complete on $\mathcal{N}$ if for all $\mathbf{a}, \mathbf{b} \in \mathcal{N}$ are $\preceq$ -comparable, and it is incomplete otherwise.

In order to guarantee that the players make their decisions on the basis of the expected utility principle, the ordering relations used in the definitions of equilibriums must be incomplete preference preordering.

Definition 6. *The relation $\preceq$ is an incomplete preference preorder, if for all $\mathbf{a}, \mathbf{b}, \mathbf{c} \in \mathcal{N}$ the following conditions hold:*

C1) the relation $\preceq$ is reflexive and transitive;

C2) if $\lambda \in]0, 1[$, then $\mathbf{a} \preceq \mathbf{b}$ if and only if $\lambda \mathbf{a} + (1 - \lambda) \mathbf{c} \preceq \lambda \mathbf{b} + (1 - \lambda) \mathbf{c}$.

Here C1 is the preorder assumption and C2 is the compatible assumption with the addition and multiplication by a scalar.

3. Correlated equilibrium of interval valued bimatrix games

Let $I = \{1, 2, \dots, m\}$ and $J = \{1, 2, \dots, n\}$ be the sets of pure strategies of player I and player J , respectively. The mixed strategies of players are represented by the sets S_I and S_J .

Definition 7. Let $\mathbf{a}_{ij} = [\underline{a}_{ij}, \bar{a}_{ij}]$ represent the incomes of player I and $\mathbf{b}_{ij} = [\underline{b}_{ij}, \bar{b}_{ij}]$ represent the incomes of player J based on the strategy pair $(i, j) \in I \times J$, where $[\underline{a}_{ij}, \bar{a}_{ij}]$ and $[\underline{b}_{ij}, \bar{b}_{ij}]$ are closed intervals of $\mathbb{R}$. The interval valued payoff matrices of the game are $\mathbf{A} = (\mathbf{a}_{ij})_{m \times n}$ and $\mathbf{B} = (\mathbf{b}_{ij})_{m \times n}$. The relations $\preccurlyeq_I$ and $\preccurlyeq_J$ are the incomplete preference ordering of the players. This interval valued bimatrix game is denoted by $\mathbf{G} = (I, J, S_I, S_J, \mathbf{A}, \mathbf{B}, \preccurlyeq_I, \preccurlyeq_J)$.

The expected payoffs of the players are the following intervals

$$E_I(x, y) = x^T \mathbf{A} y = \sum_{i=1}^m \sum_{j=1}^n x_i \mathbf{a}_{ij} y_j,$$

$$E_J(x, y) = x^T \mathbf{B} y = \sum_{i=1}^m \sum_{j=1}^n x_i \mathbf{b}_{ij} y_j.$$

The Nash-equilibrium of interval games defined by the help of incomplete preferences is the follows.

Definition 8. A point $(x^*, y^*) \in S_I \times S_J$ is said to be an Nash-equilibrium (for short INE) strategy to game $\mathbf{G} = (I, J, S_I, S_J, \mathbf{A}, \mathbf{B}, \preccurlyeq_I, \preccurlyeq_J)$ if it holds that

$$x^{*T} \mathbf{A} y^* \preccurlyeq_I x^{*T} \mathbf{A} y^* \text{ for all } x \in S_I;$$

$$x^{*T} \mathbf{B} y^* \preccurlyeq_J x^{*T} \mathbf{B} y^* \text{ for all } y \in S_J.$$

Now we can introduce the notion of correlated equilibrium for a game $\mathbf{G}$ defined by preference ordering.

Definition 9. A joint distribution P is said to be an correlated equilibrium (for short ICE) strategy for a game $\mathbf{G} = (I, J, S_I, S_J, \mathbf{A}, \mathbf{B}, \preccurlyeq_I, \preccurlyeq_J)$ if

$$\sum_{j=1}^n p_{ij} \mathbf{a}_{kj} \preccurlyeq_I \sum_{j=1}^n p_{ij} \mathbf{a}_{ij}, \text{ for all } i \in I \text{ and } k \in I \setminus \{i\},$$

$$\sum_{i=1}^m p_{ij} \mathbf{b}_{il} \preccurlyeq_J \sum_{i=1}^m p_{ij} \mathbf{b}_{ij}, \text{ for all } j \in J \text{ and } l \in J \setminus \{j\}.$$

In the followings we present a particular case when the incomplete preference preordering is the product preference relation.

Definition 10. If $\mathbf{a} = [\underline{a}, \bar{a}]$, $\mathbf{b} = [\underline{b}, \bar{b}]$ are closed intervals then $\mathbf{a} \preccurlyeq \mathbf{b}$ if and only if $\underline{a} \leq \underline{b}$ and $\bar{a} \leq \bar{b}$.

Remark 11. It can be simply verified that the relations in Theorem 3 are satisfied even in case of Nash and correlated equilibria for interval games.

We can obtain similar results for correlated equilibriums for interval games to those given by Maeda 2003, Cunlin – Qiang 2011 for interval Nash equilibria.

Proposition 12. A joint distribution P is a ICE of the game $\mathbf{G} = (I, J, S_I, S_J, \mathbf{A}, \mathbf{B}, \preccurlyeq, \preccurlyeq)$ if and only if P is a CE of the crisp games $\underline{\mathbf{G}} = (I, J, S_I, S_J, \underline{\mathbf{A}}, \underline{\mathbf{B}})$ and $\bar{\mathbf{G}} = (I, J, S_I, S_J, \bar{\mathbf{A}}, \bar{\mathbf{B}})$, i.e.

$$\begin{aligned}
\sum_{j=1}^n p_{ij} \underline{a}_{ij} &\geq \sum_{j=1}^n p_{ij} \underline{a}_{kj}, \\
\sum_{j=1}^n p_{ij} \bar{a}_{ij} &\geq \sum_{j=1}^n p_{ij} \bar{a}_{kj}, \text{ for all } i, k \in I, \\
\sum_{i=1}^m p_{ij} \underline{b}_{ij} &\geq \sum_{i=1}^m p_{il} \underline{b}_{il}, \\
\sum_{i=1}^m p_{ij} \bar{b}_{ij} &\geq \sum_{i=1}^m p_{il} \bar{b}_{il}, \text{ for all } j, l \in J.
\end{aligned}$$

The game $\mathbf{G} = (I, J, S_I, S_J, \mathbf{A}, \mathbf{B}, \leq, \leq)$ is said to be a *proportional interval valued game* if and only if there exist $k_j, t_i > 1, i \in I, j \in J$ such that $\bar{a}_{ij} = k_j \underline{a}_{ij}$ and $\bar{b}_{ij} = t_i \underline{b}_{ij}$ for all $i \in I, j \in J$.

The game $\mathbf{G} = (I, J, S_I, S_J, \mathbf{A}, \mathbf{B}, \leq, \leq)$ is said to be a *constant extension interval valued game* if and only if $\bar{a}_{ij} - \underline{a}_{ij} = \bar{a}_{kj} - \underline{a}_{kj}$ and $\bar{b}_{ij} - \underline{b}_{ij} = \bar{b}_{il} - \underline{b}_{il}$ for all $i, k \in I, j, l \in J$. It is easy to prove the statement of the following proposition.

Proposition 13. *If the game $\mathbf{G} = (I, J, S_I, S_J, \mathbf{A}, \mathbf{B}, \leq, \leq)$ is proportional or constant extension, then $\mathbf{G}$ has ICE and INE.*

We consider the crisp games with payoff matrices $A(u) = (u \underline{a}_{ij} + (1-u) \bar{a}_{ij})_{m \times n}$ $B(v) = (v \underline{b}_{ij} + (1-v) \bar{b}_{ij})_{m \times n}$, where $u, v \in [0,1]$.

Proposition 14. *A joint distribution P is an ICE of the game $\mathbf{G} = (I, J, S_I, S_J, \mathbf{A}, \mathbf{B}, \leq, \leq)$ if and only if P is a CE of the crisp game $G(u, v) = (I, J, S_I, S_J, A(u), B(v))$ for all $u, v \in [0,1]$.*

Proof. If P is an ICE then for all $i, k \in I$ and $u \in [0,1]$ we have

$$u \sum_{j=1}^n p_{ij} \underline{a}_{ij} \geq u \sum_{j=1}^n p_{ij} \underline{a}_{kj} \text{ and } (1-u) \sum_{j=1}^n p_{ij} \bar{a}_{ij} \geq (1-u) \sum_{j=1}^n p_{ij} \bar{a}_{kj}.$$

From where it follows

$$\sum_{j=1}^n p_{ij} (u \underline{a}_{ij} + (1-u) \bar{a}_{ij}) \geq \sum_{j=1}^n p_{ij} (u \underline{a}_{kj} + (1-u) \bar{a}_{kj}).$$

We can obtain similar relation for player J . Hence P is correlated equilibrium of the game $G(u, v)$.

From Proposition 12 we obtain that P is a ICE of game $\mathbf{G}$, if we choose $u, v \in \{0,1\}$ in the game $G(u, v) = (I, J, S_I, S_J, A(u), B(v))$.

It is worth to work with correlated equilibriums since we can give examples for interval games which have correlated equilibriums, but have no Nash equilibrium points.

Example 15. *We consider the game where the left and right part games (games that contain the lower and upper limits of the interval incomes matrix) incomes are*

$\underline{G}$	1	2	3	$\overline{G}$	1	2	3
1	(26,13)	(17,22)	(24,21)	1	(28,17)	(20,29)	(30,27)
2	(19,30)	(27,27)	(16,18)	2	(26,35)	(32,32)	(24,24)
3	(29,17)	(22,15)	(20,26)	3	(35,25)	(27,22)	(22,32)

The game $\overline{G}$ has only one NE

$$\bar{x}^* = \left(\frac{1}{5}, \frac{19}{45}, \frac{17}{45}\right), \bar{y}^* = \left(\frac{9}{35}, \frac{29}{105}, \frac{7}{15}\right),$$

which is not NE of game $\underline{G}$. Therefore this interval valued game does not have INE.

In other hand the distributions

$$P_1 = \begin{bmatrix} 0 & 0.1 & 0.3 \\ 0.1 & 0.2 & 0 \\ 0.1 & 0.1 & 0.1 \end{bmatrix}, P_2 = \begin{bmatrix} 0 & 0.1 & 0.25 \\ 0.1 & 0.2 & 0 \\ 0.1 & 0.1 & 0.15 \end{bmatrix}, P_3 = \begin{bmatrix} 0 & 0.1 & 0.2 \\ 0.1 & 0.2 & 0 \\ 0.1 & 0.1 & 0.2 \end{bmatrix}$$

are ICE of this game.

Next we show that unlike the crisp game, not all interval valued games have INE and ICE.

Example 16. We consider the following interval valued game $\mathbf{G}$ where the left and right part games incomes are

$\underline{G}$	1	2	$\overline{G}$	1	2
1	(2,2)	(5,1)	1	(5,3)	(10,4)
2	(1,4)	(6,5)	2	(6,7)	(9,5)

The NEs of the $\underline{G}$ game are

$$P_1 = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}, P_2 = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}, P_3 = \begin{bmatrix} 1/4 & 1/4 \\ 1/4 & 1/4 \end{bmatrix}.$$

in other hand the NEs of this $\overline{G}$ game are different

$$P_1^* = \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix}, P_2^* = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix}, P_3^* = \begin{bmatrix} 1/3 & 1/3 \\ 1/6 & 1/6 \end{bmatrix}.$$

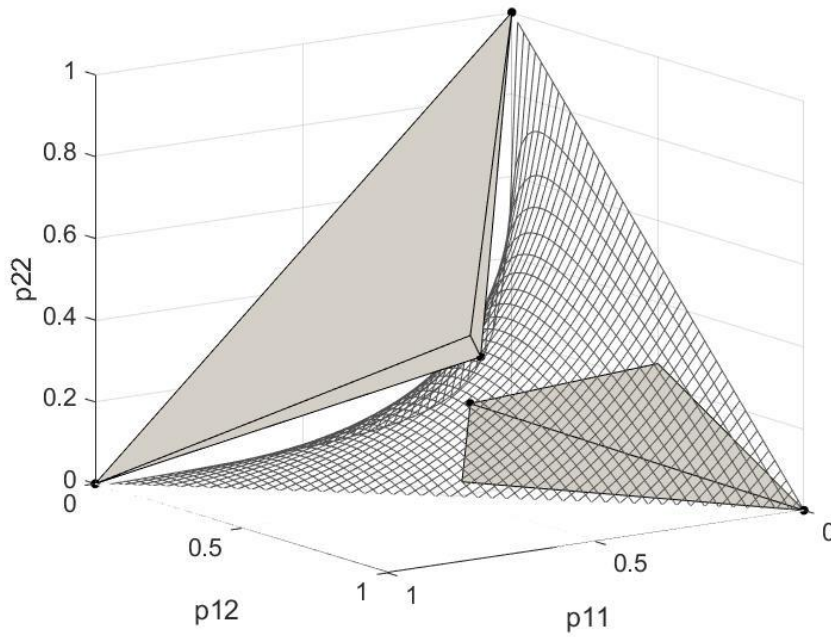


Figure 1 The geometrical interpretation of the correlated and the Nash equilibriums
in the interval games

Figure 1 shows the geometry of ICEs and INEs of Example 16. The small black circles are the NEs. The mesh grid illustrates the saddle of distributions independent between players i.e. the NEs must lie on this surface. The gray color indicates the polytopes of correlated equilibriums of the games $\underline{G}$ and $\overline{G}$. It can be observed that polytopes are located on different sides of the surface E . From where it follows that the interval valued game has no correlated equilibrium point.

Unfortunately, even if there exists a correlated equilibrium point for the interval valued game, the obtained equilibrium points will not always be the equilibrium points of the specific game that is realized. This approach is useful only when it is known for sure that the real profits are proportional to the extreme value estimates of the players (Proposition 14). Otherwise, the problem occurs from the fact, that the given ordering relation is incomplete, we can not guarantee that the NE or CE of a game, where $a_{ij} \in [\underline{a}_{ij}, \overline{a}_{ij}]$ and $b_{ij} \in [\underline{b}_{ij}, \overline{b}_{ij}]$ is an INE or ICE of the interval valued game. The next example confirms this statement.

Example 17. Starting from the Example 16 we consider the following interval valued game $\mathbf{G}$:

$\mathbf{G}$	1	2
1	$([2,9],[2,9])$	$([5,12],[1,8])$
2	$([1,8],[4,11])$	$([6,13],[5,12])$

The game $\mathbf{G}$ is a constant extension interval valued game therefore the INEs are

$$P_1 = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}, P_2 = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}, P_3 = \begin{bmatrix} 1/4 & 1/4 \\ 1/4 & 1/4 \end{bmatrix}$$

and the set of ICE is the upper gray polytope on the Figure 1.

In this case the $\overline{G}$ of Example 16 will be an internal game

$\mathbf{G}$	1	2
1	(5,3)	(10,4)
2	(6,7)	(9,5)

the NEs of this game are different from the INEs of the interval valued game

$$P_1^* = \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix}, P_2^* = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix}, P_3^* = \begin{bmatrix} 1/3 & 1/3 \\ 1/6 & 1/6 \end{bmatrix}$$

and the set of CE is the lower gray polytope on the Figure 1.

Thus we have an internal game where the correlated equilibrium points of the interval valued game G not will be equilibrium points.

Remark 18. This problem occurs in case of each ordering relation, since the ordering relation defined for intervals are incomplete, we always have to count with information loss.

From a practical point of view, this problem can be managed if the players can determine a preference ordering between the game specified outcomes. Inspired by the standard lexicographical ordering (Bustince et al. 2013), we suggest a procedure which can be used in real decision making situations:

Algorithm 19.

Step 1: determine the possible cases which can occur. Let $O = \{o_1, o_2, o_3, \dots, o_n\}$ be the set of cases, with cardinality n , and $E_0 = [0, 1]^m \times [0, 1]^n$ is the set of joint distributions.

Step 2: arrange these possible situations in preference order: $o_1 > o_2 > o_3 > \dots > o_n$, by taking into account, for example, the probability of their occurrence. Initially $i = 1$.

Step 3: specify the income matrix for case o_i , to determine the set K the set of NE or CE.

Step 4: $E_i = E_{i-1} \cap K$. If E_i is empty, then $E = E_{i-1}$ and go to step 5. If $i = n$, then $E = E_i$ and go to step 5, otherwise $i = i + 1$ and go to step 3.

Step 5: choose a strategy from set E .

Remark 20. If the algorithm stops when $i = n$, then the output of the algorithm does not depend on the preference order of the possible situations.

Most often, three possible situations are considered, the most likely case, the worst case scenario, and the most favorable case scenario.

The following example shows how the algorithm works.

Example 21. Let's consider the game where the income matrix are the follows

	1	2	3
1	(118,60)	(71,116)	(124,109)
2	(104,138)	(141,122)	(87,87)
3	(148,94)	(116,78)	(97,129)

The players do not know which of the following two possible situations will be materialize next year.

o1. the tax on profits is unitary $x = r\%$;

o2. the tax on profits is

$$x = \begin{cases} 20\% & \text{if } a_{ij} \geq 100 \\ 10\% & \text{if } a_{ij} < 100 \end{cases}$$

When the tax is uniform, since the values of data changes proportionally, according to Proposition 13, the equilibriums remain the same as in the initial game. In this case there exists only one NE

$$x_1^* = \left(\frac{2}{9}, \frac{343}{774}, \frac{259}{774} \right), y_1^* = \left(\frac{75}{1481}, \frac{496}{1481}, \frac{910}{1481} \right).$$

The expected incomes are (105.95,105.94) multiplied by $1 - r\%$.

In the case of second situations the income matrices are

	1	2	3
1	(94.4, 54)	(63.9, 92.8)	(99.2, 87.2)
2	(83.2, 110.4)	(112.8, 97.6)	(78.3, 78.3)
3	(118.4, 84.6)	(92.8, 70.2)	(87.3, 103.2)

We have also one but different NE

$$x_2^* = \left(\frac{165}{193}, 0, \frac{28}{193}\right), y_2^* = \left(0, \frac{7}{24}, \frac{17}{24}\right)$$

with (88.9,89.52) expected incomes.

If the decision-making takes place under the CE protocol, then

$$P = \begin{bmatrix} 0 & 0.1 & 0.3 \\ 0.1 & 0.3 & 0 \\ 0.1 & 0 & 0.1 \end{bmatrix}$$

is the CE in but case. The expected incomes in the first case are (121.5,117) multiplied by $1 - r\%$, and in second case (98.88,94.54). We can observe that, in both situations, the CE yields higher profits than the Nash equilibrium.

If the players consider only the Nash equilibria, then the algorithm returns that Nash equilibrium which belongs to the player's most preferred situation. This will not be an equilibrium point if the other situation occurs.

If even the correlate equilibrium points are taken in consideration, then the algorithm returns a polytope, which belongs to the polytopes of correlated equilibria obtained in each situations.

Remark 22. If we solve the previous example as interval valued matrix game for $r = 15\%$ then the income matrices corresponding to the lower and upper bounds of the intervals are

$\underline{G}$	1	2	3
1	(94.4, 51)	(60.35, 92.8)	(99.2, 87.2)
2	(83.2, 110.4)	(112.8, 97.6)	(73.95, 73.95)
3	(118.4, 79.9)	(92.8, 66.3)	(82.45, 103.2)
$\overline{G}$	1	2	3
1	(100.3, 54)	(63.9, 98.6)	(105.4, 92.65)
2	(88.4, 117.3)	(119.85, 103.7)	(78.3, 78.3)
3	(125.8, 84.6)	(98.6, 70.2)	(87.3, 109.65)

This interval valued game does not have interval Nash equilibrium point either. Every correlated equilibrium point obtained in Example 21 will be interval correlated equilibrium. The only difference is that here we obtain such interval correlated equilibria that in a real situation (presented in Example 21) there will not be equilibrium points, such as

$$P = \begin{bmatrix} 0 & 0.1 & 0.3 \\ 0.1 & 0.2 & 0 \\ 0.1 & 0.1 & 0.1 \end{bmatrix}.$$

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Júlia Salamon

Department of Economic Sciences,

Sapientia Hungarian University of Transylvania, Miercurea Ciuc, Romania

salamonjulia@uni.sapientia.ro

Zoltán Makó

Department of Economic Sciences,

Sapientia Hungarian University of Transylvania, Miercurea Ciuc, Romania

makozoltan@uni.sapientia.ro

THE SOLUTION OF QUADRATIC AND CUBIC FUNCTIONS WITH ADDITIONAL CONDITIONS

EDIT GARDA-MÁTYÁS

Abstract

In this paper we consider quadratic and cubic functions $f, g: \mathbb{R} \mapsto \mathbb{R}$ that satisfy the additional equations

$$y^2 f(x) = x^2 g(y)$$

or

$$y^3 f(x) = x^3 f(y)$$

for all points (x, y) on a specified curve.

First we investigate cubic functions that satisfy the additional equation along the semicubical parabola $y^2 - x^3 = 0$. Then we study quadratic functions that fulfill the additional equation involving sine and cosine trigonometric functions.

We find that in all examined cases f and g are equal and continuous.

Keywords: quadratic functions, cubic functions, conditional equation.

1. Introduction

Let $\mathbb{R}$, $\mathbb{Q}$, and $\mathbb{N}$ denote the set of all real numbers, rationals, and positive integers, respectively. A function $f: \mathbb{R} \rightarrow \mathbb{R}$ is called *additive* if it satisfies the property

$$f(x + y) = f(x) + f(y)$$

for all $x, y \in \mathbb{R}$. The function f is called $\mathbb{Q}$ -homogeneous if the equation $f(qx) = qf(x)$ is fulfilled by every $q \in \mathbb{Q}$ and $x \in \mathbb{R}$. As it is also well-known (**Error! Reference source not found.**, Theorem 5.2.1), if $f: \mathbb{R} \rightarrow \mathbb{R}$ is additive, then f is $\mathbb{Q}$ -homogeneous as well.

Among several problems in the theory of functional equations, J. Aczél posed a question originally raised by I. Halperin (**Error! Reference source not found.**): is every additive mapping $f: \mathbb{R} \rightarrow \mathbb{R}$, which satisfies

$$f\left(\frac{1}{x}\right) = \frac{1}{x^2} f(x)$$

for all $x \neq 0$, of the form $f(x) = f(1)x$ for all $x \in \mathbb{R}$ (i.e., linear)? Two independent affirmative answers to Halperin's question are due to (**Error! Reference source not found.**) and (**Error! Reference source not found.**). These results were extended in various directions by several authors (**Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**, Theorem 14.3.3 **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**).

Another related problem was proposed by W. Benz (**Error! Reference source not found.**). Suppose that $f: \mathbb{R} \rightarrow \mathbb{R}$ is an additive function satisfying $yf(x) = xf(y)$ for every $x, y \in \mathbb{R}$ such that $x^2 + y^2 = 1$. Does it imply that f is linear? Z. Boros and P. Erdei (**Error! Reference source not found.**) answered this question affirmatively, along with a similar one concerning derivations.

The cited papers investigate additive functions f that satisfy the additional equation $yf(x) = xf(y)$ under the condition $P(x, y) = 0$ for some fixed polynomial P of two variables. For some special polynomials P this assumption implies that f is linear. B. Ebanks (**Error! Reference source not found.**) generalizes the problem to a pair of additive functions f, g related by the functional equation $yf(x) = xg(y)$ for all points (x, y) on a specified curve.

The motivation for such studies is the possible representation of solutions to various functional equations in terms of additive functions. If the functional equation under consideration is derived from an axiomatic description of some mathematical models of applied mathematics, some additional algebraic conditions might be obtained from the same theory. In this case, it is an important question whether the additional condition implies the linearity of the additive function appearing in the above representation.

The solutions of a wide class of linear functional equations are generalized polynomials, which can be represented as the sum of generalized monomials. Therefore, it is appropriate to extend the above quoted investigations to generalized monomials, which can be considered as generalizations of additive functions.

Let $n \in \mathbb{N}$. A function $F: \mathbb{R}^n \rightarrow \mathbb{R}$ is called n -additive if, for every $i \in \{1, 2, \dots, n\}$ and for every $x_1, \dots, x_n, y_i \in \mathbb{R}$,

$$\begin{aligned} & F(x_1, \dots, x_{i-1}, x_i + y_i, x_{i+1}, \dots, x_n) \\ &= F(x_1, \dots, x_{i-1}, x_i, x_{i+1}, \dots, x_n) + F(x_1, \dots, x_{i-1}, y_i, x_{i+1}, \dots, x_n), \end{aligned}$$

i.e., F is additive in each of its variables $x_i \in \mathbb{R}$, $i = 1, \dots, n$. We call 1-additive functions simply additive, 2-additive functions biadditive. Clearly, an n -additive function is also $\mathbb{Q}$ -homogeneous in each variable.

Given a function $F: \mathbb{R}^n \rightarrow \mathbb{R}$, by the *diagonalization (or trace)* of F we understand the function $f: \mathbb{R} \rightarrow \mathbb{R}$ arising from F by putting all the variables (from $\mathbb{R}$) equal

$$(1.1) \quad f(x) = F(x, x, \dots, x) \quad (x \in \mathbb{R}).$$

If, in particular, f is the diagonalization of an n -additive function $F: \mathbb{R}^n \rightarrow \mathbb{R}$, we say that f is a *generalized monomial of degree n* . In such a case we obtain $f(rx) = r^n f(x)$ whenever $x \in \mathbb{R}$ and $r \in \mathbb{Q}$.

Generalized monomials of degree 3 are called *cubic* functions, *quadratic* functions are generalized monomials of degree 2. Further, additive functions are generalized monomials of degree 1 and non-zero constants are generalized monomials of degree 0.

Let F_s denote the symmetric part of $F: \mathbb{R}^n \rightarrow \mathbb{R}$, i.e.,

$$F_s(x_1, x_2, \dots, x_n) = \frac{1}{n!} \sum_{\sigma \in P_n} F(x_{\sigma(1)}, x_{\sigma(2)}, \dots, x_{\sigma(n)})$$

for every $(x_1, x_2, \dots, x_n) \in \mathbb{R}^n$, where P_n denotes the set of all permutations of the index set $\{1, 2, \dots, n\}$. Clearly, if f is defined by **Error! Reference source not found.**, then we have $f(x) = F_s(x, x, \dots, x)$ (for all $x \in \mathbb{R}$) as well. Moreover, if F is n -additive, then F_s is also n -additive. Therefore, if $f: \mathbb{R} \rightarrow \mathbb{R}$ is a generalized monomial of degree n , then there exists a symmetric n -additive function $F: \mathbb{R}^n \rightarrow \mathbb{R}$ such that **Error! Reference source not found.** holds. Furthermore, as it is also well known, in that case we have

$$(1.2) \quad \Delta_{h_1} \Delta_{h_2} \dots \Delta_{h_n} f(x) = n! F(h_1, h_2, \dots, h_n)$$

for every $x, h_1, h_2, \dots, h_n \in \mathbb{R}$, where $\Delta_y f(x) = f(x+y) - f(x)$ ($x, y \in \mathbb{R}$). This shows the uniqueness of F .

It is a consequence of the identity **Error! Reference source not found.** that any generalized monomial $f: \mathbb{R} \rightarrow \mathbb{R}$ of degree n satisfies the n -monomial functional equation

$$(1.3) \quad \Delta_y^n f(x) = n! f(y) \quad (x, y \in \mathbb{R}),$$

where Δ_y^n denotes the n -th iterate of the operation Δ_y . In fact (**Error! Reference source not found.** Chapter 15, **Error! Reference source not found.** Chapter 1), generalized monomials of degree n are characterized as the solutions of the n -monomial functional equation **Error! Reference source not found.**

Recently, Z. Boros and the present author formulated the following question for generalized monomial functions:

Let us consider a generalized monomial function f of degree n ($n \geq 2$), that satisfies the additional equation $y^n f(x) = x^n f(y)$ for each $(x, y) \in S$, where S is the graph of a certain planar curve. The question is whether it is true that f is continuous. Affirmative answers were given for various particular algebraic (or some specific transcendental) curves $S \subset \mathbb{R}^2$:

- $2 \leq n \in \mathbb{N}$ and S is given by $y = a_m x^m + a_{m-1} x^{m-1} + \dots + a_1 x + a_0$ with $m \in \mathbb{N}$, $a_i \in \mathbb{R}$, $i = 0, \dots, m$, $a_0 \neq 0$ (**Error! Reference source not found., Error! Reference source not found.**);
- $n \in \{2, 3\}$ and S is given by $y = x^m$ with $m \in \mathbb{Z}$, $|m| \geq 2$ (**Error! Reference source not found., Error! Reference source not found.**);
- $n = 2$ and S is given by $x^2 \pm y^2 = 1$ (two cases) (**Error! Reference source not found.**);

When S denotes the hyperbola given by the equation $xy = 1$, the authors obtain counterexamples for any $2 \leq n \in \mathbb{N}$. In (**Error! Reference source not found.**) the authors give necessary conditions for quadratic functions f that satisfy the additional equation $y^2 f(x) = x^2 f(y)$ under the condition $xy = 1$.

We shall also make use of the following observation.

Lemma 1.1. *If $\mathbb{F}$ is a field, $n \in \mathbb{N}$, X is an arbitrary set, $V \subset \mathbb{F}$ contains at least $n + 1$ elements, and the functions $H_k: X \rightarrow \mathbb{F}$ ($k = 0, 1, \dots, n$) satisfy the equation*

$$(1.4) \quad \sum_{k=0}^n H_k(x) r^k = 0$$

for every $x \in X$ and $r \in V$, then $H_k(x) = 0$ for every $x \in X$ and $k \in \{0, 1, \dots, n\}$.

In this paper, we shall apply Lemma 1 for $X = \mathbb{F} = \mathbb{R}$ and $V = \mathbb{Q}$.

We define the following sets:

$$S_1 = \{(x, y) \in \mathbb{R}^2 \mid x^3 - y^2 = 0\},$$

$$S_2 = \{(x, y) \in \mathbb{R}^2 \mid y = \sin x\},$$

$$S_3 = \{(x, y) \in \mathbb{R}^2 \mid y = \cos x\}.$$

2. Main results

We begin our investigation by the study of cubic functions that fulfill the additional condition $y^3 f(x) = x^3 f(y)$ whenever $y^2 = x^3$.

Theorem 2.1. *Let S_1 denote the set of all pairs (x, y) of real numbers that fulfil the condition $x^3 - y^2 = 0$. If $f: \mathbb{R} \rightarrow \mathbb{R}$ is a generalized monomial of degree 3 that satisfies the additional equation $y^3 f(x) = x^3 f(y)$ for the pairs $(x, y) \in S_1$, then $f(x) = x^3 f(1)$ for all $x \in \mathbb{R}$.*

Proof. The additional equation is

$$\pm x^{\frac{9}{2}} f(x) = x^3 f\left(\pm x^{\frac{3}{2}}\right), \quad \forall x \geq 0$$

Replacing x with x^2 in this equation and applying the rational homogeneity properties of f we obtain

$$x^9 f(x^2) = x^6 f(x^3), \quad \forall x \geq 0.$$

Dividing the latter equation by x^6 if $x \neq 0$ and taking $f(0) = 0$ into consideration as well, we obtain

$$(2.1) \quad x^3 f(x^2) = f(x^3).$$

Replacing x with $x + r$ for arbitrary $r \in \mathbb{Q}$ in equation **Error! Reference source not found.** we obtain

$$(2.2) \quad (x^3 + 3rx^2 + 3r^2x + r^3) f(x^2 + 2rx + r^2) = f(x^3 + 3rx^2 + 3r^2x + r^3).$$

We can associate with the generalized monomial f (of degree 3) a 3-additive and symmetric functional $F: \mathbb{R}^3 \rightarrow \mathbb{R}$ such that $f(x) = F(x, x, x)$ for every $x \in \mathbb{R}$. Thus, equation **Error! Reference source not found.** can be written in the form

$$(2.3) \quad (x^3 + 3rx^2 + 3r^2x + r^3)F(x^2 + 2rx + r^2, x^2 + 2rx + r^2, x^2 + 2rx + r^2) - F(x^3 + 3rx^2 + 3r^2x + r^3, x^3 + 3rx^2 + 3r^2x + r^3, x^3 + 3rx^2 + 3r^2x + r^3) = 0$$

On the left-hand side of equation **Error! Reference source not found.**, for each fixed $x \in \mathbb{R}$, with respect to the variable r , we obtain a polynomial (of degree at most 9) that equals zero for every $r \in \mathbb{Q}$. According to Lemma 1.1, each coefficient of this polynomial has to equal zero (for each $x \in \mathbb{R}$). For the coefficient of r^8 this observation yields

$$3xf(1) + 3F(2x, 1, 1) - 3F(3x, 1, 1) = 0,$$

i.e.

$$(2.4) \quad F(x, 1, 1) = xf(1)$$

for all $x \in \mathbb{R}$. The equality of the coefficient of r^7 to zero can be written as

$$3x^2f(1) + 9xF(2x, 1, 1) + 3F(x^2, 1, 1) + 3F(2x, 2x, 1) - 3F(3x, 3x, 1) - 3F(3x^2, 1, 1) = 0$$

Applying property **Error! Reference source not found.** and $F(x^2, 1, 1) = x^2f(1)$ that follows from **Error! Reference source not found.**, we have

$$3x^2f(1) + 18x^2f(1) + 3x^2f(1) + 12F(x, x, 1) - 27F(x, x, 1) - 9x^2f(1) = 0,$$

i.e.

$$(2.5) \quad F(x, x, 1) = x^2f(1).$$

The equality of the coefficient of r^6 to zero can be written as

$$x^2f(1) + 9x^2F(2x, 1, 1) + 9xF(x^2, 1, 1) + 9xF(2x, 2x, 1) + 6F(x^2, 2x, 1) + F(2x, 2x, 2x) - 3F(x^3, 1, 1) - 6F(3x^2, 3x, 1) - F(3x, 3x, 3x) = 0$$

Applying property **Error! Reference source not found.** and **Error! Reference source not found.**, we obtain

$$(2.6) \quad 61x^3f(1) - 19f(x) - 42F(x^2, x, 1) = 0.$$

Property **Error! Reference source not found.** implies that

$$F(x^2, x^2, 1) = x^4f(1).$$

Replacing x with $x + 1$ in the latter equation, we get

$$F(x^2 + 2x + 1, x^2 + 2x + 1, 1) = (x^4 + 4x^3 + 6x^2 + 4x + 1)f(1).$$

Due to the 3-additivity of F and properties **Error! Reference source not found.** and **Error! Reference source not found.**, we have

$$F(x^2, x, 1) = x^3f(1).$$

Substituting this in equation **Error! Reference source not found.**, we obtain $f(x) = x^3f(1)$ for all $x \in \mathbb{R}$. $\square$

We continue our investigation by examining quadratic functions that satisfy the additional equation involving trigonometric functions.

Theorem 2.2. Let S_2 denote the set of all pairs (x, y) of real numbers that fulfil the condition $y = \sin x$.

If the quadratic functions $f, g: \mathbb{R} \rightarrow \mathbb{R}$ satisfy the additional equation

$$y^2f(x) = x^2g(y)$$

for the pairs $(x, y) \in S_2$, then $f(x) = g(x) = x^2g(1)$ for all $x \in \mathbb{R}$.

Proof. The additional equation is

$$(2.7) \quad \sin^2 x \cdot f(x) = x^2g(\sin x), \quad \forall x \in \mathbb{R}.$$

Dividing this equation by $\sin^2 x$ if $\sin^2 x \neq 0$ ($f(0) = g(0) = 0$), we obtain

$$(2.8) \quad f(x) = \frac{x^2g(\sin x)}{\sin^2 x}.$$

Putting $2x$ in place of x in equation **Error! Reference source not found.**, we have

$$\sin^2(2x)f(2x) = (2x)^2g(\sin 2x).$$

Applying the identity $\sin 2x = 2\sin x \cos x$, we obtain

$$4\sin^2 x \cos^2 x \cdot 4f(x) = 4x^2 4g(\sin x \cos x).$$

Dividing the latter equation by 16, we get

$$(2.9) \quad \sin^2 x \cos^2 x f(x) = x^2 g(\sin x \cos x).$$

Dividing **Error! Reference source not found.** by $\sin^2 x \cos^2 x$ if $\sin^2 x \cos^2 x \neq 0$ ($g(0) = 0$), we have

$$(2.10) \quad f(x) = \frac{x^2 g(\sin x \cos x)}{\sin^2 x \cos^2 x}.$$

From the equality of the left sides of **Error! Reference source not found.** and **Error! Reference source not found.**, we obtain

$$\frac{x^2 g(\sin x)}{\sin^2 x} = \frac{x^2 g(\sin x \cos x)}{\sin^2 x \cos^2 x},$$

i.e.

$$\cos^2 x \cdot g(\sin x) = g(\sin x \cos x).$$

Now, applying the identity $\sin^2 x + \cos^2 x = 1$ that is $\sin x = \pm\sqrt{1 - \cos^2 x}$ and the rational homogeneity properties of g , we obtain

$$\cos^2 x \cdot g(\sqrt{1 - \cos^2 x}) = g(\sqrt{1 - \cos^2 x} \cdot \cos x).$$

Let $u = \cos x$. Thus

$$(2.11) \quad u^2 \cdot g(\sqrt{1 - u^2}) = g(u \cdot \sqrt{1 - u^2}), u \in [-1, 1].$$

Let $x = \sqrt{1 - u^2}$, thus $x^2 = 1 - u^2$, we observe $u^2 = 1 - x^2$, $u = \pm\sqrt{1 - x^2}$. Therefore

$$(2.12) \quad (1 - x^2) \cdot g(x) = g(x \cdot \sqrt{1 - x^2}).$$

From the equality of the right sides of **Error! Reference source not found.** and **Error! Reference source not found.**, we have

$$(1 - x^2) \cdot g(x) = x^2 \cdot g(\sqrt{1 - x^2}).$$

Therefore by Theorem 4.4 (**Error! Reference source not found.**) $g(x) = x^2 g(1)$. Substituting g in equation $y^2 f(x) = x^2 g(y)$, we get

$$f(x) = x^2 g(1). \quad \square$$

Theorem 2.3. Let S_3 denote the set of all pairs (x, y) of real numbers that fulfil the condition $y = \cos x$.

If the quadratic functions $f, g: \mathbb{R} \rightarrow \mathbb{R}$ satisfy the additional equation $y^2 f(x) = x^2 g(y)$ for the pairs $(x, y) \in S_3$, then $f(x) = g(x) = x^2 g(1)$ for all $x \in \mathbb{R}$.

Proof. The additional equation is

$$(2.13) \quad \cos^2 x \cdot f(x) = x^2 g(\cos x), \quad \forall x \in \mathbb{R}.$$

Dividing this equation by $\cos^2 x$ if $\cos^2 x \neq 0$ ($f(0) = g(0) = 0$), we obtain

$$(2.14) \quad f(x) = \frac{x^2 g(\cos x)}{\cos^2 x}.$$

Putting $2x$ in place of x in equation **Error! Reference source not found.** and applying the identity $\cos 2x = \cos^2 x - \sin^2 x$, i.e. $\cos 2x = 2\cos^2 x - 1$, we have

$$(2.15) \quad (2\cos^2 x - 1)^2 f(x) = x^2 g(2\cos^2 x - 1).$$

Dividing **Error! Reference source not found.** by $2\cos^2 x - 1$ if $\cos^2 x \neq \frac{1}{2}$, we get

$$(2.16) \quad f(x) = \frac{x^2 g(2\cos^2 x - 1)}{(2\cos^2 x - 1)^2}.$$

We can associate with the quadratic function g a biadditive and symmetric functional $G: \mathbb{R}^2 \rightarrow \mathbb{R}$ such that $g(x) = G(x, x)$ for every $x \in \mathbb{R}$. Thus, $g(2\cos^2 x - 1)$ can be written in the form

$$\begin{aligned} g(2\cos^2 x - 1) &= g(2\cos^2 x) + g(1) - 2G(2\cos^2 x, 1) \\ &= 4g(\cos^2 x) + g(1) - 4G(\cos^2 x, 1). \end{aligned}$$

Substituting this in equation **Error! Reference source not found.**, we have

$$(2.17) \quad f(x) = \frac{x^2 (4g(\cos^2 x) + g(1) - 4G(\cos^2 x, 1))}{(2\cos^2 x - 1)^2}.$$

From the equality of the left sides of **Error! Reference source not found.** and **Error! Reference source not found.**, we obtain

$$\frac{g(\cos x)}{\cos^2 x} = \frac{4g(\cos^2 x) + g(1) - 4G(\cos^2 x, 1)}{(2\cos^2 x - 1)^2}.$$

Let $t = \cos x$. Thus

$$\frac{g(t)}{t^2} = \frac{4g(t^2) + g(1) - 4G(t^2, 1)}{(2t^2 - 1)^2}.$$

From this we get

$$(4t^4 - 4t^2 + 1)g(t) = 4t^2 g(t^2) + t^2 g(1) - 4t^2 G(t^2, 1).$$

Therefore

$$(2.18) \quad g(t) - t^2 g(1) = -4t^4 g(t) + 4t^2 g(t) + 4t^2 g(t^2) - 4t^2 G(t^2, 1).$$

Putting $2x$ in place of x in equation **Error! Reference source not found.** then dividing the resulting equation by 4 we obtain

$$(2.19) \quad \begin{aligned} g(t) - t^2 g(1) &= \\ &= -4 \cdot 16t^4 g(t) + 16t^2 g(t) + 4 \cdot 16t^2 g(t^2) - 16t^2 G(t^2, 1). \end{aligned}$$

From the equality of the left sides of **Error! Reference source not found.** and **Error! Reference source not found.**, we get

$$\begin{aligned} -4t^4 g(t) + 4t^2 g(t) + 4t^2 g(t^2) - 4t^2 G(t^2, 1) \\ = -4 \cdot 16t^4 g(t) + 16t^2 g(t) + 4 \cdot 16t^2 g(t^2) - 16t^2 G(t^2, 1). \end{aligned}$$

Rearranging the latter equation and divide by $12t^2$ if $t \neq 0$, we get

$$5g(t^2) - 5t^2 g(t) = G(t^2, 1) - g(t)$$

Replacing t by $2t$ then dividing by 4 we obtain

$$20g(t^2) - 20t^2 g(t) = G(t^2, 1) - g(t).$$

From the last two equation we have $g(t^2) = t^2g(t)$ and $g(t) = G(t^2, 1)$.

Inserting this in equation **Error! Reference source not found.**, we obtain $G(t^2, 1) = t^2g(1)$.
Therefore $g(t) = t^2g(1)$.

Substituting this result in equation **Error! Reference source not found.**, we have $\cos^2 f(x) = x^2 \cos^2 x \cdot g(1)$,

so

$$f(x) = x^2 g(1). \quad \square$$

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Edit Garda-Mátyás
Department of Economic Sciences,
Sapientia Hungarian University of Transylvania, Miercurea Ciuc, Romania
gardamatyasedit@uni.sapientia.ro

THE RELATIONAL MODEL OF THE LIBRARY DATABASE

LÁSZLÓ ILLYÉS

Abstract

The library database has many of the characteristics of a relational model. We'll go through the design phase, looking at why it is not possible/desirable to remove redundancy completely, but solve it to keep our database consistent. We will use tag words to represent a tree structure and show how we manage borrowings. Existential redundancy will be defined in the paper and query optimization will also be addressed.

Keywords: relational model, tree structure, existential redundancy, query optimization

1. Introduction

The author has quite a lot of experience in the field of library applications. He wrote the first library program at Sapientia Faculty in Miercurea Ciuc, he created the database for it, it was in operation between 2001-2005. It included, in addition to uploading modules, a lending module, statistical reports and an online catalogue. What we present is a simplified model of a library application that does not comply with the requirements of the library's RAR, but can be used. The author obtained his basic knowledge from the book Ullman, Widrow [UW09].

First the structure of the whole database is presented, and then the implementation of the keyword tree structure is discussed. An important stage of this paper will be the introduction of the redundancies that are included in the system. One is a simple redundancy and the other is an *existential redundancy*, which we have not seen discussed anywhere. So we will define what an existential redundancy is. In the following, we will use triggers to solve the redundancy issue.

2. Material and Methods

The full structure of the database includes the following tables:

1. `daily_penalty` - contains the penalty interest calculated on the daily overdue amount, after the `due_date`. It is a number.
2. `books_data` - contains general information about the book, such as title, author(s), publisher, etc.
3. `tags` - contains tags that are in use at the library level, such as: computer science, databases, MySQL, Python, Java, literature, etc.
4. `library_users` - people who use the library, borrow books
5. `book_copies` - there are books that need to be in the library in multiple copies because more than one person wants to use them at the same time. This, in many cases, is of the student note type, of which there may be 5-10 copies. These are copies of the same `books_data` entry
6. `tags_for_books` - tags should be linked to `books_data`, as a tag can be related to more than one `books_data`, e.g. computer science is not just a subject word for one book, `books_data` can have multiple subject words, e.g. computer science and databases.
7. `tag_structure` - specifies the tree structure of the subject words
8. `borrowing_transactions` - borrowing transactions

Table populating is determined by *foreign keys*. *First-order populating* tables do not contain a foreign key.

The first table, *daily_penalty*, contains a single column and a single row, i.e. a scalar. This is good because when used in Descartes multiplication, it does not increase the dimension of the query and it is enough to store it in one place. It has no primary key too.

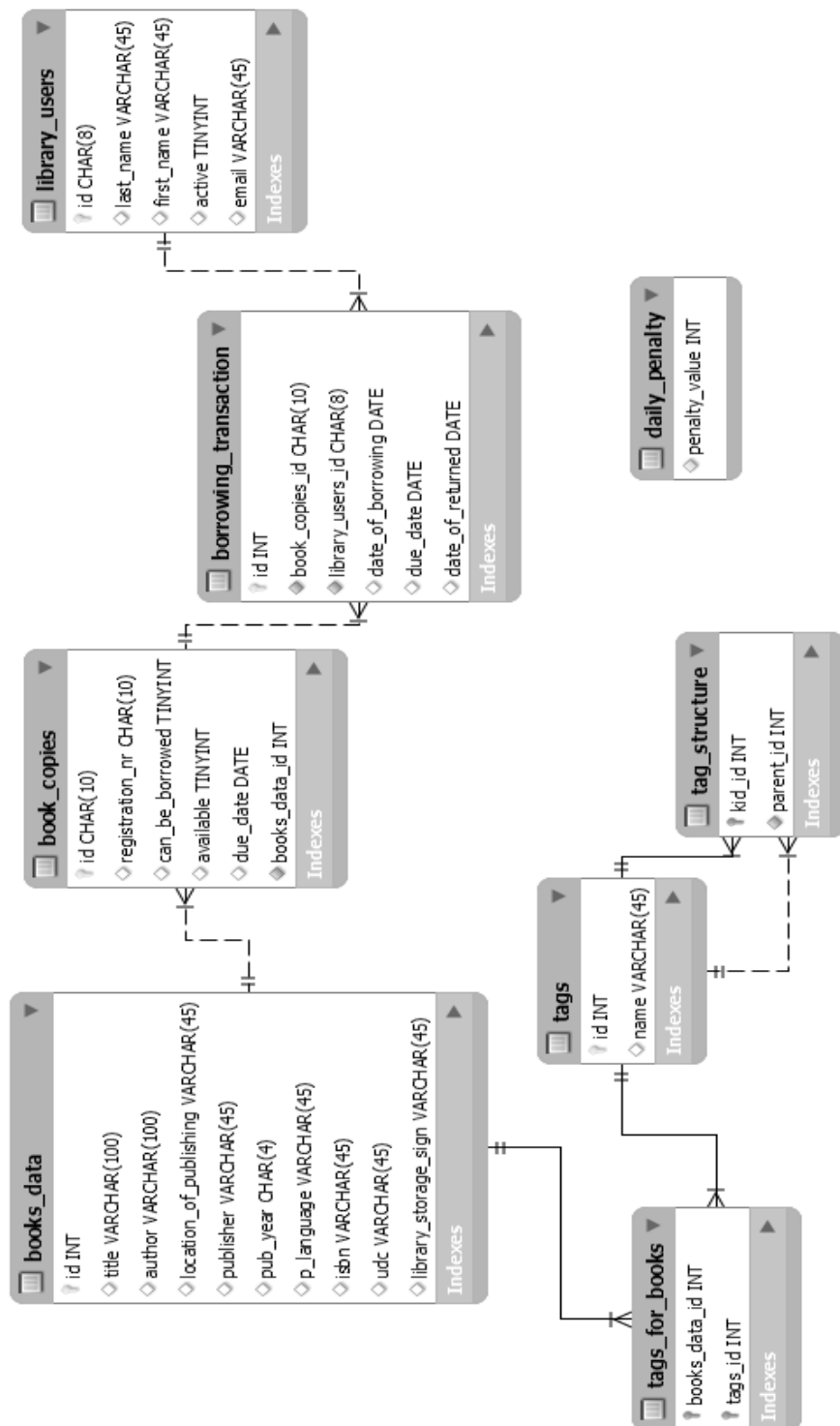
The *books_data*, *tags*, *library_users* tables do not contain a foreign key, so these tables can be loaded independently of the others. These are the *primary upload tables*.

The second-order fill tables rely solely on the first-order fill tables, these tables are:

tag_structure → *tags*

tags_for_books → (*tags*, *books_data*)

book_copies → *books_data*



1. Library database design created in MySQL Workbench.

Third-order load tables depends on at least one second-order load table. The only third-order transaction table is *borrowing_transaction*. It depends on one first-order transaction table and one second-order transaction table.

borrowing_transaction $\rightarrow$ (*library_users*, *book_copies*)

The structure of tags can be modeled in the following way:

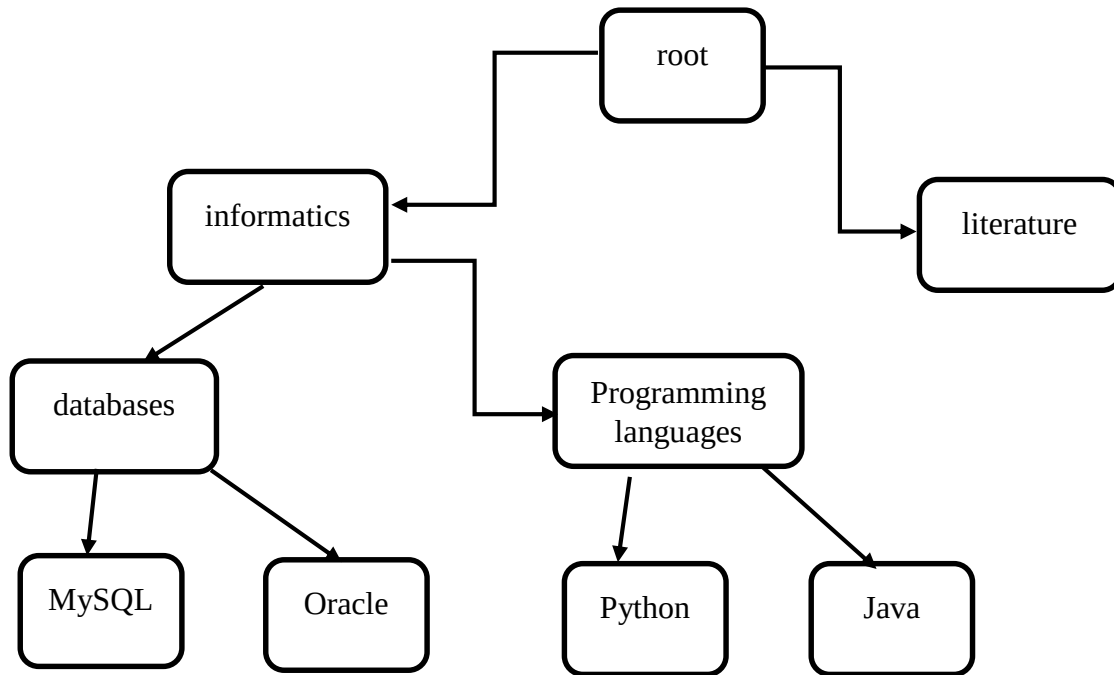


Fig. 2. A particular instance of tag_structure. Using Visual Paradigm Community Edition

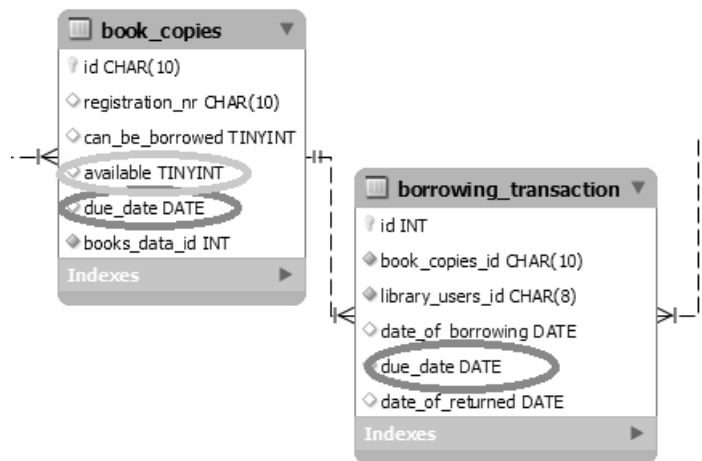
id	name
0	root
1	informatics
2	literature
3	databases
4	programming languages
5	MySQL
6	Oracle
7	Python
8	Java

kid_id	parent_id
0	null
1	0
2	0
3	1
4	1
5	3
6	3
7	4
8	4

Fig. 3. Possible encoding of tags and tag_structure.

3. Results and Discussion

Redundancies:



The due_date is a factual, normal redundancy. It exists in two tables.
The availability of the book is an existential redundancy.

	id	registration_nr	can_be_borrowed	available	due_date	books_data_id
▶	0040487	0040487	1	1	NULL	201
	10030309	0053037	1	0	2025-05-12	201
	10046442	0064102	1	1	NULL	201
*	NULL	NULL	NULL	NULL	NULL	NULL

	id	book_copies_id	library_users_id	date_of_borrowing	due_date	date_of_returned
▶	1	0040487	300101	2024-09-18	2025-01-16	2025-04-20
	2	10030309	300101	2025-01-05	2025-05-12	NULL
*	NULL	NULL	NULL	NULL	NULL	NULL

We define in this case the existential redundancy:

For the 0 availability of the 10030309 book copy *there exists a row* in borrowing transaction with the same code of the book with **null** value at the date_of_return ie. the book is out, not available.

Solving all the redundancy issues with triggers:

1. When somebody is borrowing a book

*/*The procedure called by the trigger*/*

DROP PROCEDURE IF EXISTS book_out;

delimiter \$\$

CREATE PROCEDURE book_out(IN p_book_copy_id CHAR(10),
IN p_due_date DATE)

BEGIN

UPDATE book_copies SET available=0,due_date=p_due_date
WHERE id=p_book_copy_id;

END\$\$

delimiter ;

*/*trigger*/*

DROP TRIGGER IF EXISTS borrowing_ins;

```

delimiter $$
CREATE TRIGGER borrowing_ins AFTER INSERT ON borrowing_transaction
FOR EACH ROW
BEGIN

    CALL book_out(NEW.book_copies_id,NEW.due_date);

END$$
delimiter ;

```

2. When we have an update on the borrowing_transaction we have 2 cases
 - a. We have an extension of the due_date with consent of the librarians
 - b. The borrowers returns the book.

```

/*return of book*/
DROP PROCEDURE IF EXISTS book_back;

delimiter $$
CREATE PROCEDURE book_back(IN p_book_copy_id CHAR(10),
IN p_due_date_NEW DATE,IN p_date_of_returned_N DATE)
BEGIN

    IF p_date_of_returned_N IS NOT NULL /*for true is a real return of book*/
    THEN
        UPDATE book_copies SET available=1, due_date=NULL
        WHERE id=p_book_copy_id;
    ELSE /* the update of the due_date */
        UPDATE book_copies SET due_date=p_due_date_NEW
        WHERE id=p_book_copy_id;
    END IF;

END$$
delimiter ;
/**/
DROP TRIGGER IF EXISTS borrowing_upd;

```

```

delimiter $$
CREATE TRIGGER borrowing_upd AFTER UPDATE ON borrowing_transaction
FOR EACH ROW
BEGIN
    CALL book_back(NEW.book_copies_id,NEW.due_date,
    NEW.date_of_returned);
END$$
delimiter ;

```

Addressing the optimization of the queries.

```

SELECT library_users.last_name,library_users.first_name, tags.name
FROM library_users INNER JOIN borrowing_transaction ON library_users.id=
borrowing_transaction.library_users_id INNER JOIN book_copies ON
borrowing_transaction.book_copies_id=book_copies.id INNER JOIN books_data ON

```

```
book_copies.books_data_id = books_data.id INNER JOIN tags_for_books ON  
books_data.id = tags_for_books.books_data_id INNER JOIN tags ON  
tags_for_books.tags_id = tags.id;
```

When we have a chain of tables with joins, we have to join all tables. But, when in a chain exists a table, that has no foreign key(s); his key is used as foreign keys in the other two connected table; we can make a shortcut and neglect that table. The bolded part of the query is not used, but we have to transform one equality to match the chained attributes. We neglect the table *books_data* from the query.

```
SELECT library_users.last_name,library_users.first_name, tags.name  
FROM library_users INNER JOIN borrowing_transaction ON library_users.id=  
borrowing_transaction.library_users_id INNER JOIN book_copies ON  
borrowing_transaction.book_copies_id=book_copies.id INNER JOIN tags_for_books ON  
book_copies.books_data_id = tags_for_books.books_data_id INNER JOIN tags ON  
tags_for_books.tags_id = tags.id;
```

4. Conclusion

We have created a simplified model of the library application, which is operational. Redundancy has been introduced for some specific reasons. We have two types of redundancy, one real and one existential. We have defined existential redundancy in our case. The redundancy got rid of a series of join queries for each instance of *book_copies*. However, the redundancy must be resolved on the back-end. We wrote two functions and two triggers that solve the redundancy part. Some selection stuff also needs to be handled on the front-end, which we didn't deal with in the procedures (e.g., eliminating the need to retrieve an outstanding book). We have dealt a bit with query optimization in the sense that there are times when a table can be omitted from the query.

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Author's adress

Department of Economic Sciences, Sapientia University, Piața Libertății nr. 1., Miercurea Ciuc (Csíkszereda), Romania
Email address: illyeslaszlo@uni.sapientia.ro

**INNOVATION, AGILITY, LEADING CHANGE IN THE TURBULENT 21ST CENTURY
— POSTER SECTION**

EXAMINING THE CONSCIOUS AND UNCONSCIOUS PRESENCE OF AGILITY AMONG HUNGARIAN UNIVERSITY STUDENTS

ISTVÁN MÁRK TÓTH

ABSTRACT

In today's customer-centric world of digitalisation, the ability to effectively manage change, flexibility and adaptability has become more important than ever for organisations and individuals. These qualities are expressed in one word: agility, by which more and more people identify the ability to apply an agile approach. This application can happen to some depth at a skill level, without learning, but we can be truly effective at being agile if we do it consciously, learning, practising and developing it. The main pillars of this agility were summarised in the Agile Manifesto, drafted by software developers in 2001, which has since become known worldwide and is now regarded as the source of agility. The aim of this research is to present the main results of a questionnaire survey of university students, future employees, to find out how they identify with the values of the Agile Manifesto.

Keywords: Agility, Agile approaches, Agile Manifesto, Hungarian students

1. INTRODUCTION

Although the agile approach has become well known in the field of software development, it is now used in many industries and research fields (Eilers - Peters - Leimeister, 2022). In fact, in the world of project management, it has become unavoidable (Varga - Csiszárík-Kocsir, 2019). The pioneers were the software developers who formulated the Agile Manifesto in 2001, which is now widely accepted as the basis for the agile approach worldwide. Its authors and first signatories identified four pillars and values: individuals and personal communication between them, working software, collaboration with the customer, and effective change management - which they considered more important than the methods and tools used, detailed documentation, contract negotiations, or adherence to plans (Beck et al., 2001).

Of course, agility is not just about taking this advice, and the path to agility and agile transformation can be a significant challenge (Denning, 2016). However, achieving the highest possible levels of customer satisfaction is a very important goal today (Varga, 2021), and it is worth taking on these challenges to achieve it.

The effective application of an agile approach requires a specific attitude on the part of individuals, teams and organisations, which is called agile mindset (Miller - Gaida, 2019). On the one hand, it can be said that agile mindset is essential for the effective and sustainable application of an agile approach (Senapathi - Srinivasan, 2013). On the other hand, the agile mindset of individuals is key to achieving agility at the organisational level (Van Manen - Van Vliet, 2014). However, the acquisition of this mindset is often a challenge in the transition to agility (Bider - Söderberg, 2016) and often not given adequate attention (Ryskowski, 2018).

For these reasons, it may be important to assess the conscious and unconscious presence of agility in individuals.

The aim of this research is to present the main results of a questionnaire survey on this topic among university students, prospective employees in the world of work.

2. MATERIAL AND METHOD

During the research, I wanted to investigate the extent to which the identification with agile values is typical for university students who are not yet familiar with the agile approach, i.e. they are not aware of its presence. I wanted to compare the results obtained in their case with the results of those who are somewhat familiar with, or at least roughly aware of, the agile approach.

The results described above were examined by means of a non-representative questionnaire survey. The questionnaire was pre-tested to ensure clarity and comprehensibility. The sample was taken from Hungarian university students in the spring of 2025.

A total of 164 students participated in the survey: their responses indicated that 111 (68%) had never heard of the approach or had heard of it but did not know what it meant; the number of respondents who had knowledge of it or even used it regularly was 53 (32%).

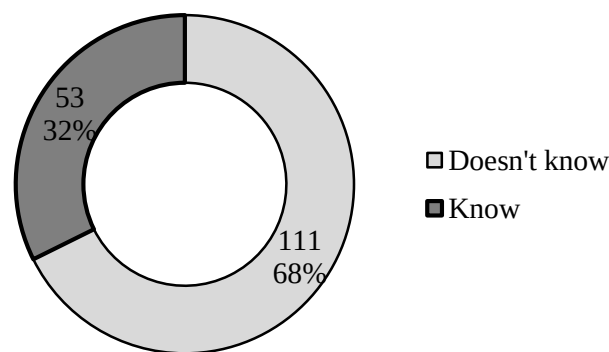


Figure 1. Distribution of research participants by knowledge of the agile approach
Source: Own research, 2025

Among the questions, I was particularly curious to know how the respondents felt about the elements contrasted in the Agile Manifesto. They were asked to express their position on a 6-point Likert scale, with two endpoints being a clear vote for one (A) or the other (B) of the comparison, and a transition between them. For quantification and averaging purposes, I have assigned numbers from -5 to 5, and the mapping is shown in Table 1.

Table 1. Scale used for the questionnaire

clearly A	rather A	slightly more A	slightly more B	rather B	clearly B
-5	-3	-1	1	3	5

Source: Own research, 2025

I examined the relative frequency of the responses, the average of the values assigned to the responses, and divided the 6-point scale into 3 groups (the two extreme responses, or one response close to one of the two extremes, are one group, and the middle two are "neutral").

3. RESULTS

3.1. The importance of individuals and interactions

A visualisation of the answers given for the choice between processes and tools used, and between individuals and face-to-face communication, revealed a shape resembling a Gaussian curve: the majority of respondents were clearly neither for nor against, and none of the six scales had more than 23% of responses concentrated on any one of them - this was true for those who were familiar with the agile approach as well as those who were not.

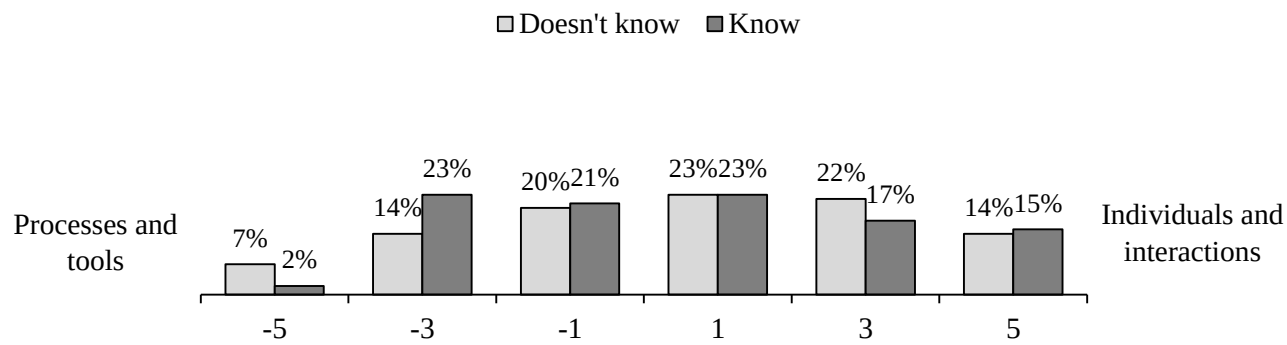


Figure 2. Processes and tools or Individuals and interactions: Relative frequency of responses received
Source: Own research, 2025

When the responses are broken down into 3 groups, it can be seen that overall, slightly more people voted for individuals and face-to-face communication than for processes and tools, but a significant proportion of respondents fall in the middle.

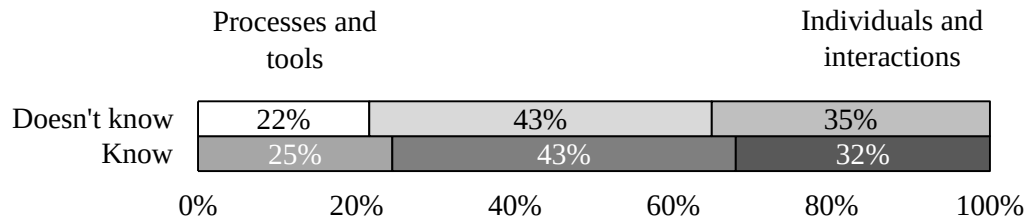


Figure 3. Processes and tools or Individuals and interactions: Relative frequency of clustered responses
Source: Own research, 2025

If we look at the averages of the values assigned to the responses received, the results are not surprising: there is a minimal bias towards individuals and interactions among those who are not familiar with the agile approach and those who are.

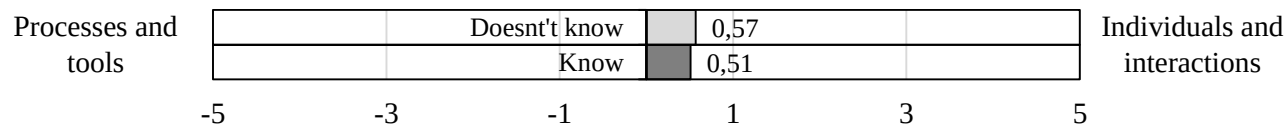


Figure 4. Processes and tools or Individuals and interactions: The averages
Source: Own research, 2025

3.2. The importance of customer collaboration

The choice between contract negotiation and cooperation with the customer also seems unclear, although there is a slight shift towards the latter.

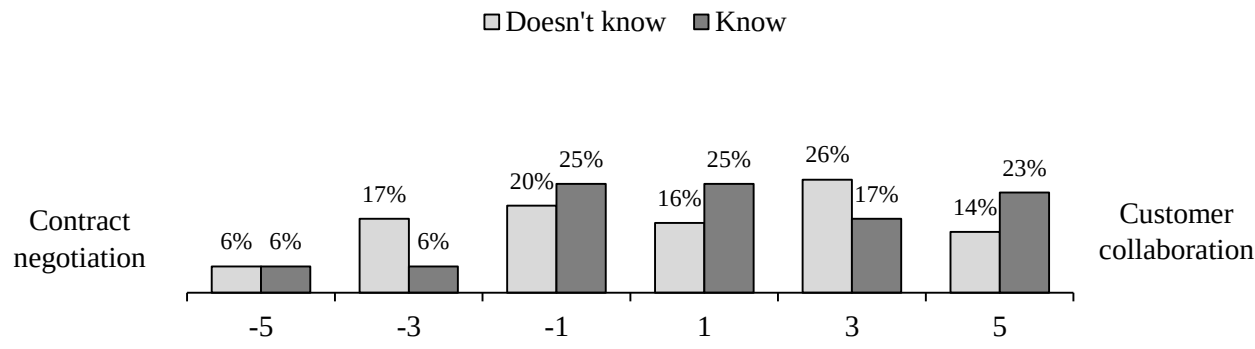


Figure 5. Contract negotiation or Customer collaboration: Relative frequency of responses received
Source: Own research, 2025

If we move away from the two values in the middle of the scale, there is a noticeable shift towards collaboration with the customer, especially among those who are familiar with the agile approach.

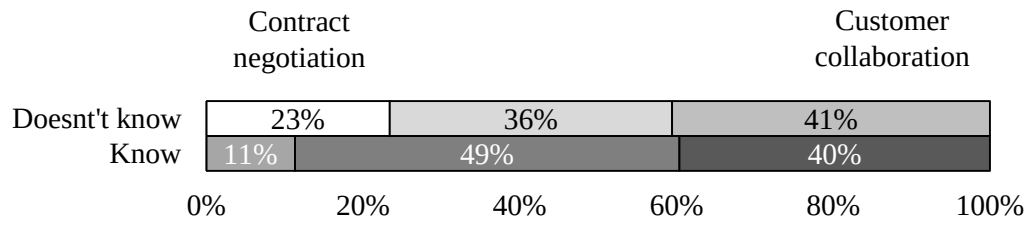


Figure 6. Contract negotiation or Customer collaboration: Relative frequency of clustered responses
Source: Own research, 2025

The average of the values assigned to the answers shows that, among the respondents, cooperation with the customer is more important than contract negotiation.

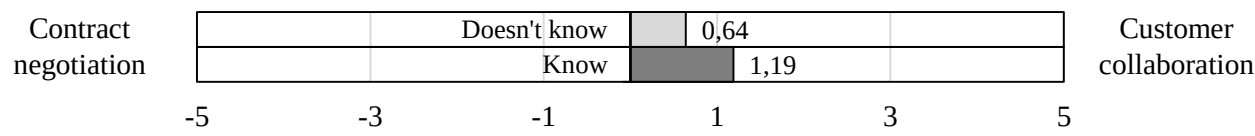


Figure 7. Contract negotiation or Customer collaboration: The averages
Source: Own research, 2025

3.3. The importance of responding to change

When asked about the importance of effective change management, the shift is even more striking: following plans to the letter was found to be stronger for only a few respondents.

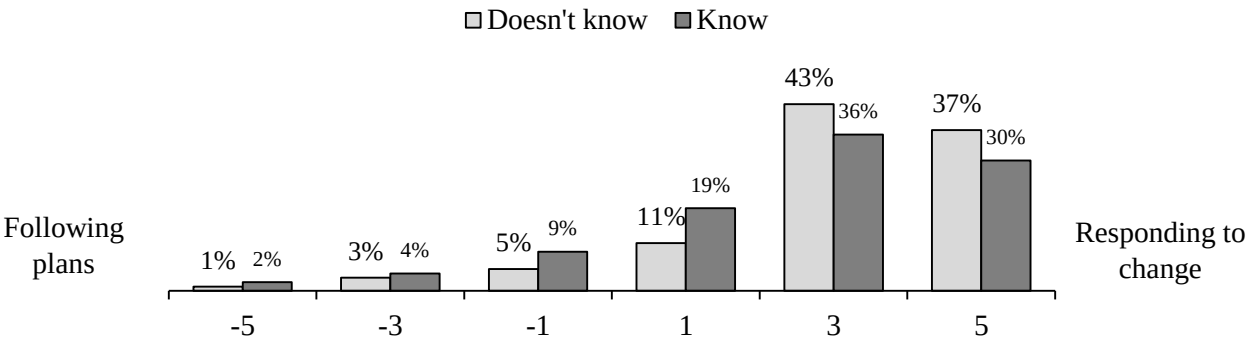


Figure 8. Following plans or Responding to change: Relative frequency of responses received
Source: Own research, 2025

When the responses are divided into 3 groups, it can be seen that the absolute majority of respondents consider effective change management to be more important, and there is minimal difference between those who know agile and those who do not.

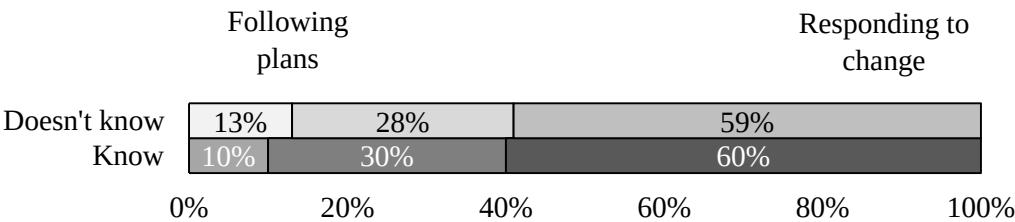


Figure 9. Following plans or Responding to change: Relative frequency of clustered responses
Source: Own research, 2025

This is also observed for averages.

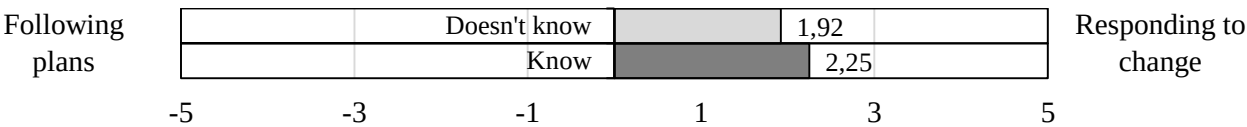


Figure 10. Following plans or Responding to change: The averages
Source: Own research, 2025

3.4. The importance of a working outcome

Since the Agile Manifesto was written by software developers, it is understandable that they specifically called attention to the importance of working software. In general terms, we can talk about a working outcome - and I wanted to assess the importance of this. As can be seen in Figure 11, there are already significant differences: the responses are significantly skewed towards the working outcome side.

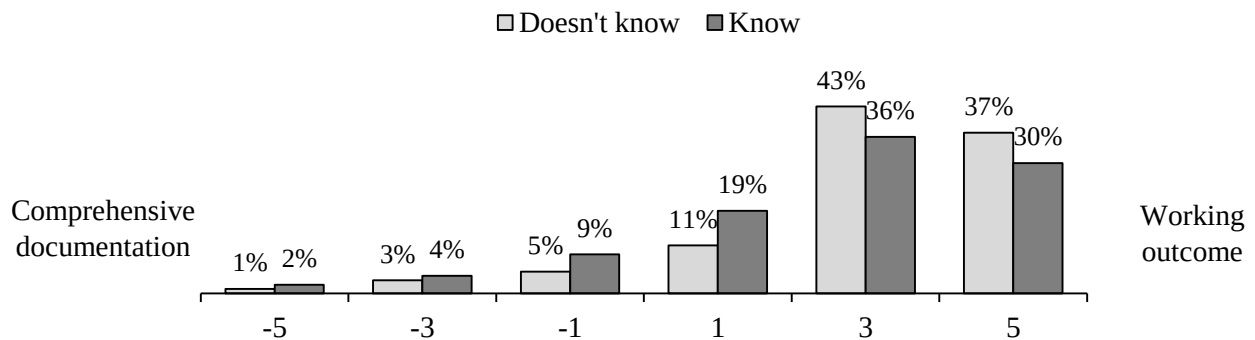


Figure 11. Comprehensive documentation or Working outcome: Relative frequency of responses received
Source: Own research, 2025

The grouping also produced spectacular results. What is perhaps most interesting is that among those who are not familiar with the agile approach, there is less hesitation and more support for a working outcome.

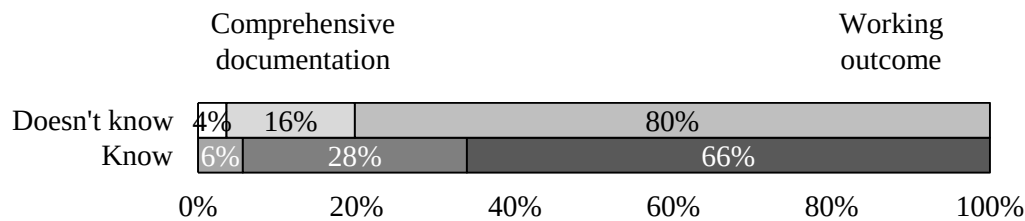


Figure 12. Comprehensive documentation or Working outcome: Relative frequency of clustered responses
Source: Own research, 2025

The averages of the values assigned to the responses also show that the importance of a working outcome is strong, and no less so for those who are not familiar with the agile approach.

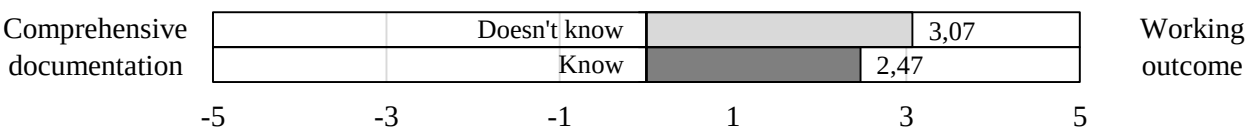


Figure 13. Comprehensive documentation or Working outcome: The averages
Source: Own research, 2025

4. CONCLUSIONS

Based on the responses received and their evaluation, I concluded that the values of the Agile Manifesto are generally present in the minds of the Hungarian university students surveyed: they clearly value good, working outcomes over detailed documents, and they prefer effective change management over following plans to the letter.

The other two values, personal communication (as opposed to methodologies and tools) and frequent consultation with the client (as opposed to contractual consultation), were less clearly held, but also not dismissed.

It seems that this is true not only for those who are familiar with the basics of the agile approach and consciously apply it, but also for those in general who are not yet familiar with this way of thinking, so that in their case we cannot speak of awareness.

Further statistical analysis is needed to investigate these differences in more detail, and it may be interesting to see how the current lack of awareness of agile thinking changes as respondents become more familiar with the subject.

In addition, as the survey is not representative, no general conclusions can be drawn, but it may provide some insights into the attitudes of future workers towards agile approaches and could also form the basis for a future, more extensive survey. In any case, I think that the results of this research could be useful for employees: it can be assumed that the majority are open to adopting an agile approach, and that many of them are not consciously aware of the basic principles of agile.

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THE ROLE OF CRITICAL INFRASTRUCTURE INDUSTRIES IN THE RESEARCH, DEVELOPMENT AND INNOVATION (RDI) ECOSYSTEM: AN EMPIRICAL ANALYSIS OF INNOVATION ACTIVITIES IN THE CI INDUSTRIES

OSZKAR DOBOS

ABSTRACT

This research investigates the role of critical infrastructure (CI) organisations in the research, development and innovation (RDI) ecosystem. Based on a quantitative analysis involving 287 organisations, the study investigates the extent to which organisations belonging to the CI industry are active in the field of RDI, and whether a correlation can be detected between belonging to the CI industry and perceptions of RDI project management factors. The results show that although critical infrastructure organisations have a significant presence (65%) in the innovation ecosystem, membership of the CI industry alone does not significantly influence perceptions of KPI project management factors. The research contributes to a better understanding of the relationship between critical infrastructure and innovation activity.

Keywords: critical infrastructure, R&D-innovation, project management, innovation ecosystem, empirical analysis

1. INTRODUCTION

Research, development and innovation (RDI) activities play a key role in maintaining and developing the competitiveness of modern economies. Critical Infrastructure (CI) industries, which provide the basic functioning of society and the economy, play a particularly important role in the innovation ecosystem. The aim of this research is to investigate the extent to which organisations belonging to the CI industries are active in the RDI ecosystem and to determine whether there is a correlation between belonging to the CI industry and perceptions of RDI project management factors.

The basic hypothesis of the research (H4) is that there is no significant effect on RDI project management factors if an organisation is from an AI industry. This hypothesis is based on the observation that the CI industries are highly diversified and cover a significant part of the market, thus forming a heterogeneous group.

The topicality of the research topic is that today the protection and development of critical infrastructure is a high priority for national security and economic reasons. The consequences of pandemic COVID-19, increasing cyber-attacks and climate change have highlighted the vulnerability of these systems and the importance of innovation in increasing their resilience.

2. LITERATURE SUMMARY

2.1 Concept and sectors of critical infrastructure

There is no clear, precise definition of critical infrastructure and it can vary from country to country. Critical infrastructure sectors are those whose assets, systems and networks are critical to society. Their collapse or even partial loss would seriously affect security, the economy, public health or any combination of these vital areas.

There are sixteen critical infrastructure sectors that form part of a complex, interconnected ecosystem [1]. These are:

Energy supply: the production, transport and distribution of electricity and natural gas; the production, transport and distribution of petroleum and petroleum products; the supply of heating by natural gas, fuel oil or district heating.

Nuclear reactors, nuclear materials and waste sector: includes nuclear power plants and nuclear materials and nuclear waste management. Nuclear power plants require special safety precautions.

Water management: water supply, where drinking water and surface water are a priority, but wastewater and its treatment are an issue to be addressed.

Agriculture and food supply: agriculture, food production and distribution, from farms to restaurants.

Health and sanitation sector: includes hospitals, clinics, laboratories, pharmaceuticals and health services. The Lisbon Treaty requires the European Union to "ensure a high level of human health protection" [2].

Other sectors include critical manufacturing, the dam sector, the defence industrial base sector, telecommunications, commercial facilities, transport systems [3], chemicals, financial services [4], government facilities, IT and security services.

2.2 The role of innovation in protecting critical infrastructure

Today's biggest challenges include dealing with the consequences of pandemics, increasing climate change, and the proliferation of cyber-attacks, which are spreading across multiple sectors and having a growing impact. The latter threaten all areas of critical infrastructure, can have a negative impact on energy supply, the food and drinking water supply chain, production, transport, and can disrupt the orderly functioning of political, economic and cultural-educational institutions.

2.2.1 Resilience to climate change

Adapting the built environment and our critical infrastructure is necessary to increase their resilience to climate change. The focus of resilience is to minimise disruption caused by extreme weather events and to quickly restore service to pre-disruption levels. Climate change poses a unique challenge, as it is characterised by short, medium and long time scales, predictable and unpredictable events, and slow and rapid events. Today's changing climate requires critical infrastructures to be resilient, modular and multi-faceted [6].

2.2.2 Cyber security and cyber attacks

Any cyber attack against critical infrastructure has the potential to compromise a nation's security, affect the economy, cause injury, disease, death and destruction. Advances in technology have increased the threat and opened new opportunities for cyber attackers to penetrate industrial control systems and other critical systems.

Examples of cyber-attacks: in May 2021, DarkSide ransomware attacked a major US oil pipeline operator, disrupting fuel supplies. In the same month, Conti launched an attack against healthcare provider Irish Health that affected patient care for months.

The integration of Information Technology (IT) and Operational Technology (OT), Software as a Service (SaaS), Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) solutions, and the emergence of the Internet of Things (IoT) all create new opportunities for adversaries [5].

2.2.3 Zero Trust architectures

Zero Trust Architectures protect you against the latest cyber threats. In today's digital age, more and more organisations are adopting Zero Trust security models. Trusted security architectures such as NIST SP 800-207 are designed specifically for today's era, meeting the requirements of hybrid IT environments and hybrid work models.

The Zero Trust approach protects modern operating environments by assuming everything; it assumes that no single identity is trusted, all must be authenticated and authorised, regardless of the location or network from which they are trying to enter [7].

2.2.4 Innovative solutions for modernising critical infrastructure

The most significant innovations in government require collaboration between different disciplines. In 2019, the US Department of Housing and Urban Development (HUD) created the Office of Innovation (OI) to enable innovation across data repositories.

The modernization of critical information infrastructure at HUD HQ includes 5G hybrid fiber/wireless network architecture and software-defined network technologies that is technically and financially feasible and would result in annual savings of more than \$73 million (+20%) on top of a project cost of \$289 million [7].

3. MATERIAL AND METHOD

3.1 Research approach and design

The research uses a quantitative approach based on a standardised, pre-tested questionnaire. The research design is a cross-sectional study, which captures the views and practices of the organisations surveyed on their RDI activities at a given point in time.

3.2 Data collection and sampling

The questionnaire pays particular attention to the findings and recommendations of the literature and the expectations of the Oslo Manual. The questionnaire meets international requirements in terms of both content and format, while at the same time incorporating national specificities, as allowed by EU legislation. [8]

The questionnaire was developed using online targeting software and was available to respondents through this tool. The questionnaire was distributed through online channels, mainly in the form of email.

Sampling data:

- Organisations contacted: 4300+
- Number of respondents: 318
- Purified sample: 287 organisations
- Response rate: 7.4%

3.3 Measurement scales and variables

The questionnaire used nominal and proportional scales to measure respondents' opinions, attitudes and attitudes towards RDI in relation to the questions asked in each module. The distribution of the sample by industry can be broadly divided into three categories:

- **Critical Infrastructure Sectors:** based on the industry breakdown by disaster management
- **Academic sector:** higher education and research institutions
- **Other sectors:** organisations not included in the above categories

3.4 Statistical analysis methods

The data collected were analysed using a variety of statistical methods, which are essential in quantitative research. The following methods were used in the data processing:

- **Descriptive statistics:** frequency distributions, means, standard deviations
- **Analysis of variance (ANOVA):** testing differences between groups

In the analysis, particular attention was paid to between-group variance and significance, which were assessed using the F-value and p-value. The significance level was set at $p < 0.05$.

4. Results

4.1 Sample characteristics

The research covers a wide range of critical infrastructure industries, which together account for the majority of the organisations participating in the research, i.e. more than 65%. This proportion is a significant indication of the presence of critical infrastructure organisations in the innovation ecosystem.

Sector	Number of organisations	Share (%)
Critical infrastructure sectors	187	65,2
Academic sector	57	19,9
Other sectors	43	14,9

The prominent role of the academic sector remains key in driving innovation and scientific research, accounting for nearly 20%, and other industry players have also been involved in a notable share of research. The share of participation in different industries provides important insights into national research and development priorities.

4.2 Critical infrastructure organisations' perception of RDI activity

The distribution of the sample in this research supports the role of CI in the innovation ecosystem. The CI is a quasi-horizontal logical group, i.e. the organisations belonging to the CI can fall into any of the categories analysed, based on their size, core activities and RDI experience. Therefore, we have examined the variety of organisations in the CI, whether they have an impact on the perception of RDI activities, i.e. whether any correlation can be detected between them.

4.3 Analysis of variance results

The analysis was performed using One-Way ANOVA, looking for significance values below 0.05 for any of the KFI-related statements. In total, 15 different KFI project management factors were analysed.

The analysis clearly shows that there is no significant effect on the perception of any of the statements if the organisations belong to the CI. The results of the analysis of variance show that the p-value for all the factors tested is above the 0.05 level of significance, which means that there is no clear correlation between the perception of the claims and the classification of the CI.

Claim	F	Sig.	Claim	F	Sig.	Claim	F	Sig.
RDI is an integral part of the strategy.	0,059	0,942	The organisation is involved in RDI projects.	0,007	0,993	There is a place for RDI projects in the organisational strategy.	0,722	0,487
Your organisation uses intellectual property protection (e.g. legal protection, licensing, etc.).	0,882	0,415	The organisation runs RDI projects.	0,067	0,935	RDI projects are more effective when they are carried out in consortia with research organisations (universities, research institutes).	0,805	0,448
The origin of innovation in the organisation is internal (own research, development).	0,508	0,602	The organisation launches RDI projects on its own.	0,720	0,488	RDI projects are more effective when research organisations (universities, research institutes) are suppliers to the project.	0,898	0,409
The origin of innovation in the organisation is external (asset/licence purchase/rental, use of consultants).	0,003	0,997	Formal project management is sufficient to achieve RDI project results.	0,338	0,713	RDI projects are more effective when implemented in consortia with market organisations (professional organisation, subcontractor, client, other company).	0,332	0,718
In the organisation, innovation is business process innovation (business, marketing or organisational development).	0,245	0,783	RDI activities can be carried out without project management.	0,115	0,891	RDI projects are more effective when market organisations (professional organisation, client, other company) are subcontractors in the project.	1,743	0,177
Innovation in the organisation is product innovation (product and/or service development).	2,404	0,092	The organisation has formal RDI project management (which is specifically tailored to RDI projects).	0,701	0,497	An important success factor of the RDI project is the usability of the results.	0,201	0,818
The organisation uses internal financial resources to finance innovation.	1,532	0,218	Researchers and technicians should lead the RDI projects.	1,616	0,201	An important success factor of the RDI project is the sustainability of the results.	0,981	0,376
Your organisation uses external financial resources to finance innovation.	0,063	0,939	[RDI results are better if there is formal RDI project management within the organisation.	1,500	0,225	[KFI projects are less effective than general projects.	1,610	0,202

Table 1: Main results of the analysis of variance (selected factors)

4.4 Interpreting the results

Interpreting the results, it can be concluded that the KI classification alone does not influence the perception of the organisations' RDI activities. In our opinion, this is clearly due to the fact that the organisations in the sample can be categorised and grouped in several ways.

While the other groupings (size, experience, core activity) describe the main parameters of the organisation that affect its operations and strategy, CI is a functional, legal category, developed along complex national security governance principles. There is a high degree of intersection between

categories based on the main parameters of organisations and CI as a logical grouping developed independently of the organisations' operations.

Therefore, the little or no relationship between the claims and the CI grouping was to be expected. This finding confirms the research hypothesis that there is no effect on KFI project management factors when the organization is from an CI industry.

5. CONCLUSIONS

5.1 Main research findings

The aim of the research was to examine RDI activity through critical infrastructure. In particular, we were interested in the level of participation of organisations in the RDI industries in the innovation ecosystem. By working through the definition of KI, and learning about the KI industries, we hypothesised that they would have a strong coverage in the innovation ecosystem.

This assumption is confirmed in practice by the distribution of the sample by industry, with 65.2% of AI industry participation. Our hypothesis is also supported by the fact that the sample is based on the network of contacts between the NRDI and the NIÜ, which naturally attracts innovative organisations.

5.2 Proving the hypothesis

The hypothesis of the research objective was also confirmed on the basis of the above: there is no significant effect of belonging to the KI industry on the perception of any of the RDI-related statements. The results of the analysis of variance clearly support this finding, as the p-value for all the factors tested is above the 0.05 significance level.

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e-mail: dobos.oszkar@uni-obuda.hu

FOOD INDUSTRY AS AN IMPORTANT PART OF CRITICAL INFRASTRUCTURE

ANITA PLÖTZ - JÁNOS VARGA

ABSTRACT

The food industry is a key element of critical infrastructure, as it has a direct impact on the functioning of society, the stability of the economy and the well-being of the population. The safety and sustainability of food supply chains have received particular attention in recent years, especially in the wake of global crises such as the COVID-19 epidemic. The aim of this study is to explore the vulnerabilities and risks in food supply chains and to present technological innovations that contribute to a safer and more sustainable food industry. The literature review will analyse the role of critical infrastructure in food security, the impact of crises such as epidemics, natural disasters and geopolitical conflicts on supply chains, and recent industry developments and regulatory measures. The study pays particular attention to sustainability issues, alternative protein sources, digitalisation and smart food logistics solutions. The findings show that the future of the food industry is closely linked to supply chain flexibility, technological advances and the integration of sustainability considerations. Collaboration between industry stakeholders - governments, businesses and consumers - is key to maintaining long-term food security and economic stability.

Keywords: food industry, critical infrastructure, food safety, supply chain

1. INTRODUCTION

The term critical infrastructure refers to systems, services and facilities whose operation is essential for the smooth running of a society, the economy and daily life. This includes, but is not limited to, energy supply, transport networks, water supply, information systems and, not least, the food industry. The key role of the food industry, in addition to providing human nutrition, is that it is essential for the health of individuals, the stability of society and the functioning of economic processes (Felice et al., 2022).

The modern food supply chain is a highly complex system that includes the production, processing, packaging, transport and distribution of raw materials. The actors in the supply chain, from producers to consumers, are closely interlinked, so that in the event of any disruption or crisis, food safety may be at risk. Global market trends, the Covid-19 pandemic, technological developments, climate change and geopolitical conflicts can all affect food supply as the other industries (Pató et al., 2020; Pató et al., 2022). Recognising and managing risks is key to ensuring that food sources are always available and safe for the population (Haessner et al., 2024).

The protection and sustainable operation of the food industry, which is part of critical infrastructure, has become a central issue in recent years. The COVID-19 outbreak worldwide has highlighted how vulnerable food supply systems can be to unexpected crises. The combination of supply chain disruptions, labour shortages and logistical difficulties has forced governments, companies and experts to rethink current supply strategies. Over the past decade, there has been an increasing focus on developing sustainable and resilient food supply systems that can respond to these challenges through the use of digitalization, automation and innovative technologies (Orengo-Sanchez-Jauregui, 2021).

The aim of this paper is to describe the role of the food industry within critical infrastructure, to explore its vulnerabilities and to highlight strategies and innovations that can help strengthen this

vital sector. Understanding the challenges we face and developing appropriate responses is essential to ensure that the food industry can continue to provide a secure and stable supply to societies in the long term.

2. LITERATURE REVIEW

The chapter reviews the main literature sources on the safety and sustainability of the food supply. First, the relationship between critical infrastructure and food security is analysed, followed by a focus on the food security context and the vulnerabilities and risks in the food supply chain. The impact of COVID-19 and other crises on the food supply will then be presented, as well as important technological innovations emerging in the food industry. Finally, sustainability and future prospects will be analysed, with a particular focus on the challenges and opportunities facing the industry.

Critical infrastructure and food security

The relationship between critical infrastructure and food security is a crucial issue in the functioning of modern societies, as food supply is not only an economic issue but also a fundamental factor of social stability. Critical infrastructures are the basic systems without which the functioning of a country can be seriously compromised. These infrastructures include energy, transport, health, water, financial services and, of course, food production and distribution. And food security means that food is available to all in sufficient quantity, quality and safety. Ensuring this is a complex and global task, in which public regulation, economic actors and international organisations all play a crucial role (Choi et al., 2023).

Modern food supply chains are highly complex and based on systems that span several continents. Production, processing, storage, and logistics are all critical points that, if compromised, can cause the whole system to collapse. A natural disaster, such as drought or floods, can devastate agricultural production, leading to food shortages and price rises. Likewise, a cyber-attack that paralyses a large food processing plant or a logistics centre, for example, can also cause severe disruptions in the supply chain. The food industry and trade networks are also heavily dependent on transport and transport infrastructure. If a transport system, such as a rail network or a port, becomes inoperable, access to imported and exported food is at risk (Munuhwa-Sibanda, 2024).

The interactions between critical infrastructures make the protection of food security not only an agricultural or health issue, but also a priority for national security. Providing food to a country's population is a fundamental social stability issue. At many times in history, food shortages have led to social unrest or even political collapse. In the modern world, such a crisis may not only be a problem at the local level, but may also have global implications, as a significant proportion of food is delivered to consumers through international trade networks (Makhanova et al., 2024).

The relationship between critical infrastructure and food security is further complicated by the role of climate change and sustainability issues. Increasingly frequent extreme weather events such as heat waves, storms and droughts are making agricultural production increasingly unpredictable. As a result, food supply systems are becoming more vulnerable and it is becoming increasingly challenging to maintain security of supply. While industrialised agricultural production can produce significant quantities of food, it is putting increasing pressure on the environment and is becoming more vulnerable to risks such as soil depletion, water scarcity and biodiversity loss (Qazi-Al-Mhdawi, 2024).

Digitalisation and innovation are playing an increasingly important role in food security and the protection of critical infrastructure. Automated systems, intelligent logistics solutions and supply chain management driven by artificial intelligence can significantly increase efficiency, reduce losses

and enable rapid response to unexpected events. At the same time, these new technologies also bring new types of risks. In parallel with digitalisation, the threat of cyber-attacks, which could even disrupt food supply chains, is increasing. It is therefore crucial for food companies and government agencies to implement appropriate cybersecurity measures and continuously improve the resilience of their supply chains. International cooperation and regulatory frameworks also play a crucial role in maintaining food security. There are different regulations and food safety standards in different parts of the world, and harmonisation is essential for global trade (Zheng et al., 2025).

For example, the European Union has very strict food safety standards to protect consumer health and guarantee food quality. However, food adulteration, the spread of contamination or inadequately controlled imported goods continue to pose significant risks. Addressing such problems requires cooperation at the international level, with countries working together to develop control mechanisms, rapid alert systems and crisis management strategies (Tankosić, 2022).

Protecting critical infrastructure and maintaining food safety is therefore a complex and multi-level task. In the future, it is expected that even more emphasis will be placed on increasing the resilience of food supply systems, developing alternative agricultural practices and mainstreaming sustainability. In order to maintain food security, it is essential to support local production, promote decentralised supply models and use technologies that reduce food waste and use resources more efficiently. The protection of food supply and critical infrastructure is thus not only an economic and political issue, but also a long-term strategic objective to ensure the well-being of future generations (Yusof et al., 2023).

Food supply chain vulnerabilities and risks

The vulnerabilities and risks of the food supply chain pose complex and multifaceted challenges for modern societies. The food supply chain encompasses all processes from the production of food to its delivery to consumers, including agricultural production, processing, transport, storage and distribution. As these systems are globally interconnected and highly interdependent, a number of factors can pose potential risks and vulnerabilities that can lead to supply disruptions or quality problems (Azizsafaei et al., 2021).

One of the most significant risk factors is the impact of natural disasters and climate change. Droughts, floods, storms and heat waves are becoming more frequent and have a significant impact on agricultural production. Climate change is reducing yields in some regions and making production more unpredictable in others due to extreme weather. Changes in rainfall distribution and soil degradation could threaten food supplies in the long term, while growing populations will create an increasing demand for agricultural products (Oriekhoe et al., 2024). Economic and market factors also pose significant risks. The globalisation of supply chains has made food companies and consumers alike dependent on international trade. Volatile market prices, geopolitical tensions and trade wars can affect the availability of raw materials and finished products. For example, if a key cereal-producing country imposes export restrictions, this could lead to global food shortages and price rises. Increases in transport costs, energy crises and inflation also affect food prices, which can adversely affect vulnerable groups in society in particular (Krstić et al., 2023).

The functioning of logistics and transport systems is also key to food security. Transport and supply chain infrastructure is exposed to a number of threats, including congestion in transport networks, container shortages, port congestion and rising fuel prices. The COVID-19 pandemic highlighted how vulnerable global supply chains can be to sudden disruptions. During the epidemic, food imports and exports were disrupted in many countries and production capacity was reduced due to labour shortages. These problems caused major disruptions in international supply chains, the consequences of which are still being felt in the long term (Yanginlar et al., 2023).

Biological and health risks also threaten food security. Food safety scandals, such as contaminated products or food adulteration, can cause serious public health problems and undermine consumer confidence in food companies and regulators. Diseases in livestock, such as avian influenza or African swine fever, can cause significant losses to the industry and drastically reduce the supply of these products on the market. The spread of antibiotic-resistant bacteria is also a growing threat, which may have long-term implications for food safety and human health (Chen et al., 2021).

Cyber-attacks and IT threats also pose increasing risks to food supply chains. Food companies and logistics systems are increasingly digitised, allowing for more efficient operations but also increasing vulnerability. A targeted cyber attack on a large logistics centre or food processing plant could cause severe disruptions to supply. Data theft and system downtime can even threaten the food supply of entire countries, and cyber security should therefore be a high priority for food industry stakeholders (Adewusi et al., 2022).

More and more companies and governments are adopting risk management strategies to reduce risks in the food supply chain. Diversification of the supply chain, support for local production and the promotion of alternative farming methods (e.g. vertical farms, hydroponics) can all contribute to increasing food security. In addition, advanced technologies such as artificial intelligence and blockchain-based tracking systems can help to increase supply chain transparency and reduce abuses (Singh-Dwivedi, 2024).

Collaboration between government and business actors is essential to ensure the stability of global and local food supply systems. The uptake of sustainable agricultural practices, reduction of food waste and the use of innovative solutions can all be key factors in increasing the resilience of supply chains. In the future, food supply security will become increasingly challenging, especially in the light of climate change, geopolitical tensions and technological advances, and preventive measures and long-term strategic planning are essential to maintain the stability of supply chains (Díez et al., 2021).

3. RESULTS

Global food supply chains have been through a number of crises in recent decades, of which pandemic COVID-19 was a major one. However, in addition to the pandemic, other crises such as geopolitical conflicts, economic recessions, natural disasters and climate change impacts have also posed significant challenges to food systems. These crises have highlighted the vulnerabilities of supply chains while accelerating industry transformation and innovation. Global food supply chains were severely disrupted by the COVID-19 outbreak in 2020. Restrictive measures, supply chain disruptions and labour shortages have had an impact in many areas (Barman et al., 2021).

Closures, border closures and restrictions on international trade have made the transport and distribution of food more difficult. Container shortages and port congestion in global transport have led to significant delays and cost increases. As a result, the price of some staple foods such as cereals, meat and dairy products has risen, while supply shortages have developed in some regions (Thompson, 2021).

Stringent restrictions imposed to contain the spread of the epidemic have reduced the number of workers in agriculture and manufacturing. In particular, sectors that rely on seasonal labour, such as fruit and vegetable production and the meat industry, have suffered severe labour shortages, leading to higher prices and a decline in production. During the COVID-19 crisis, consumers began to hoard staple foods en masse, leading to short-term demand shocks. In addition, the significant decline in out-of-home dining and the rise of e-commerce have created new challenges for food retailers. The

surge in online grocery shopping has prompted companies to improve their logistics systems and digitise their sales processes (Aday-Aday, 2020).

The pandemic-induced economic instability, supply chain bottlenecks and energy crisis have contributed to the global rise in food prices. Increases in commodity and transport costs have placed a particularly heavy burden on low-income households, which are more vulnerable to changes in food prices (Chanerides et al., 2020).

In addition to the pandemic, other global crises have also affected food supply chains. War situations, such as the conflict between Russia and Ukraine, have had a significant impact on global food markets. Ukraine and Russia are two of the largest grain producing regions in the world, so their reduced export capacity as a result of the war has led to a global food crisis. Russian sanctions and rising prices of agricultural inputs such as fertilisers have further increased food insecurity (Dyson et al., 2023).

Extreme weather events such as droughts, floods, heat waves and forest fires cause significant damage to agricultural production. Increasingly frequent and intense natural disasters due to climate change reduce crop yields and make supply chains insecure. Extreme weather is a particular challenge in developing countries, where agricultural infrastructure is less developed and adaptation options are limited. In the long term, climate change may also lead to a geographical shift in food production, creating additional risks for supply chains (Tchoukouang et al., 2024). Economic recessions and inflationary crises have a significant impact on food supply chains, as falling demand and rising production costs create imbalances. Inflation, in particular, makes food production and distribution more expensive through increases in energy prices and transport costs (Hobbs-Hadachek, 2024).

COVID-19 and other crises have highlighted the need for food supply chains to become more resilient and resilient to future challenges. In this context, some key lessons and strategies can be identified, which include, but are not limited to:

1. Supply chain diversification - Supporting regional and local food production can reduce risks, rather than over-centralised and globalised supply chains.
2. Digitalisation and data-driven decision making - Smart logistics systems, blockchain technology and predictive analytics can help improve the efficiency of food supply.
3. Workforce automation - The use of robotisation and artificial intelligence can reduce the problems caused by labour shortages.
4. Circular economy and sustainable agriculture - The introduction of waste reduction and sustainable production practices can mitigate the effects of climate change and crises.
5. Increasing reserves and emergency stocks - Countries and companies need longer-term stockpiling strategies to deal with unexpected events.

Overall, the impact of COVID-19 and other crises is transforming food supply systems, with an increasing emphasis on resilience, sustainability and innovation (Boratynska, 2024).

The food industry and technological innovation

The food industry is one of the fastest growing sectors, constantly adapting to changing consumer demands, sustainability requirements and global challenges. Technological innovation plays a key role in increasing the industry's competitiveness, improving food safety and enhancing the efficiency of supply chains. New solutions are not only revolutionising production and processing processes, but also bringing new dimensions to the storage, transport and consumption of products (Castillo-Vergara et al., 2021).

Automated systems and robotics are playing an increasing role in food processing plants. Smart production lines enable faster, more precise and cost-effective production, while reducing the need for human labour. Automated packaging systems, robotic arms and autonomous logistics solutions minimise waste, optimise productivity and increase worker safety (Panigrahi et al., 2024). For example, artificial intelligence (AI)-enabled systems can detect product defects, monitor quality and automatically correct production processes. AI-enabled data processing helps forecasting and inventory management, reducing unnecessary food waste and supply chain disruptions (Nikola-Alexieva, 2024).

The food industry is constantly looking for technologies that can extend the shelf life of products without the need for harmful additives. One such innovation is ultra-high pressure processing (HPP), which acts as an alternative to heat treatment and preserves the original taste, texture and nutritional value of food while killing pathogens (Nabi et al., 2021).

Another major advance is pulsed electric field (PEF) technology, which helps disrupt cell walls, making the pasteurisation of food or even the production of plant-based milk replacers more efficient. These processes not only improve food safety, but also make production processes more sustainable (Munshi, 2024). 3D printing technologies have emerged in the food industry, enabling the creation of food with specific shapes and textures. These solutions can be particularly important for people on special diets, such as the elderly or those with swallowing difficulties. 3D printing could also revolutionise the production of customised meals in the future (Shah et al., 2024).

Sustainability is one of the biggest challenges for the food industry and technological innovations play an important role in developing environmentally friendly solutions. Alternative protein sources, such as laboratory-produced meat (cultured meat), algae and insect proteins, are gaining attention as they can reduce the environmental burden of animal production and contribute to food security (Rui-Sundram, 2024). In the case of cultured meat, animal cells are used to grow meat in a laboratory environment, which has the same taste and nutritional content as conventional meat but requires far fewer resources to produce. In the long term, this technology can reduce the greenhouse gas emissions and land use associated with animal production (Ramezani-Motamedzadegan, 2024).

Plant-based meat substitutes are also becoming increasingly popular, particularly products made from pea, soy and mushroom proteins, which are increasingly similar in texture and taste to meat. Innovations in the food industry are enabling these products to become more widely available and economical to produce (Geng, 2024). Transparency in food supply chains is key to food safety and consumer confidence (Astill et al., 2019).

Blockchain technology offers the potential to fully trace the origin of food from production to consumption. In a blockchain-based system, the journey of each product is digitally recorded, so that it is possible to instantly trace where it came from, what processing steps it has undergone and under what conditions it has been stored. This data not only improves food safety, but also helps to reduce fraud and raise consumer awareness. For example, by scanning a QR code, consumers can get instant information on the exact origin of the product they are buying (Rejeb et al., 2020).

Precision agriculture has revolutionised the production of food ingredients. Internet of Things (IoT)-based sensors, drone technology and big data analytics allow farmers to monitor crop conditions in real time, optimise irrigation and minimise pesticide use (Gulaiya et al., 2024). Vertical farms and smart greenhouses, for example, allow maximum yields to be achieved with minimal water use and land. Hydroponics and aeroponics systems allow crops to be grown without land, which is particularly important for urban agriculture (Panotra et al., 2024). Overall, technological innovations in the food industry are having a significant impact on the sustainability, efficiency and safety of the industry. New processing methods, automation, alternative protein sources and digital technologies all

contribute to the food industry's ability to respond to future challenges. Innovations will enable food supply chains to become more resilient while providing consumers with healthier, more sustainable and safer food (Rui-Sundram, 2024).

Sustainability and future prospects

Sustainability is becoming an increasingly important aspect of the food supply chain, as global population growth, climate change and limited availability of natural resources pose serious challenges. The sustainability of the food industry is not only an environmental issue, but also a key economic and social issue, as producers, consumers and supply chain actors are all involved (Munuhwa-Sibanda, 2024). One of the most significant sustainability challenges is the reduction of the ecological footprint of agriculture. Intensive agricultural production contributes to greenhouse gas emissions, soil degradation, deforestation and overuse of water resources. For this reason, sustainable agricultural practices such as precision farming, regenerative agriculture and vertical farms are spreading in more and more countries and companies. These innovations allow for increased yields while reducing environmental pressures (Naeem et al., 2024).

Another key element of sustainable food production is the reduction of food waste. It is estimated that one third of food produced in the world ends up as waste, which represents a huge waste of resources. Consumers and businesses alike can take responsibility for reducing this problem by improving storage and logistics, optimising the food chain and encouraging conscious consumption. A growing number of countries are introducing stricter regulations against food waste and supporting initiatives such as food banks and donation programmes (Swetha et al., 2024). Looking ahead, new technologies will play a key role in increasing the sustainability of the food supply chain. Alternative protein sources such as plant-based meat substitutes, laboratory meats and insect proteins are gaining ground as they can reduce the environmental burden of conventional livestock production. In addition, the digitalisation of the food industry, such as blockchain technology to increase supply chain transparency or AI-based forecasting systems to optimise food production, can also play an important role in shaping a sustainable future (Su et al, 2024).

Consumer habits are also changing, with a growing demand for sustainable, locally produced and healthy food. The *farm-to-table* movement, the popularity of short supply chains and seasonal diets show that consumers are making increasingly informed choices. This trend is also supported by governments and companies by encouraging sustainable farming, local farmers' markets and organic certified products (Hassoun et al., 2022). Overall, the issue of sustainability is fundamental to the future of the food industry. Through continuous innovation, regulation and social responsibility, industry players must ensure that the food supply system remains stable, efficient and environmentally friendly in the long term (Alkhafaji, 2024).

4. CONCLUSIONS

The security and sustainability of the food supply chain is a global issue that depends on many factors. The challenges of recent years, including the COVID-19 epidemic, geopolitical conflicts and climate change, have highlighted the vulnerabilities of the system, while technological innovations and sustainability efforts have created new opportunities for the food industry. The role of critical infrastructure in maintaining food security is paramount. The smooth functioning of supply chains requires reliable logistics systems, adequate storage capacity and effective food safety measures. However, the complexity of global supply chains can make the system vulnerable, especially in the event of natural disasters, epidemics or political conflicts. Vulnerabilities and risks to the food supply chain include the dependence of production and transport on external factors, volatility of raw material prices, and coordination problems between supply chain actors.

Disruptions in global food markets, such as rising commodity prices or labour shortages, can further increase the fragility of supply chains, with direct impacts on consumer prices and food security. The COVID-19 epidemic and other crises have highlighted that supply chain stability cannot be taken for granted. Epidemic constraints, labour market changes and logistical difficulties have led to temporary disruptions in food supply, resulting in localised supply shortages and price increases. At the same time, the crises have fostered digitalisation and technological developments in the food industry, such as automated production processes, smart warehouses and demand forecasting supported by artificial intelligence. Innovations in the food industry offer opportunities to improve supply chain efficiency and sustainability. The use of alternative protein sources, precision agriculture and blockchain technology can all contribute to transparency and reduce environmental pressures. Smart packaging, automated quality control systems and data-driven supply management solutions can all help to reduce waste and increase food safety. Sustainability is one of the most important factors shaping the future of the food industry.

Over-exploitation of natural resources, climate change and food waste combine to push for sustainable solutions. Shorter supply chains, the promotion of local production and regenerative farming techniques can all contribute to a greener and more resilient food system. In summary, the challenges facing food supply chains are complex and require continuous adaptation. The crises have highlighted the vulnerability of the globalised food system, but steps towards innovation and sustainability offer the opportunity to create a safer and more efficient future. Together, technological developments, legal regulation and changes in consumer habits are shaping the future outlook for the food industry, in which resilience, adaptation and sustainability play a key role.

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e-mail: plotz.anita@phd.uni-obuda.hu

e-mail: varga.janos@kgk.uni-obuda.hu

INNOVATION STRATEGIES OF THE DOMESTIC SME SECTOR: EXPERIENCES OF ACTIVE AND ADAPTIVE INNOVATORS

JÁNOS VARGA - ANITA PLÖTZ

ABSTRACT

In the rapidly evolving global economy, innovation is a fundamental driver for sustaining and enhancing competitiveness. This study aims to systematically examine the theoretical foundations of the relationship between innovation and competitiveness, with a particular emphasis on the distinctive characteristics of various industries and business environments. The research investigates how innovation strategies influence firms' market positions and explores the contribution of product and process innovations to competitiveness, utilizing both a comprehensive literature review and empirical analysis. Our findings indicate that successful innovation extends beyond technological advancements, encompassing the transformation of organizational cultures and internal processes as well. In developing our theoretical framework, we present an integrated perspective on innovation systems that supports the sustainable improvement of competitiveness within the corporate sector. This paper advances the understanding of the interplay between innovation and competitiveness and offers practical recommendations for companies seeking to leverage innovation for long-term success.

Keywords: innovation, competitiveness, interaction, theoretical overview

1. INTRODUCTION

In the 21st century, Europe's status as a leading economic force has been undermined by the repercussions of multiple crises in recent years. Events such as the eurozone crisis, the refugee situation, Brexit, and the ongoing conflict in Ukraine have all exposed significant vulnerabilities that threaten the region's economic stability. Alongside these challenges, urgent action is required to address the critical issues of global warming and sustainability. This situation calls for a fundamental transformation of the system, one that seeks to harmoniously integrate social, economic, and technological development so these areas can strengthen one another. Innovation and sustainability are deeply interconnected and have become indispensable for businesses aiming to thrive in a rapidly evolving marketplace. The pace of technological advancement and economic shifts present organizations with both new obstacles and opportunities. As a result, the pursuit of innovation and sustainable practices is increasingly recognized as a cornerstone of competitiveness. At the same time, Europe is grappling with demographic shifts, difficulties in efficiently utilizing natural resources, and a slowdown in its innovation momentum. Addressing these challenges requires collaborative efforts to develop sustainable solutions that will safeguard social, economic, and political stability. Innovation is central to this endeavor. Historically, Europe has been at the forefront of groundbreaking inventions and discoveries. Despite notable achievements by European research institutions and companies, international comparisons indicate that progress in innovation is incremental, and the region produces relatively few breakthrough innovations (OECD, 2022).

Europe therefore needs an innovation policy that not only enhances economic and technological competitiveness but also supports social development. While innovation permeates every aspect of modern life—often without our conscious awareness—it remains difficult to define precisely.

Kerezsi's 2023 research explored how young people conceptualize innovation and how receptive their environments—such as educational institutions and workplaces—are to innovative ideas. Although respondents generally viewed innovation positively, few could articulate a clear definition. Most associated innovation with novelty, and many highlighted improvement and optimization as essential elements. This ambiguity regarding the definition of innovation also complicates its measurement. The relevance of this research is underscored by intensifying global economic competition and the rapid acceleration of technological progress, both of which present new challenges and opportunities for businesses. Additionally, rising expectations for sustainability and demographic changes are compelling companies to innovate in order to maintain their competitiveness in an ever-shifting business landscape.

2. LITERATURE REVIEW

In the next chapter, we will analyse in detail the weaknesses of measurement methods that make it difficult to accurately assess innovation and competitiveness. In addition, we discuss the impact of the middle-income trap, which can be a barrier to economic development, and in this context we highlight the importance of communication as a key element of cooperation and information flows between firms. By exploring the interactions between these factors, we can better understand how they shape the challenges and opportunities of the modern business environment.

As Nagy (2023) points out in his article, when evaluating the results of innovation measurements, it is essential to take into account how the measurement defines innovation - if it mentions it at all. Although there are professional sources, such as the Oslo Manual, to which a growing number of researchers refer, a precise definition is essential. The performance of innovation is measured using a variety of indicators which, while offering impressive and eye-catching results, also have a number of limitations and weaknesses. Experts who question the validity of the measurements can be divided into two main groups: one group criticises the indicators, while the other highlights methodological problems such as the confusion of input and output indicators (Csath, 2018).

Szunyogh (2010) highlights four factors that remain a problem: gaps in the interpretation of concepts, limitations of the indicators measured, missing information and problems of access to data. These factors prevent measurements from reflecting real results.

Schubert (2010) and Varga-Csajkás (2020) also draw attention to methodological problems, stressing that "there is no clear theory to justify the choice of indicators when measuring innovation performance; and the weighting used to train composite indicators significantly affects the results" (Nagy, 2023, p. 287).

As a consequence, the same country may be ranked differently according to different weightings. Instead, the authors recommend a dimension-by-dimension analysis to avoid problems and to accurately identify strengths and weaknesses. At present, innovation measurements greatly simplify the real situation, allowing a poor performance to be compensated by a good result in another area. These measures merely point to the need for further analysis, and spectacular rankings can lead to flawed decisions if no deeper analysis is done. In political life and in the media, selected results are often used, which can lead to false conclusions. For example, policymakers may mistakenly believe

that successful measures have been taken to boost the economy, while the results presented may convince the public of the correctness of the government's policy stance (Nagy, 2023, p. 273).

The distorted results from measurement gaps are easy to detect in countries that pride themselves on the opportunities they offer foreign investors, but often ignore the fact that a significant part of the profits from these investments leave the country. Economics has long been concerned with this phenomenon, particularly in relation to the countries of East Asia, where they have been caught in the 'middle-income trap'. These countries initially developed rapidly, but later failed to progress and became stuck at the level they had reached. In particular, economies that continue to base their future prosperity on the assembly plants of foreign firms are unable to develop (Béresné-Kiss-Nagy, 2023).

Globalisation processes in recent decades have enabled the international division of labour, which involves sourcing raw materials from other countries, selling products abroad and outsourcing labour. Companies with international links set up plants in countries with lower labour costs in order to make higher profits, further increasing the dependence of local economies.

Rodrik (2018) emphasises that the development of countries is inextricably intertwined with the development of local economies, while Pásztor (2020) adds that foreign investment not only increases disparities between regions but also distorts the degree of economic development (Béresné-Kiss-Nagy, 2023).

This situation highlights the distinction between 'false' and 'real' competitiveness: while the first is related to static advantages (e.g. exchange rate changes, labour costs), the second is based on dynamic advantages. Padilla (2006) also addresses the problem of false competitiveness, pointing out that this misleading picture is often the result of low wages, exploitation of natural resources and inadequate working conditions. However, raising living standards and achieving higher wage scales can only be achieved through innovation. A country that commits itself to serving larger countries can easily lose its well-educated, ambitious young people who are looking for more to achieve than manual work. It is extremely difficult, and in many cases impossible, to attract them back if the economic structure does not change (Hornyák, 2024).

Foreign dependence also hinders the rise of countries in other ways. The cost of importing raw materials directly affects the price of products, forcing the purchasing country to buy them, even if prices rise dramatically. Furthermore, exports are also hampered by fluctuating exchange rates and higher taxes. It is impossible for a country to prosper without mapping its own resources and economic potential. This requires good communication, a high level of education, openness to innovation and a willingness to innovate.

In the early history of mankind, communication was the basis of progress, allowing knowledge to be shared and communities to advance. The key recognition of cooperation was that individuals could not survive on their own, but could only succeed by working together with others. Trust, as a fundamental factor, was also essential: if people did not trust each other, even the best advice would be meaningless (Varga, 2023, p. 52).

Genuine and value-creating innovation can only come about if the parties are able to overcome professional, cultural and territorial boundaries and engage in a genuine dialogue, taking into account the needs of the society concerned. In addition to listening to each other and being open to new ideas, it is important that all participants are aware of the risks involved in trying out new ideas and are willing to take them. A supportive environment and a willingness to face failure encourages a willingness to innovate. This is reflected in the example of Japan, where national programmes aim to promote social change through high-risk technology projects (Keidanren, 2018).

Varga's (2023) research shows that a majority of European citizens want countries to work together rather than compete, in a joint effort to exploit the continent's innovation potential. Countries around the world could learn a lot from each other if they were open to the good examples of others. Positive examples can be found in countries such as the Netherlands (EZK, 2019), the UK (UKRI), Sweden (Fagerberg, 2017) and Canada, where different perspectives can enrich each other. Coming together and listening to each other can help to align key priorities and objectives, without which it is difficult to define any innovative endeavour.

While Europe has always been at the forefront of innovation, it has lagged behind America and Asia in recent decades. Germany, which is at the forefront of optimisation, is also pushing innovation into the background. Research on companies shows a lack of innovation expertise and that half of firms have failed to adapt to new circumstances (Bertelsmann Stiftung, 2023). 16% of companies surveyed have no innovation strategy, while others are unwilling or unable to innovate (Bertelsmann Stiftung, 2023). Dobos and Csiszárík-Kocsir examined the role of research, development and innovation (RDI) in Hungarian enterprises, finding significant differences in terms of enterprise size, sector and market position (Csiszárík-Kocsir - Dobos, 2023). They also examined individual perceptions of research, development and innovation and found that the personal attitudes, experiences and motivations of the actors play a key role in the success and acceptance of RDI activities (Dobos - Csiszárík-Kocsir, 2023).

Kerecsi (2023) also found in his research that although most institutions expect innovative ideas, in many places management does not listen to them, and in some firms even explicitly forbid employees to make any suggestions. By developing ambitious strategies, leaving the beaten track and taking risks, innovative efforts can be more successful. Young, inventive enterprises play a key role in this role and their support is vital. Unfortunately, the trend shows that fewer start-ups are being created and that there is a lack of in-depth preparation among young start-ups. Only innovative and novel technologies can provide solutions to new problems. However, innovation, as important as it is for companies, must not be an end in itself but must serve the development of society. Exploiting nature for the sole benefit of companies is unacceptable. Human and liberal values must guide action so that innovation can become a creator of peace and prosperity.

3. MATERIAL AND METHOD

The research utilized an online questionnaire to conduct a quantitative analysis, designed by the authors using the SurveyMonkey platform. The primary method of distribution was via email to various businesses, though in some instances, participants were also reached through social media channels. The data collection period spanned May and June 2023.

The questionnaire comprised 27 items, including several that employed a four-point Likert scale to gauge respondents' opinions. Other questions provided a list of predefined answers, with some allowing for multiple selections. At the conclusion of the survey, participants had the opportunity to freely share their thoughts and perspectives on the subject matter. Throughout the research process, the authors ensured complete anonymity for all respondents. In total, 134 responses were collected. However, 26 were excluded due to formal or other issues, resulting in 108 valid responses for analysis. While the sample cannot be considered statistically representative, the findings offer meaningful insights into corporate attitudes and can serve as a foundation for future studies.

Analysis of the responses reveals that the majority of participants from large companies—those with 250–499 or more than 1,000 employees—are employed by foreign-owned firms, accounting for 47.2% of the sample. Conversely, 52.8% work in predominantly Hungarian-owned, privately held small and medium-sized enterprises (SMEs). Most of the surveyed companies operate in the trade sector, with 21.3% involved in motor vehicle manufacturing and 20.37% in general manufacturing.

The remaining 15.74% are active in public administration, education, healthcare or social services, the arts, or other service industries.

The respondents' professional backgrounds are also notable: 44.44% have over 20 years of experience, approximately one quarter have more than 10 years, and nearly 15% possess between 6 and 10 years of professional experience. Regarding their roles, 11.11% are business owners, 12.96% are senior executives, 24.07% are middle managers, and 22.22% are operational managers. Nearly one third of respondents do not hold managerial positions. This distribution highlights the considerable professional experience of the participants and their broad perspective on company operations, owing to the diversity of their roles.

4. RESULTS

Innovation is of paramount importance for companies active in international markets, where competition and pressures are higher. To be successful and competitive, companies need to innovate continuously, in terms of products, services and customer relations. A digital presence is particularly important for companies operating outside their home market, as new technologies are essential for achieving fast data processing and flows. In addition, speed, responsiveness to customer needs and innovation are essential in the domestic market.

The most important aspect is how well the company supports a digital culture and agile operations. Based on the responses, participants believe that management is mainly focused on two areas: knowledge sharing and digital workflows and virtual teams. A total of 134 responses were collected in the survey. After excluding 26 responses due to formal or other issues, 108 valid responses remained for evaluation. The sample included a balanced mix of company types, with 47.2% of respondents employed by foreign-owned large enterprises and 52.8% working for Hungarian-owned small and medium-sized enterprises (SMEs). In terms of sectoral distribution, the majority of participating companies operate in the trade sector. Additionally, 21.3% are involved in motor vehicle manufacturing, 20.37% in general manufacturing, while 15.74% represent other sectors such as public administration, education, healthcare, the arts, and various services. The professional experience of respondents is noteworthy: 44.44% have more than 20 years of experience, approximately a quarter have between 10 and 20 years, and about 15% have worked for 6 to 10 years. Regarding their positions within their organizations, 11.11% are company owners, 12.96% are senior executives, 24.07% are middle managers, and 22.22% are operational managers. Nearly one third of respondents hold nonmanagerial roles. While the sample is not statistically representative, the data nonetheless provide valuable insights into company attitudes and the professional backgrounds of employees across a diverse range of sectors.

Over half of the respondents—64.82%—emphasized that establishing a digital work environment is highly important (with 35.19% rating it as significant and 29.63% as very important). In contrast, 35.18% indicated that their organizations do not devote sufficient attention to this matter, and only 9.26% stated that their company completely neglects digitalization. These findings suggest that digital transformation is a prominent issue in Hungary, beginning with the digitization of the workplace.

This process can occur at various organizational levels, from office settings to manufacturing plants. Companies place a strong emphasis on continuous learning and knowledge sharing, which are closely tied to the adoption of digital technologies. The creation of virtual teams and the use of secure networks and cloud-based information storage enable multiple users to access and modify data simultaneously, with changes instantly saved and visible to all. Such technological capabilities are now indispensable for modern businesses.

However, the survey also reveals a concerning lack of focus on innovation. More than half of the respondents believe their companies do not foster innovation. Only 20.37% feel their organization has a positive attitude toward new ideas, while 40.74% report that their workplace pays little or no attention to innovation. The situation is similarly discouraging regarding open innovation: although it is crucial for companies to learn from one another, nearly two-thirds of respondents believe their organizations are not taking full advantage of collaborative opportunities. Only about a third consider their company an active partner in open innovation. This is particularly disappointing given that Industry 4.0—aimed at integrating data and information along the supply chain—has been around since the early 2010s. Effective collaboration and real-time data sharing can significantly enhance competitiveness, efficiency, transparency, and trust among business partners.

Ongoing development of employees' knowledge and skills is essential for fostering an innovative mindset, and, encouragingly, the responses indicate that companies are investing in this area. Nevertheless, concerns remain about organizational flexibility and risk-taking. Only 26% of respondents perceive their workplace as flexible and open to taking risks; the majority feel that risk tolerance is limited or entirely absent. Since innovation inherently involves risk—and mistakes, though potentially costly, are part of the journey toward success—companies must cultivate an environment that encourages experimentation and learning from failure. Interestingly, only 38.33% of respondents identified dealing with mistakes as a key area for improvement, suggesting that this competency is undervalued.

Teamwork, collaboration, and a spirit of experimentation, innovation, and creativity are also not rated highly by respondents, with 51.67% identifying these as areas needing greater emphasis. Most notably, 70% believe that their organizations should further develop data management and analytical skills—competencies that are fundamental to innovation, as data analysis can help guide strategic direction and identify what customers value most. The remainder of the research also explored whether there are significant differences in perceptions between employees of Hungarian-owned and foreign-owned companies..

The survey results highlight several key areas related to workplace culture and employee competencies. Only 26% of respondents described their workplace as flexible and open to taking risks, indicating that adaptability and risk tolerance are not widespread. When it comes to developing a constructive attitude toward errors, just 38.33% of participants identified this as an area of focus within their organizations. On a more positive note, the importance of teamwork and cooperation, as well as fostering an innovative spirit and creativity, was recognized by 51.67% of respondents in both cases. This suggests that while there is some emphasis on collaboration and creative thinking, there remains significant room for improvement, particularly in encouraging risk-taking and learning from mistakes.

The willingness to cooperate is more evident in Hungarian state-owned or privately-owned companies, while it is not so pronounced in international companies. However, agility, quick adaptation to new developments, efficiency in decision-making, intuitive use of digital technologies and support for creativity and innovation development are the main areas of focus for international companies, according to respondents. Foreign-owned firms seem to have a more favourable attitude towards failure, while in other areas, professionals attach similar importance to improvement, regardless of whether they work for a Hungarian or foreign-owned company. The use of cloud storage and applications is already common in most companies, but it is still a long way from being adopted by all companies. ERP systems are used by almost half of companies, while the adoption of customer relationship management systems, IoT (Internet of Things) and robotics is even lower. So for Hungarian companies, new technologies are still in their infancy, even though their knowledge and use are essential to stay competitive. The concept of competitiveness is ambiguous and depends on a number of factors.

The literature points out that a false image of competitiveness can be created, for example when a company achieves its results by exploiting labour or natural resources. I was interested to hear how the professionals interviewed perceived their own company's products.

The survey findings reveal that, while most companies have begun to use cloud storage and cloud-based applications, these technologies are not yet widely adopted across the board. Nearly half of the surveyed firms have implemented enterprise resource planning (ERP) systems, indicating a moderate level of digital integration. In contrast, the use of customer relationship management (CRM) systems lags behind ERP adoption, suggesting that many companies have yet to fully embrace digital tools for managing client interactions.

The uptake of advanced technologies such as the Internet of Things (IoT) and robotics remains low, reflecting that these innovations are still in the early stages of adoption among Hungarian businesses. Overall, the state of technology in Hungary can be characterized as being in its infancy, with new digital solutions only gradually gaining ground.

Additionally, the concept of competitiveness is not clearly defined among respondents and appears to depend on a variety of factors. This ambiguity highlights the need for a more comprehensive understanding of what drives competitiveness in the current business environment.

A significant proportion of professionals, 57%, strongly agree, while 15.38% tend to agree that their company's products are competitive. Only 3.85% believe that their products are lagging behind other products on the market, while 48.91% consider the products they produce or distribute to be average. I then asked respondents what direction they thought they should take to improve their competitiveness. It is important to emphasise that competitive products need to be continuously improved, otherwise they could easily fall into the market and the company could lose its leading position.

The survey results indicate that 57% of respondents fully agree that their products are competitive, while an additional 15.38% rather agree with this statement. Nearly half of the participants (48.91%) consider their products to be of average competitiveness, and only a small proportion—3.85%—feel that their products are lagging behind those available on the market.

An important takeaway from these findings is that, in order to maintain or enhance market position, companies must focus on the continuous improvement of their products. Without ongoing development, even currently competitive offerings may risk falling behind in an increasingly dynamic business environment.

Reliability stands out as a top priority across all types of companies, with professionals also identifying speed and continuous improvement as critical drivers of success. However, there is a notable reluctance to share data within most organizations, which is concerning given that enhanced collaboration and cooperation could significantly elevate company performance.

Interestingly, the emphasis on understanding and responding to customer needs is most pronounced among small businesses, despite the fact that regularly assessing evolving customer expectations is essential for all companies aiming to sell their products or services effectively. When it comes to producing high-quality products, this is primarily a focus for larger enterprises, whereas for businesses with fewer than ten employees, quality does not play a central role in their competitiveness.

Among companies with 250–499 employees, responses were the most evenly distributed, indicating a balanced approach to various competitive factors. Two main categories of priorities emerged: those considered more important and those seen as less critical. The most valued factors include customer

orientation, product quality, continuous improvement, cost efficiency, direct customer engagement, problem-solving capabilities, data confidentiality, innovation, agility, and trust. While other opportunities are also recognized as beneficial, there are no factors deemed entirely irrelevant to achieving a competitive edge. This suggests that a multifaceted approach is essential for companies striving to maintain and enhance their market position.

5. CONCLUSIONS

The primary objective of this research was to assess the innovation potential, digital transformation, and competitiveness of Hungarian companies, with particular attention given to workplace culture and employee perceptions. The findings indicate that, while a considerable proportion of companies acknowledge the importance of innovation and digitalization, many still encounter significant obstacles when it comes to implementation.

Although 64.82% of respondents highlighted the importance of establishing a digital working environment, 35.18% admitted that this area does not receive adequate attention within their organizations. This underscores not only the necessity but also the urgency of digital transformation in Hungary, as the contemporary business landscape demands swift and effective adaptation. The adoption of digital technologies—such as cloud-based solutions and enterprise resource planning (ERP) systems—remains limited, which could hinder the competitiveness of these firms.

Equally concerning is the low level of commitment to innovation. More than half of those surveyed believe their workplace does not support innovative initiatives. Only 20.37% view their company's innovation culture positively, and 40.74% report insufficient engagement with open innovation. This is particularly disappointing, as open innovation—rooted in knowledge sharing between organizations—has the potential to drive growth and enhance competitiveness.

Respondents identified reliability, speed, and continuous improvement as key factors for success. Interestingly, data sharing and responsiveness to customer needs were more prominent among smaller companies, even though ongoing market monitoring is crucial for businesses of all sizes. Quality production was cited as a priority primarily by larger firms, suggesting that smaller companies may not place as much emphasis on this aspect.

The research points to the necessity for greater collaboration and knowledge exchange among companies to bolster the competitiveness of Hungarian businesses. Continuous development of employees' skills and expertise is also vital for fostering an innovative mindset. Overall, the results emphasize that companies should focus not only on technological advancements but also on cultivating a supportive workplace culture and actively involving employees in innovation processes. While Hungarian companies possess significant innovation potential, realizing this potential will require decisive action. Advancing digital transformation, encouraging innovation, and nurturing a strong employee culture are essential steps for future growth. By prioritizing these factors, companies can enhance their competitiveness, which is fundamental to broader economic development.

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TEACHERS' DIGITAL COMPETENCE IN ONLINE EDUCATION FROM A STUDENT PERSPECTIVE

BERNADETT REVÁK - ÁGNES CSISZÁRIK-KOCSIR

Abstract

The rapid evolution of digital education and the rise of online learning are creating new challenges for teachers, who must constantly adapt to technological changes. This calls for a kind of innovation by reforming familiar methods and combining new and old in 'blended' solutions. Our present research aims to explore how today's learners perceive teachers' knowledge and preparation in the online space. We aimed to get a clearer picture of the extent to which teachers use and integrate new digital spaces and tools in their everyday teaching. The questionnaire survey asked students to give their views on the extent to which they experience the use of digital tools in the classroom and how they rate teachers' digital competence. Our study data were collected in a secondary school setting. We worked both nationally and internationally, which gave us the opportunity to compare the opinions collected from students in Hungary and Turkey.

Keywords: digital education, digital competence, teacher competences, primary research

1. INTRODUCTION

The digital transformation of education has become a central issue in global education policy and pedagogical practice in recent years. It has come into particular focus during the COVID-19 pandemic, which has created numerous challenges and opportunities through school closures and the spread of distance learning. These changes have required and continue to require new approaches and competencies from teachers. Above all, the teaching-learning process requires the presence and application of digital competence, as well as its coordination with older methodological elements. The concept of digital competence has become increasingly important in the education process over the last decade, but it has played a truly decisive role during the pandemic. Teachers had to adapt quickly to new platforms, digital teaching tools and supporting students in a completely changed digital learning environment. This transition was influenced by several factors, not only technical, but also pedagogical and psychological.

The literature expresses a similar opinion, according to which teachers' digital competence does not only mean the ability to use tools, but also the critical, reflective and pedagogically sound application of digital technologies, which requires special attention and puts the support of learning in the foreground. At this point, the students' perspective plays a valuable role. It is important how they perceive teachers' digital competence and how effective, supportive and motivating they consider it to be in the learning process. An increasing number of international and domestic studies are being published on this topic, examining teachers' digital preparedness from various perspectives. However, a significant proportion of these are based on self-assessments by teachers or education professionals. In contrast, relatively few studies focus on the opinions of students. Although they are the ones who directly experience the digital aspect of teaching practice, their role is of paramount importance in addressing this topic. Accordingly, the aim of our current research is to interpret the significance and practical implementation of teachers' digital competence from the students' perspective.

2. LITERATURE REVIEW

2.1. *Digital competence and its framework*

The definition of digital competence can be found in the DigComp (Digital Competence Framework) developed by the European Union (European Commission, 2022). According to DigComp version 2.2, digital competence means the confident, critical and responsible use of digital technologies in learning, work and social participation. In fact, it refers to a combination of skills and attitudes. Individuals need to apply all of these to participate actively and responsibly in the digital environment.

The DigComp framework developed by the European Union classifies digital competences into five broad areas of competence. These areas determine how effectively, safely and critically someone can exist in digital environments. The first area is information and data management, which includes the ability to search for, filter, evaluate and process information in a structured manner. The second area is communication and collaboration, which refers to the conscious use of digital technologies in online communication, collaborative work, and inclusive thinking in social and cultural contexts. The third area of competence is digital content creation, which refers to the creation, editing and reuse of digital content, as well as knowledge and respect for copyright and licensing issues. The fourth area is security, which covers personal, device and data protection in the digital environment, as well as aspects of digital well-being and environmental sustainability. The fifth area of competence is problem solving, which is the ability to identify and solve problems related to digital tools and environments, as well as to develop and effectively apply new digital solutions in different life situations (European Commission, 2022).

Teachers' digital competence goes far beyond technical knowledge of how to use IT tools. Current international research and policy documents emphasise that teachers' digital competence is a complex, multidimensional concept that is closely intertwined with pedagogical goals, the planning of learning and teaching processes, and the use of digital opportunities for assessment and student support. Research by Balogh and Varga shows that the majority of students have a positive attitude towards digital life, including the use of AI, but they emphasise the importance of appropriate guidance from teachers and ethical issues. This, in turn, requires teachers to play an appropriate role (Balogh & Varga, 2025).

One of the most comprehensive descriptions of teachers' digital competence is provided by the DigCompEdu framework developed by the European Commission, which was designed specifically for those working in the education sector (Redecker, 2017). The model distinguishes six main areas of competence, which are aimed at the conscious use of digital tools to support pedagogical goals. These include the professional use of digital technologies to support professional work and their integration into educational practice, as well as into the planning and implementation of the teaching and learning process. In addition, emphasis is placed on digital assessment tools, which enable teachers to monitor student progress and provide continuous, differentiated feedback. The framework also highlights the development of students' digital competences and the promotion of active, self-regulated and reflective learning as pedagogical goals. Finally, an important element is the consideration and management of student diversity in the digital environment, whether in terms of abilities, social or cultural factors. All of this is also a cornerstone of the differentiation method, which supports a methodology of paramount importance thanks to digital capabilities.

It is important to emphasise that these competences should not be interpreted independently. They interact with each other to form the pedagogical approach that enables teachers to deliver effective, inclusive and learner-centred education in a digital environment. Digital competence therefore requires knowledge of technological tools, the ability to adapt to pedagogical objectives, and an empathetic, supportive teaching attitude. Assessing teachers' digital competence is also a complex task that cannot be limited to a mere inventory of technical knowledge. Modern educational research

has developed several models to provide a comprehensive picture of the intertwining of teachers' technological, pedagogical and content knowledge and its integration into practice. One such well-known model is the TPACK model (Technological Pedagogical Content Knowledge), which serves to describe the intersection of pedagogical knowledge (PK), content knowledge (CK) and technological knowledge (TK) (Mishra & Koehler, 2006). The essence of the model is that effective digital pedagogy does not stem solely from the use of technology, but from the teacher's ability to adapt the appropriate digital tools and methods to the curriculum and student needs. The TPACK model is particularly useful in planning teacher competence development, as it enables the targeted development of specific areas of knowledge and highlights the fact that digital technology cannot be separated from pedagogical goals and subject content.

Another widely used system is the SAMR model (Substitution, Augmentation, Modification, Redefinition), which is associated with Ruben Puentedura (Puentedura, 2006). This model describes four levels of technology integration in education (Hamilton, 2016). At the substitution level, digital tools simply replace traditional methods (e.g. digital notes instead of paper), while augmentation involves certain functional improvements. The Modification level involves restructuring learning processes, while Redefinition enables learning activities that were not previously possible. However, research shows that teachers often remain at the lower levels (substitution, augmentation) due to a lack of necessary methodological support, time or experience in using digital tools (Hilton, 2016). This has become a particular problem during online education, when not only the use of digital tools was expected, but also their creative and learner-centred application (Garai-Fodor & Csercsa, 2022). Both models offer useful tools for the reflective evaluation of pedagogical practice and the development of teachers' digital competence, as they can examine not only the use of tools, but also their quality and pedagogical methodological level. The advantage of both the TPACK and SAMR models is that they not only provide a theoretical framework, but also practical guidelines for analysing and developing teachers' digital activities. These models can therefore play a key role not only in assessing teachers' competences, but also in setting directions for pedagogical development, especially when teaching takes place in a digital environment (Hilton, 2016).

2.2. *The role of teachers' digital competence in online education*

The rise of online education – especially during the COVID-19 pandemic – has fundamentally changed educational practices and shed new light on the importance of teachers' digital competence. The impact of this can still be felt today. The use of digital tools in teaching requires not only technical adaptation, but also a comprehensive pedagogical rethink. Teachers must be able to reinterpret the learning environment while maintaining student motivation, activity and effectiveness. In practice, this requires a fusion and harmonisation of the old and the new. Digitally competent teachers can consciously and purposefully integrate various technological tools into the teaching and learning process, taking into account the age characteristics, learning styles and digital intelligence levels of their students. Research clearly shows that teachers' digital competence has a significant impact on the quality of education, the variety of methods used, and the learning experience of students (Gudmundsdottir & Hatlevik, 2017).

Teachers with high levels of digital competence are not only able to use online platforms more effectively, but are also able to create active, constructive and collaborative learning processes in their everyday work. In addition, they are more likely to use forms of assessment and feedback methods that support students' self-regulated learning and development, as well as their self-assessment skills. This also shapes and supports the healthy development of their values. However, it is important to emphasise that teachers' digital competence affects not only their performance but also their students' attitude towards learning. Student feedback often indicates that teachers' technical confidence, digital communication style and use of digital tools in teaching have a direct impact on their learning experience, engagement and motivation. Just think of the emergence of gamification. Thanks to the

characteristics of the current generation of students, cooperation and learning are more readily and effectively manifested in practices of this kind (Garai-Fodor, 2023). In light of all this, it can be said that teachers' digital competence is not merely an individual skill, but a key factor in the success of education, especially with the integration of online educational tools and methods.

A useful approach to interpreting and evaluating teachers' digital competence is to examine the different levels of digital tool use. Based on the literature, teaching practice can be described along three basic dimensions: technical, pedagogical and communicative (Krumsvik, 2011; Ilomäki et al., 2016). The technical level encompasses the most basic usage skills, including knowledge of how to operate various digital tools and platforms (e.g. video conferencing systems, learning management systems, digital content editing programmes). This level is necessary but not sufficient for effective teaching. The pedagogical level refers to the targeted, methodologically sound application of digital technologies. Here, the teacher can support the learning process with digital tools, apply differentiated learning organisation methods, and consider the individual needs and learning styles of students. The pedagogical level therefore measures how well the teacher can create meaningful, student-centred didactic structures with the help of digital tools.

The third level, communication, focuses on the quality of digital interactions between teachers and students, as well as among students. This includes, for example, providing regular, supportive feedback to students, encouraging collaborative learning in online spaces, and maintaining student motivation through digital tools. This level is key to the learning experience and the emotional engagement of students, especially in a distance learning environment. It essentially frees up the learning process, moving away from the traditional classroom environment. These three levels build on each other and must exist together to create high-quality, reflective digital teaching practices. The true value of a teacher's digital competence becomes apparent when technical knowledge is not an end but serves pedagogical and communicative purposes. Thinking through this process, its complexity and interdependence become clear.

Teachers' digital competence not only influences the technological implementation of education but also has a direct impact on the diversity and quality of teaching methods used and, consequently, on student performance. Research shows that teachers with a high level of digital knowledge and pedagogical sensitivity are more likely to use student-centred methods that support active learning (Tondeur et al., 2016). These methods often include project-based learning, collaborative task solving, digital portfolios or interactive teaching materials. The conscious and goal-oriented use of digital tools offers more flexible learning organisation, more personalised learning paths and differentiated assessment options. All of this can have a positive impact on students' collaboration, motivation and, ultimately, their learning outcomes (Redecker, 2017). At the same time, the mere presence of technology does not in itself guarantee effective learning; the key is thoughtful methodological integration that fits the pedagogical goal.

However, teachers' lack of digital competence can limit the methodological toolkit and reduce teaching to a lower level of technological presence, which is only suitable for information transfer and frontal teaching. In such cases, student performance does not necessarily improve; on the contrary, overly one-sided or poorly structured digital education can cause learning fatigue, passivity or even anxiety in students (Zilka, 2021). Overall, it can be concluded that teachers with digital competence are not only able to adapt to the challenges of the digital environment, but also actively shape the learning process, opening new opportunities for the development of teaching methods and the support of student performance thanks to new, innovative tools.

The digital competence of high school students fundamentally influences their learning experience and engagement. Teachers with the right digital skills can create a learning environment that encourages students to actively participate and engage more deeply. Teachers' digital competence

therefore has a direct impact on students' motivation and learning experience. When we consider what the online space means to digital natives, we see even greater justification for this. Digital competence is a key element of today's education, especially for high school students. The use of technological tools in education not only helps students learn the material but also encourages their active participation and motivation. Teachers' digital skills play a fundamental role in ensuring that students develop in a learning environment that encourages commitment and independent thinking (Muhridza et al., 2018).

Student engagement can manifest itself in several dimensions, including behavioural activity, emotional attachment, and cognitive deep engagement. Teachers with a high level of digital competence can create learning situations that support all three areas, thereby increasing students' motivation and participation in the educational process. However, when developing digital competence, it is important to consider individual differences among students and issues related to access to tools. Although digital technologies offer numerous opportunities for personalized learning and educational innovation, it is important that technology not be an end but rather serve to achieve pedagogical goals. The digitization of education will be successful if teachers receive adequate support for the pedagogical integration of digital tools. The rise of digital pedagogy has brought significant changes to learning processes and student experiences. Students in the 21st century, especially members of Generation Z and Alpha, increasingly expect education to be technology-based, visually rich, and interactive. Such environments promote active learning and independent knowledge acquisition and contribute to the development of intrinsic motivation. In terms of student motivation, digital pedagogy is most effective when technology is not merely a means of conveying information but offers an experiential platform that supports the learning process. Well-applied digital tools, such as educational software, interactive tests, gamified tasks (gamification), or applications that support cooperative learning, such as Padlet, Mentimeter, and Kahoot! can increase student engagement and positive attitudes toward learning.

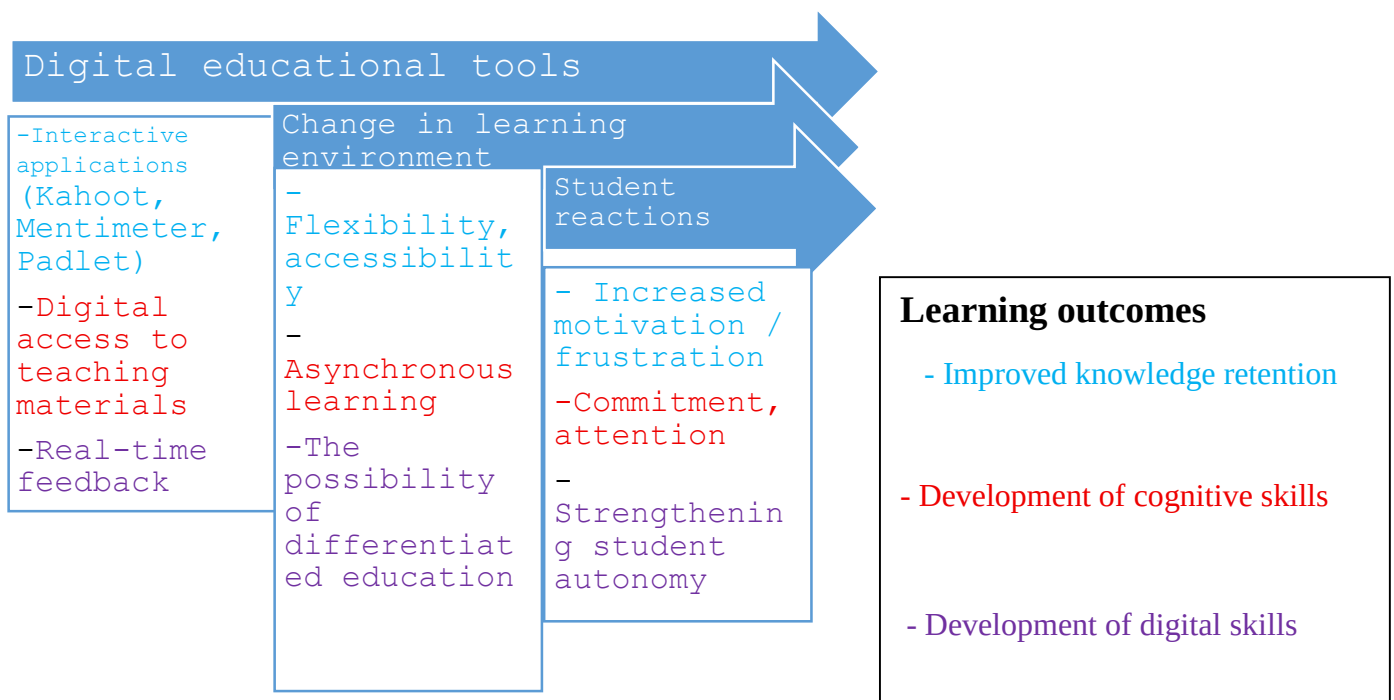


Figure 1: Changes in the learning process considering digital education
Source: own compilation

2.3. Education in virtual space from the student's perspective

Today's younger generation loves and demands the digital world because social media, online communication and digital content consumption are a natural part of their everyday lives, providing entertainment, information and opportunities for self-expression. Members of Generations Z and Alpha are digital natives who easily adapt to new technologies and find experiences in the metaverse or other digital platforms novel, exciting and convenient. However, this requires clear boundaries, competencies and guidelines. A study by Varga and Csiszárík-Kocsir (2024) also points out that younger generations are more open to digital shopping, are quicker to accept new technologies, and that experiences gained in virtual spaces play an important role in their consumer decisions. The same study (Csiszárík-Kocsir - Varga, 2023) emphasises that advanced digital infrastructure and user-friendly solutions further increase young people's commitment to and satisfaction with the digital world. The striking examples above also show how much need there is for appropriate digital foundations and guidance.

With the spread of online and hybrid learning environments, students' expectations of teachers have changed significantly. There is a growing demand among high school and university students for their teachers to use digital tools not only on a technical level, but also pedagogically. It is not enough for students that teachers are able to share a presentation or start a video call. Nowadays, they expect teachers to be able to deliver clearly structured, engaging, and active lessons in the digital space. Based on student feedback, 21st-century teachers are not only technically skilled, but also use methods that consider students' learning styles, prior knowledge, and motivation levels. It is particularly important that teachers are able to maintain contact with students, ensure a transparent learning process, and support them through digital platforms, whether formally or informally (Redecker, 2017). Students' expectations also include digital flexibility; they appreciate it when teachers make the curriculum available in multiple formats (e.g., videos, podcasts, visual aids). They like to have the option of asynchronous learning, which helps develop independent learning skills. In contrast, when teachers are less prepared, students often become frustrated, more passive, and less committed to the learning process. Students are also sensitive to how interactive the digital learning

environment is. Simple frontal online lectures are less engaging for the current generation of students than lessons that offer opportunities for group work, real-time feedback, or the use of interactive applications such as Kahoot, Mentimeter, and Padlet. All this shows that digital competence can be interpreted not only as technical knowledge, but also as a skill that manifests itself in the diversity of teaching methods and teacher attitudes.

3. MATERIAL AND METHOD

The aim of our quantitative survey 2024 is to assess the opinions of Hungarian and Turkish secondary school students on their individual assessment of teachers' IT competences. We analysed the responses of **340 Hungarian** and **153 Turkish students** who completed an online questionnaire. The students are enrolled in IT education in each country, so their opinions are relevant, but not representative, but a good starting point for further studies. The questionnaire contained **25 closed questions**, with a particular focus on two areas:

1. Assessing teachers' IT support and tool training,
2. Student assessment of the level of digital literacy of teachers.

The questionnaire method chosen for the quantitative analysis allowed for standardised data collection. The questionnaire was **in Hungarian and Turkish**, which allowed for international comparisons as well as exploring differences between the two countries. Participants completed the questionnaire **completely anonymously**, which guaranteed the honesty of the answers. Responses were assessed on a country-by-country basis. The data was collected through **an online platform** via Google Forms, so that students from both schools in Hungary and Turkey could access the questionnaire. For data analysis, we used **basic statistical methods** (frequency analysis, distributions) and **cross-tabulation analysis** by calculating the Chi-square value to detect differences and identities between age groups.

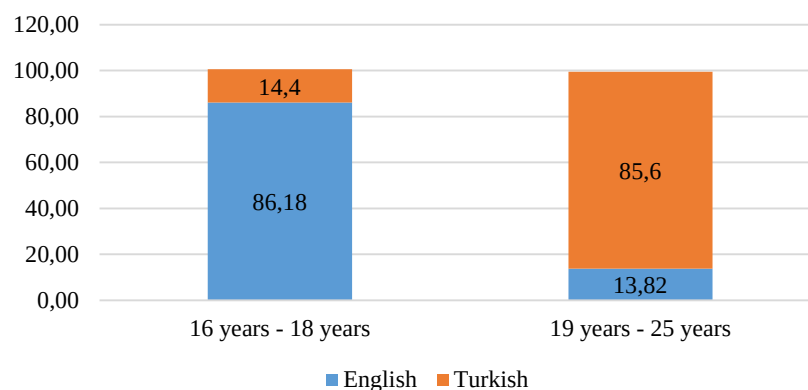


Figure 2: Composition of the sample

Source: own research, 2024, N = 340 (Hungarian), N = 153 (Turkish)

4. RESULTS

Firstly, we surveyed the opinions of Hungarian and Turkish students in order to investigate the extent to which the teachers of the students' classroom play an advisory and supportive role in relation to the use of IT tools. One of the main similarities is that in both countries most students do not consider teachers to be particularly active helpers, with the highest proportion in both groups answering 'To an average extent' (43.8% for Turkish students and 37.83% for Hungarian students). This suggests that, in general, the role of teachers in providing IT support is considered to be rather medium. Among the differences, a higher proportion of Hungarian students feel that their teachers do not help them at all (15.84%), while this proportion is much lower among Turkish students (5.9%). At the same time, a higher proportion of Turkish students feel that their teachers often help them (18.3% compared to

14.38% of Hungarian students). The proportion of students who answered "Some" is also higher among Turkish students (30.7%) than among Hungarians (28.45%). The responses show that Turkish students are more satisfied with the IT assistance they receive from their teachers than their Hungarian counterparts. Although the difference is not large, it is certainly striking for each category.

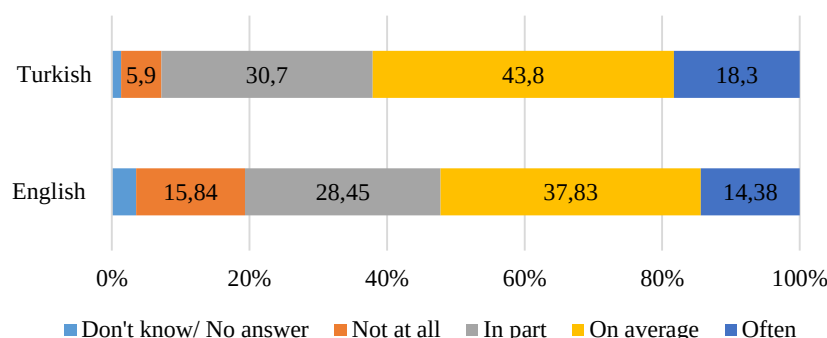


Figure 3: Student perceptions of the advisory and supportive role of teacher trainers in relation to the use of IT tools

Source: own research, 2024, N = 340 (Hungarian), N = 153 (Turkish)

The table below examines the above questions by age along the distributions. In both countries, the most common response was "To an average extent": 38.2% (16-18 years) and 36.2% (19-25 years) for Hungarian students, while 50% (16-18 years) and 42.7% (19-25 years) for Turkish students. However, here again, the differences between countries are interesting: half of the younger Turkish respondents felt this way, while for Hungarians it was 38.2%, i.e. this age group is much more critical in Hungary than in Turkey. The answer "Not at all" was selected by a higher percentage of Hungarian students (15.4% and 19.1%) than Turkish students (9.1% and 5.3%), suggesting that Hungarian young people are again more critical in this area. The answer "Often" was chosen by a higher proportion of younger Turkish students (22.7%), while the proportion was lower for Hungarian students (13.7% and 17%). The above two categories are also interesting because Hungarian and Turkish students in all age groups gave the highest proportion of answers "To an average extent", but the second highest proportion of answers was "To some extent" for Hungarians in all age groups and "Often answer" for the older age group and "To some extent" for the younger age group in Turkey. This difference could be due to the fact that young people entering the Turkish system have lower IT knowledge at the moment of starting, which makes them more appreciative of the role of their instructors, or these young people are less critical and critical of their instructors. Chi-square values (Hungarian: 0.876; Turkish: 0.627) indicate that age differences are not significant in either country, i.e. there is no relationship between respondents' views and age.

Table 1: Students' perceptions of the advisory and support role of teacher trainers in relation to the use of IT tools in the age groups

	English			Turkish		
	16 years - 18 years	19 years - 25 years	Chi-square	16 years - 18 years	19 years - 25 years	Chi-square
Don't know/ No answer	3,8%	2,1%	0,876	0,0%	1,5%	0,627
Not at all	15,4%	19,1%		9,1%	5,3%	
In part	29,0%	25,5%		18,2%	32,8%	
On average	38,2%	36,2%		50,0%	42,7%	
Often	13,7%	17,0%		22,7%	17,6%	

Source: own research, 2024, N = 340 (Hungarian), N = 153 (Turkish)

Figure 3 shows teachers' preparation and proficiency in IT skills and digital tools. The main similarity between the two countries' samples is that most respondents believe that their teachers are prepared and proficient in the use of IT tools: 52.3% of Turkish students and 48.97% of Hungarian students selected this option. This shows that the majority of students responding have a positive perception of their teachers' digital competence. Among the differences, a higher proportion of Hungarian students perceive their teachers as less prepared and less knowledgeable (21.4%) than Turkish students (16.3%). At the same time, a higher proportion of Turkish students perceive their teachers as excellently prepared and knowledgeable (23.5%), compared to 13.5% of Hungarian students. Once again, the picture is that Turkish students are more positive about their teachers' IT skills and use of digital tools, while Hungarian students are more critical, with more of them seeing their teachers as less prepared for the expectations of the digital world. However, in both countries, a majority of teachers in both countries consider that their teachers are at least moderately proficient in the use of digital tools.

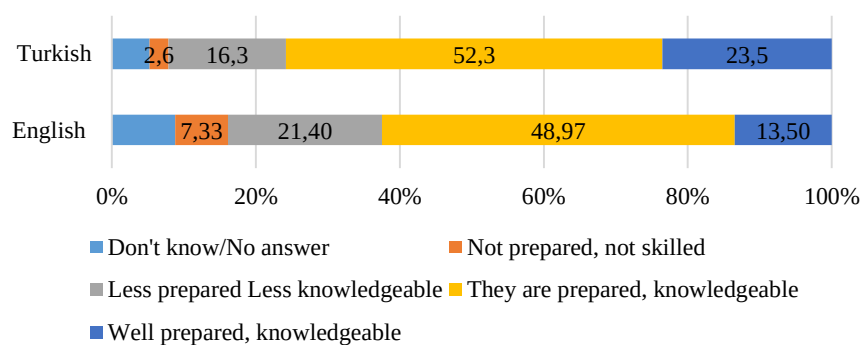


Figure 4: Students' perceptions of teachers' IT skills and use of digital tools
Source: own research, 2024, N = 340 (Hungarian), N = 153 (Turkish)

Looking at the age breakdown of the above question, we found that in both countries, the highest percentages of students in both countries chose the category "Prepared, proficient": 50.2% (16-18 years) and 42.6% (19-25 years) for Hungarian students, while the percentage was even higher for Turkish students, 59.1% (16-18 years) and 51.1% (19-25 years). This indicates that the majority in both countries have a positive perception of their teachers' digital competence, but Turkish students have an even more positive perception. The answer "Less prepared, less proficient" was mainly selected by younger Hungarian students (22.5%), while the proportion was lower for Turkish students in both age groups (9.1% and 17.6%). The answer "Very prepared, proficient" was higher for older Hungarian students (21.3%) than for younger students (11.9%), while the proportion was similar for Turkish students in both age groups (22.7% and 23.7%). The main similarity is that most students in both countries perceive their teachers as prepared, while the difference is that Turkish students in both age groups have higher positive perceptions of their teachers and fewer students perceive their teachers as less or not at all prepared. Based on Chi-squared scores, age differences were not found to be significant in either country.

Table 2: Students' perceptions of teachers' IT skills and digital tool use in the age-graded groups

	English			Turkish		
	16 years - 18 years	19 years - 25 years	Chi-square	16 years - 18 years	19 years - 25 years	Chi-square
Don't know/No answer	8,5%	10,6%	0,263	9,1%	4,6%	0,651
Not prepared, not skilled	6,8%	10,6%		0,0%	3,1%	

Less prepared Less knowledgeable	22,5%	14,9%		9,1%	17,6%	
They are prepared, knowledgeable	50,2%	42,6%		59,1%	51,1%	
Well prepared, knowledgeable	11,9%	21,3%		22,7%	23,7%	

Source: own research, 2024, N = 340 (Hungarian), N = 153 (Turkish)

5. CONCLUSIONS

The above analysis was intended to provide insights into how people perceive the technical competence of their teachers in the highly digitalised world of the 21st century. The results show that the majority of Hungarian students have a positive perception of their teachers' role in advising and supporting them in the use of IT tools and that they consider their teachers' digital literacy level to be adequate. Turkish students, on the other hand, are slightly more reserved but also generally positive about their teachers' digital competences. In both countries, the ability of teachers to support students in using digital tools and the majority of students' perceptions of their teachers' skills in using modern technologies are outstanding. In terms of age, younger Hungarian students tend to be more satisfied with their teachers' IT support, while older students in the Turkish sample rate their teachers' digital skills more highly. Cross-tabulation analyses show that, besides generational differences, patterns differ across countries, but overall, students' perceptions of teachers' digital competences are positive in both countries. The results of the research show that in a digital education environment, teachers' IT support and digital literacy are key factors that are recognised and valued by the vast majority of students. This positive feedback confirms that the development of teachers' digital competences remains a priority in both Hungary and Turkey.

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e-mail: revak.bernadett@stud.uni-obuda.hu

e-mail: kocsir.agnes@uni-obuda.hu

ASSESSING THE BASIC SKILLS OF AGILE WORKING THROUGH AN INTERCULTURAL LENS

GÁBOR STERCZL - ÁGNES CSISZÁRIK-KOCSIR

Abstract

From an educational point of view, it is important to equip students with skills that will help them at the end of their studies. For a long time now, it has not been enough "just" to have the technical skills to get a job. Soft skills are becoming more important in the labour market every year. Some skills are particularly important in agile companies, where, in addition to technical skills, there is a strong emphasis on flexibility, teamwork and continuous learning, which are key to the success of projects. The aim of this research was to investigate which soft skills important for agile operations are measured by interviewers when assessing different candidates in agile companies? The results of this research can help job seekers to be better prepared for interviews for agile companies and can also help educational institutions to see the current market needs for which they need to prepare students.

Keywords: agile skills, interview collaboration, self-management, adaptability

1. INTRODUCTION

According to a 2018 McKinsey study, 60% of employees will see 30-40% of their activities fundamentally transformed by 2030 (Bughin et al., 2018). But if we look at the labour market today, we see that the 2018 estimate was rather "optimistic". The explosive growth of generative and goal-oriented AI solutions has had a major impact on most sectors, so it is not an exaggeration to say that this level of change will already be in place by 2027. AI solutions are weaving their way through more and more domains at an ever-increasing pace, constantly undercutting the demands on the workforce. Repetitive tasks and low-value-added activities have already become increasingly backward and mechanised, but as AI algorithms and AI agents become stronger and more forward-thinking, the tasks at the top end will also shift more towards automation. This situation is fundamentally changing the expectations of companies towards their employees, among others. As a result, the value of some of the 'classic' technical and technological skills is being reduced, while the value of soft skills is being increased. Artificial intelligence can perform calculations and analyses in a fraction of a second, and analyse large amounts of data with incredible accuracy, but many of the skills needed to get the job done and make decisions still require human work. There are many tasks that require intuition, real creativity, critical thinking, or other similar human intelligence in addition to automation. Having and developing these skills can now provide a strong competitive advantage among workers.

2. LITERATURE REVIEW

Based on analysis from the World Economic Forum's Future of Jobs Report 2023 (WEF, 2023):

1. Companies expect 44% of workers' skills to change over the next 5 years,
2. Cognitive skills such as analytical thinking and creative thinking continue to lead the list of the most important skills for 2023,
3. In addition to the former, social and emotional skills such as resilience, motivation and curiosity also play an important role,
4. Among the skills, cognitive skills, especially creative thinking, are the fastest growing in importance,

5. Although 60% of workers will need retraining by 2027, only half of them have adequate training opportunities at present,
6. 82% of companies plan to invest in workplace learning and training,

As can be seen from the above, technological changes (currently mainly artificial intelligence and the solutions and technologies based on them) are dynamically transforming the priority list of the most important skills expected from employees, whereby soft skills are becoming significantly more valuable, and due to the rapid technological changes, the most important skills are currently the acquisition of new knowledge and adaptation. All these processes cannot be ignored by the education system (Strauss, 2017), so that students starting their careers are able to start their careers with marketable knowledge.

Human attributes such as Emotional Intelligence, creativity, critical thinking, adaptability play an important role in places where AI-supported work takes place (de Oliveira, 2025; Green, 2024). The relationship between agile enterprises and AI is becoming increasingly important today, as the integration of AI with agile methodologies is bringing significant transformation to the way organisations operate. Already during/after the pandemic, the importance of certain skills such as communication, problem solving and strategic thinking (Akther et al., 2023; Mizser, 2025) increased, further enhanced by the rapid pace of technological development. One result of these processes is that these skills are increasingly referred to as power skills rather than soft skills. The new name better reflects the true value and importance of these skills (Succi – Wieandt, 2019).

The agile approach is not simply a management methodology, but also a skill and a fundamental capability expected of employees in the digital world (Varga, 2021), whose interpretation and application depend largely on the attitude of managers (Dobos et al., 2022). Based on the four values and twelve principles defined in the agile manifesto (Beck et al, 2001) the agile approach offers a solution to manage change and innovation generated by the environment and rapidly changing needs (Dobos, 2024; Cobb, 2011). Agile companies strive to adapt quickly and respond flexibly to changes in the world, and therefore, in such companies, efforts to integrate AI solutions and activities have been initiated quickly, so it all need an agile solution and answer from the individual and company side as well (Tóth, 2024; Mészáros, 2024). As a result, the relationship between these companies and AI is becoming increasingly significant, as the integration of AI combined with agile methodologies is bringing significant transformation in the way organisations operate. As a result, these companies have seen an earlier emergence of the need for employees and job seekers to have the right skills to do so.

In a 2023 survey of stakeholders from 9 industries, 63% of respondents identified power skills as critical to success (Akther et al, 2023). In the same study, 69% of respondents said that if a company has limited access to these skills, it is unable to innovate effectively and 69% said it also leads to a poor customer experience. From an intercultural perspective, it is also interesting to note that, according to the results of an intercultural study, Hungarian participants tend to emphasise continuous development and flexible working, while Arab respondents associate agility more with management support and organisational culture (Csiszárík-Kocsir et al., 2024). Organizations that place a higher priority on developing power skills are able to achieve 5 times higher maturity and 2.5 times higher levels of organizational agility than those that treat them as a low priority. According to Google's Project Oxygen research, empathy, interpersonal skills, critical thinking and problem solving are the 5 most important characteristics of success in a company (Strauss, 2017). In a later study, Google also found that the most successful teams are not the ones with the smartest people, but the ones where members are equal in discussions, have high levels of social sensitivity and feel safe sharing new ideas and problems.

As can be seen from this, emotional intelligence is an important factor in the functioning of agile teams. According to Daniel Goleman, "self-awareness is the ability to understand one's own emotions, their effects, and to identify the emotions of others" (Green, 2024). This ability is particularly important when working in teams, as is the case in most agile projects and companies. The ability to be emotionally intelligent provides an opportunity to be sceptical about one's own behaviour and to identify areas of emotional intelligence that need to be developed in order to achieve sustainable, conscious success (Fitzpatrick, 2022).

In a study by Luong and colleagues, the authors found that "lack of emotional intelligence has a negative impact on the human-related challenges perceived by agile teams, such as anxiety, motivation, dimensions of communication competence and mutual trust" (Luong et al., 2019). Creative thinkers are often flexible and think differently about how to approach 1 to 1 problem, even questioning their own positions, and are able to work outside the box (Feist, 1998). This ability is fundamental, whether for developing agile processes or solving everyday problems. In 2020, Tam et al. conducted a survey with 216 agile project management professionals to assess some human factors. The results of the study led to the following findings (Tam et al, 2020). These were honesty, sense of responsibility (which are culturally derived), motivation, collaboration and interpersonal skills. Their results suggest that the agile nature of agile, which focuses on personal interactions and customer collaboration (Beck et al, 2001), leads to the impact of "personal characteristics", higher team performance and increased customer buy-in, which can even lead to an increase in project success rates (Tam et al., 2020). The findings of their study point to the importance of personal characteristics and culture development and their impact on team performance.

As can be seen from the above, the development of soft/power skills is key in the labour market, so it is important that higher education also gives priority to the development of students in this area. In order to prepare students for the jobs of the future (Strauss, 2017), educational institutions should not only focus on technical but also on human development (Succi – Wieandt, 2019), and this requires that creative and human subjects, which are often neglected, are included in the curriculum alongside technical subjects. As seen in several studies and articles, such as Chiara Succi's 2019 survey (where the vast majority of participants (85.5%)), soft skills have been more emphasised in the selection process for several years now. Companies mainly use individual interviews, case studies and group observations to assess soft skills in the recruitment process (Succi – Wieandt, 2019).

3. MATERIAL AND METHOD

The aim of the survey was to gauge the experiences and opinions of professionals working on agile projects around the world. The study was based on a quantitative methodology using a pre-tested and standardised questionnaire for data collection. The target population of the survey was professionals working on agile projects. in spring 2024, with a total of 311 participants. After data cleaning, the number of questionnaire items was 272. Participants were recruited using a snowball method, which allowed to effectively reach the potential target group. Data was collected through an online questionnaire survey and the questionnaire was disseminated through electronic channels, including e-mail enquiries, professional forums and social media platforms. This method allowed for a quick and cost-effective data collection and allowed to reach geographically dispersed respondents. The research did not use any discriminatory approach towards potential respondents and the involvement in the research was voluntary, without any financial compensation and in compliance with GDPR rules. The respondents to the questionnaire were employees working in agile workplaces who are themselves familiar with agile operations and values, and can therefore give meaningful opinions on the questions asked. The questionnaire used in this research consisted of closed questions, which facilitated data processing and analysis. Pretesting was carried out to ensure the reliability and validity of the questionnaire. This process involved testing the questionnaire on a small sample and then fine-tuning it based on feedback. During the pre-testing, particular attention was paid to the clarity of the

questions, the appropriateness of the response options and the optimisation of the completion time. A thorough data cleaning process was carried out to ensure the quality of the data. This included filtering out incomplete, inconsistent or invalid responses. After data cleaning, 272 valid completions provided the basis for statistical analysis. The data was processed and recorded anonymously, ensuring the protection of respondents' personal and business information. SPSS statistical software was used for analysis to explore deeper correlations. In the present study, we aim to investigate the characteristics that are measured and examined by the employees of each organisation during a job interview in an agile environment. To this end, we conducted distributions and cross tabulation analysis to explore the importance of each skill and its perception during an interview process. Our results are presented according to the age of the respondents (generational affiliation) and the location of the respondents' workplace (location). The composition of the sample is shown in the figure below:

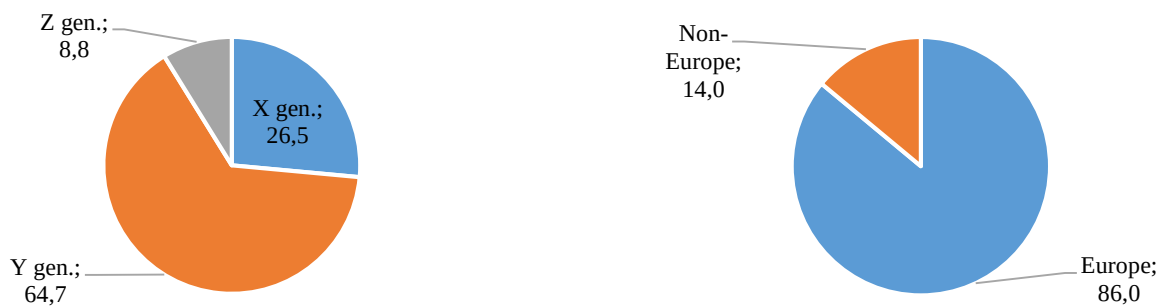


Figure 1: Composition of the sample
Source: own research, 2024, N = 272

4. RESULTS

First of all, we would like to illustrate the importance of measuring a given ability in terms of the sample. For the sample of 272 respondents, more than 80% of respondents expressed an opinion on the skill, with the proportion varying by item. Communication skills (224 respondents, 82.4%) and cultural fit (224 respondents, 82.4%) were the skills most frequently mentioned by respondents, i.e. the skills most expected and valued during the interviews. Teamwork and collaboration (222, 81.6%) and learning and development (222, 81.6%) also feature prominently, with almost equal weighting in the minds of respondents. Problem-solving (218, 80.1%) and critical thinking (218, 80.1%) are also considered important, but slightly fewer respondents mentioned these than communication or cultural fit. The skills at the bottom of the list are very surprising, however, as critical thinking has never been more important than it is today in an AI-dominated world. Adapting to changing situations is a cornerstone of agile operations, which is also a surprising result based on the responses received. The percentages for adaptability (220 respondents, 80.9%) and technical skills (220 respondents, 80.9%) are also almost the same, with only a small difference compared to the other skills.

Table 1: The emergence of a given skill or ability during interviews - based on the choices of the sample respondents

	N	%
Communication	224	82,4
Problem solving	218	80,1
Critical thinking	218	80,1
Teamwork and collaboration	222	81,6
Adaptability	220	80,9
Technical skills	220	80,9
Learning and development	222	81,6
Cultural fit	224	82,4

Source: own research, 2024, N = 272

In the following, only the yes and no answers will be further explored in order to understand which are the most important skills that future managers and colleagues measure during interviews when entering an agile organisation. Communication skills scored the highest, with 80.1% of respondents saying this is measured during interviews and only 2.2% saying no. This clearly indicates that communication is a key priority in the selection process, i.e. it is important to have the right level of communication from the moment before entry. Problem-solving skills also feature prominently, mentioned by 76.5% of respondents, while only 3.7% indicated that they are not measured. This shows that it is important for companies that candidates are able to solve problems independently and effectively, which is not a surprising expectation in an agile organisation. Teamwork and collaboration (70.6%) as well as technical skills (69.9%) and cultural fit (69.1%) also appear in significant proportions among the competences assessed during the interviews. The proportion of "no" answers for these skills is also relatively low (between 11% and 13%), meaning that the majority of respondents believe that they are also regularly encountered in the selection process. The ability to learn and develop was mentioned by 66.2% of respondents, while critical thinking was mentioned by 64.0%. These skills are also important, although they are measured at a slightly lower rate than communication or problem solving. Critical thinking has a higher proportion of "no" responses (16.2%), which may indicate that this competence is less explicitly or frequently assessed. As discussed earlier, this is a very surprising result given the increasing focus on this attribute and skill due to the rise and rise of artificial intelligence. Adaptability has the lowest proportion of 'yes' answers (59.6%) and the highest proportion of 'no' answers (21.3%), indicating that although it is considered important, its measurement is less emphasised in interviews than for the other skills listed.

Table 2: Measurement of the given skill or ability during the interviews (yes-no answers)

	Yes	No
Communication	80,1	2,2
Problem solving	76,5	3,7
Critical thinking	64,0	16,2
Teamwork and collaboration	70,6	11,0
Adaptability	59,6	21,3
Technical skills	69,9	11,0
Learning and development	66,2	15,4
Cultural fit	69,1	13,2

Source: own research, 2024, N = 272

The assessment by generation is presented below. For almost all skills, Generation X interviewers rate the measurement of these skills highly. Communication (97.0%) and problem-solving (96.8%) are considered by almost all respondents to be core competences. Teamwork and collaboration (93.9%) are also of high importance to them. Adaptability (81.3%), technical skills (81.3%), learning

and development (84.4%) and cultural fit (87.9%) also score highly, meaning that Gen X interviewers have complex, multi-faceted expectations of candidates. Although the rate for critical thinking is lower (77.4%), it is still a significant majority. The results show that Generation X is balanced in its assessment of all key competences.

Generation Y interviewers also place a very high proportion of importance on measuring communication (97.3%) and problem solving (97.3%), which are also high on their list. Technical skills (87.7%) and teamwork (82.2%) are also emphasised, but at a slightly lower rate than for Generation X. Adaptability (71.2%), learning and development (81.1%) and cultural fit (83.8%) are also important, but with a wider spread. Critical thinking (79.5%) is rated similarly to Generation X. Generation Y therefore also expects a broad range of competences, but technical skills and teamwork are more emphasised, while adaptability is less so.

The answers of Generation Z interviewees differ significantly from those of older generations. It is important to note that they represent a very small proportion of the sample, so their opinions are not very relevant due to the lack of adequate participation. For them, four skills - communication, critical thinking, teamwork and technical skills - are 100%, meaning that all Generation Z respondents believe that these should be measured in interviews. However, problem-solving, adaptability, learning and development and cultural fit scored only 60%, much lower than for Generation X or Y. This suggests that Generation Z interviewers focus very strongly on communication, teamwork, critical thinking and technical skills, while other competencies are less emphasised.

Table 3: Measurement of a given skill or ability during interviews by respondents' generational background

	X gen.	Y gen.	Z gen.
Communication	97,0%	97,3%	100,0%
Problem solving	96,8%	97,3%	60,0%
Critical thinking	77,4%	79,5%	100,0%
Teamwork and collaboration	93,9%	82,2%	100,0%
Adaptability	81,3%	71,2%	60,0%
Technical skills	81,3%	87,7%	100,0%
Learning and development	84,4%	81,1%	60,0%
Cultural fit	87,9%	83,8%	60,0%

Source: own research, 2024, N = 272

The location of respondents also yielded interesting results. Among European respondents, communication (97.9%) and problem solving (96.8%) are highly valued, with almost all interviewers placing an emphasis on measuring these, as expected from the results so far. Teamwork and collaboration (86.2%) and cultural fit (85.3%) also score highly, meaning that working together and aligning with organisational values are also important aspects. This is because European respondents are increasingly working with international teams, which makes it important for them to share a common language and understanding. Technical skills (84.9%) and learning and development (80.9%) are also significant, but slightly less important. There is a bigger difference for adaptability (71.3%) and critical thinking (79.6%): these are important but less prominent than communication or problem solving.

Communication (94.1%) and problem-solving (87.5%) continue to be high on the list of priorities for non-European respondents, but at a slightly lower rate than in Europe. In contrast, adaptability (87.5%) and technical skills (94.1%) are highly valued, with rates above European levels. Teamwork and collaboration (88.2%) and critical thinking (81.3%) also appear at high levels, similar or slightly higher than in Europe. Learning and development (82.4%) is also slightly higher, while cultural fit (76.5%) is significantly lower than among European respondents.

Table 4: Measurement of a given skill or ability during interviews based on respondents' location

	Europe	Outside Europe
Communication	97,9%	94,1%
Problem solving	96,8%	87,5%
Critical thinking	79,6%	81,3%
Teamwork and collaboration	86,2%	88,2%
Adaptability	71,3%	87,5%
Technical skills	84,9%	94,1%
Learning and development	80,9%	82,4%
Cultural fit	85,3%	76,5%

Source: own research, 2024, N = 272

Finally, we examined the impact of generational affiliation and location on the perceived importance of each skill. It can be seen that age had an effect on opinions in only two cases based on the Chi-squared value: i.e. problem solving and teamwork only. For location, there was only one case where a statistically verifiable effect was observed, namely problem solving, where the value was below 0.05.

Table 5: Impact of generational affiliation and location on the perception of specific skills

	Generation	Location
Communication	0,858	0,209
Problem solving	0,000	0,021
Critical thinking	0,251	0,827
Teamwork and collaboration	0,030	0,746
Adaptability	0,192	0,054
Technical skills	0,201	0,152
Learning and development	0,187	0,837
Cultural fit	0,082	0,199

Source: own research, 2024, N = 272

5. CONCLUSIONS

The above study showed the weight of the skills and competences that are the pillars of agile functioning for colleagues working in agile organisations and interviewing colleagues. The research shows that there is very little difference between the skills and competences listed in the perception of the respondents: more than 80% of the respondents consider each of the competences important. Communication and cultural fit were the most highly rated, while problem-solving and critical thinking were slightly less mentioned, but still highly important. The data show that almost all of the skills listed are now expected in the labour market, and the differences reflect differences in emphasis rather than real differences in importance. Generation X values all key competences highly and has complex and balanced expectations. Generation Y has a similar mindset, but with a slightly higher emphasis on technical skills and teamwork, and a lower emphasis on adaptability. Generation Z shows the most marked differences: for them, four competences are of paramount importance, while the others are considered less important. This reflects the generations' different labour market experiences and values. It was also evident that communication and problem solving are essential requirements everywhere, but outside Europe, adaptability and technical skills are more important, while in Europe cultural fit and alignment with organisational values are more important factors in interviews. This shows the factors on which future employees should place a strong emphasis in order to have a successful career. The education system can be of great help in this, both in supporting and developing these skills.

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e-mail: sterczl.gabor@uni-obuda.hu

e-mail: kocsir.agnes@uni-obuda.hu

STUDENT SPECIAL SECTION

THE FINANCIAL IMPACT OF ESG ON LARGE ENTERPRISES

BODA ZSÓFIA

ABSTRACT

The aim of this thesis is to examine investment funds operating under ESG (Environmental, Social, and Governance) principles and to analyze the impact of these principles on corporate financial performance. ESG funds have undergone dynamic growth in recent years, bringing new perspectives and challenges to investment decision-making and company valuation. This study explores the relationship between ESG performance and financial outcomes through various assessment models, literature reviews, and statistical analyses. In addition to the theoretical background, quantitative methods are used to investigate whether there is a significant connection between sustainability indicators and corporate profitability or stock returns. The results highlight that ESG ratings not only provide reputational benefits but may also contribute to financial stability and the strengthening of long-term investor confidence. The thesis aims to support a deeper understanding and practical application of ESG-based approaches in the financial sector.

Keywords: sustainability, ESG scores, risk indicators, sectoral differences, stock price volatility

1. INTRODUCTION

In recent decades, sustainability, social responsibility, and transparent corporate governance have become increasingly prominent in various areas of economic life. In parallel with this trend, the ESG (Environmental, Social, and Governance) evaluation framework has emerged as a key criterion in investment decision-making, particularly among global institutional investors, asset managers, and corporate stakeholders. ESG scores are designed to reflect the extent to which a company meets the criteria for sustainable operations and demonstrates a long-term commitment to responsible business practices. The relevance of this topic is underlined by growing concerns related to climate change, social inequalities, and corporate governance scandals, prompting market participants to place greater emphasis on ESG considerations. ESG is no longer merely an ethical or public relations matter, but a form of economic rationality that may influence corporate value creation and shareholder returns in the long term. Moreover, regulatory developments—especially the European Union's sustainability ambitions—have further elevated the importance of ESG performance. The aim of this study is to examine how and to what extent ESG scores are reflected in companies' stock market performance. While much of the existing literature suggests that the relationship between ESG and corporate operations is primarily indirect—through mechanisms such as corporate reputation, investor trust, or long-term stability—this research seeks to explore whether there is a direct correlation between ESG scores and stock prices. It also investigates potential connections between ESG ratings and company returns, risk indicators, and sectoral classifications. The first part of the dissertation outlines the theoretical foundations of the ESG framework, its interpretations, and its significance in investor decision-making. This is followed by a description of the applied database and methodology, which are based on a dataset containing ESG scores and financial indicators for major companies. The empirical section uses statistical analyses and correlation assessments to identify potential relationships between ESG scores and the examined financial parameters.

2. METHODOLOGY AND DATA COLLECTION

According to a significant portion of the literature, ESG performance can exert positive, neutral, or negative effects through indirect channels. The review of academic sources revealed that ESG rating agencies apply differing evaluation methodologies. Therefore, it is important to emphasize that I used the data from the top 100 U.S.-based companies with the highest ESG scores as ranked by the S&P 500 DJI index for the years 2022 and 2023.

The stock price data necessary for my calculations were collected from <https://www.yahooofinance.com>, while the risk-free rates were obtained from the official website of the U.S. Department of the Treasury at <https://home.treasury.gov>. The S&P 500 index served as the market benchmark in my analysis. For data processing, I used IBM SPSS Statistics version 22.0, and Microsoft Excel for the computations.

Descriptive statistics:

The most important metrics in the initial statistical analysis were the standard deviation and variance, which quantify the volatility—or risk—of stock returns. These measures provided insight into whether higher ESG scores are associated with higher or lower return volatility.

Correlation analysis:

Correlation analysis was used to explore the relationships between ESG scores and various financial indicators (actual return, CAPM expected return, Jensen's alpha, standard deviation, EPS Rating, ROI). I applied Pearson's correlation coefficient, which ranges between -1 and $+1$. A positive value indicates a direct relationship, while a negative value reflects an inverse one.

ANOVA:

A one-way ANOVA (Analysis of Variance) was performed to determine whether there were statistically significant differences in ESG scores across sectors. This helped identify whether certain industries typically perform better or worse in terms of ESG.

Linear regression:

Linear regression analysis was employed to estimate the extent to which ESG scores influence actual returns and Jensen's alpha. This model allowed me to quantify the predictive power of ESG as an explanatory variable on return-based metrics.

Financial indicators analyzed:

- *Actual return*: I used annualized logarithmic returns, which account for inflation and thus reflect the real performance of investments.
- *CAPM expected return*: Calculated using the Capital Asset Pricing Model, which incorporates risk-free return, market risk premium, and the firm's beta.
- *Jensen's alpha*: This indicator measured how much a firm's actual return deviated from the return expected under CAPM, revealing market outperformance or underperformance.
- *EPS Rating and ROI*: These fundamentals captured earnings power and investment efficiency, respectively.
- *Standard deviation*: Used in its annualized form to measure return volatility as a proxy for risk.

This methodological framework enabled a multidimensional and time-specific (2022 and 2023) exploration of the relationship between ESG performance and financial performance. By applying various statistical tools, I aimed to uncover correlations and causal patterns that may explain how sustainability influences equity market valuation.

3. RESULTS

The ESG (Environmental, Social, Governance) framework has emerged in recent years as one of the key considerations in the financial world. Measuring corporate sustainability performance is no longer merely a matter of reputation or ethics, but a factor of strategic and economic importance. The fundamental objective of ESG evaluations is to identify corporate practices and outcomes that reduce long-term financial risks and enhance investor security (Clark et al., 2015; Friede et al. 2015). The majority of the literature reports a positive or neutral relationship between ESG performance and financial outcomes. According to the meta-analysis by Clark et al. (2015), companies with a strong ESG focus tend to financially outperform their average counterparts. Friede, Busch, and Bassen (2015), in their synthesis of over 2,000 empirical studies, concluded that ESG has a demonstrable positive effect on stock returns, particularly over the long term. Conversely, other studies caution that these effects are not always consistent, especially when accounting for industry and regional differences (Revelli & Viviani 2015). The regulatory environment has also significantly contributed to the growing importance of ESG. Increasingly, countries and regions—led by the European Union—are introducing mandatory sustainability disclosure requirements. The EU's Non-Financial Reporting Directive (NFRD), and its expanded version, the Corporate Sustainability Reporting Directive (CSRD), aim to enhance transparency and comparability in corporate sustainability disclosures (European Commission 2021). As a result of these initiatives, companies are now expected to report not only on their own operations but also on sustainability risks throughout their supply chains. In parallel, ESG information is playing an increasingly important role in investment decision-making. Investors treat non-financial indicators—such as ESG scores—as risk factors and use them to shape their portfolio allocations. ESG criteria are often embedded in the decision-making frameworks of asset managers and institutional investors, particularly in strategies aimed at long-term value creation (Giese et al., 2019). Companies with higher ESG ratings frequently exhibit lower stock price volatility, which indicates lower risk and more stable returns (Giese et al. 2019). However, ESG scoring methodologies are not uniform. Rating agencies (such as MSCI, Sustainalytics, and S&P) apply different criteria, which can result in varying ESG evaluations for the same company, depending on the source. This presents a challenge for both investors and researchers, as comparability and consistency become questionable (Berg et al. 2019).

3.1 Theoretical background: esg and financial performance in the literature

The significance of ESG (Environmental, Social, Governance) criteria has steadily increased in recent years, gaining growing attention in financial decision-making as well. Meta-analyses and international studies on the topic have drawn various conclusions about the relationship between ESG scores and corporate financial performance (Friede et al. 2015). Based on numerous meta-analyses, it can generally be concluded that ESG performance tends to have either a positive or neutral relationship with financial outcomes. This suggests that high ESG scores do not, in themselves, hinder returns; in fact, they are often associated with more favorable financial performance (Clark et al. 2015). However, academic research also highlights that ESG impacts are not uniform across all companies or regions. Sectoral and geographic characteristics, along with methodological differences in ESG evaluations, all influence the nature of the relationship between ESG and financial indicators (Revelli & Viviani 2015). Some studies, for example, emphasize the environmental (E) component's significance in energy-intensive industries, while others underline the importance of the social and governance (S and G) dimensions.

Several studies suggest that companies with higher ESG scores tend to exhibit lower stock price volatility, which indicates reduced investment risk (Giese et al. 2019). This trend is supported by multiple empirical findings that show investors can expect more stable long-term performance from such firms. At the same time, the literature also includes critical perspectives on ESG: some

researchers argue that the costs associated with ESG compliance—especially for smaller firms—may reduce profitability (Bansal & DesJardine 2014). The differing methodologies and the subjective nature of ESG metrics also complicate objective comparisons.

In summary, the literature presents a mixed picture: the relationship between ESG and corporate financial performance is complex, and interpreting the results requires consideration of industry, methodological, and geographic differences. These factors are also essential for the present research, as the goal is to gain a deeper understanding of the connection between ESG and financial indicators based on an empirical dataset.

3.2 Correlation Analysis between ESG Score and Financial Indicators

The aim of the correlation analysis was to determine whether a significant relationship could be identified between ESG scores and financial performance indicators—specifically EPS Rating (Earnings Per Share) and ROE (Return on Equity).

Table 1: Correlation coefficients between ESG Score, EPS Rating and ROE (N = 100)

Correlations		ESG Score	EPS Rtg	ROE
ESG Score	Pearson Correlation	1	-,154	,068
	Sig. (2-tailed)		,126	,502
	N	100	100	100
EPS Rtg	Pearson Correlation	-,154	1	-,013
	Sig. (2-tailed)	,126		,894
	N	100	100	100
ROE	Pearson Correlation	,068	-,013	1
	Sig. (2-tailed)	,502	,894	
	N	100	100	100

Source: Own computation based on SPSS, 2025

Based on Pearson correlation coefficients, a weak negative relationship was observed between the ESG Score and EPS Rating ($r = -0.154$), which, however, was not statistically significant ($p = 0.126$). This suggests that during the examined period, an increase in ESG scores was not significantly associated with a decrease or increase in earnings per share.

The relationship between ESG Score and ROE was even weaker ($r = 0.068$), and also not statistically significant ($p = 0.502$), indicating that companies' return on equity does not directly correlate with ESG performance. Similarly, the correlation between EPS Rating and ROE was negligible ($r = -0.013$) and completely insignificant ($p = 0.894$).

Based on these results, it can be stated that for the companies examined, the ESG score alone does not show a significant relationship with either EPS or ROE. This confirms the perspectives found in the literature, which suggest that the effect of ESG is more likely to be indirect and may manifest over a longer term through other mechanisms. The lack of correlation does not rule out the possibility of more subtle connections, especially if further analysis is conducted by industry sector or over time.

3.3 ANOVA Analysis: Examining Sectoral Differences in ESG Scores

To determine whether a company's industry classification influences its ESG performance and financial indicators, a one-way analysis of variance (One-Way ANOVA) was conducted for both the years 2022 and 2023.

Table 2: Summary of ANOVA results for ESG Score, EPS Rating and ROE by Sector (2022–2023)

Year	Variable	F-value	Sig. (p-value)	Significant?
2022	ESG Score	1.046	0.411	No
	EPS Rating	1.746	0.090	No
	ROE	0.830	0.591	No
2023	ESG Score	1.271	0.264	No
	EPS Rating	5.962	0.000	Yes
	ROE	0.461	0.897	No

Source: Own computation based on SPSS, 2025

Based on the 2022 data, no significant sectoral differences were observed in ESG Scores ($F = 1.046$; $p = 0.411$), nor in EPS Rating ($F = 1.746$; $p = 0.090$) or ROE ($F = 0.830$; $p = 0.591$). This suggests that, in that year, a company's industry classification did not significantly influence its sustainability performance, earnings per share, or return on equity.

However, in 2023, significant sectoral differences were found in the EPS Rating ($F = 5.962$; $p = 0.000$), indicating that earnings per share were strongly dependent on industry affiliation during that year. This implies that sector structure played a greater role in companies' profitability. At the same time, there were still no statistically significant differences in ESG Scores ($F = 1.271$; $p = 0.264$) or ROE ($F = 0.461$; $p = 0.897$) across sectors.

In summary, while ESG performance and return on equity appeared to be sector-independent, earnings per share showed considerable industry-specific variation in 2023. This supports the notion that certain financial indicators—particularly EPS—are more sensitive to sectoral characteristics, whereas ESG performance tends to develop based on company-specific attributes.

3.4 Regression Analysis: The Relationship Between Volatility and ESG Score

Building on the results of the previous analyses, I conducted a linear regression to further investigate how the standard deviation of stock returns affects the ESG score. In the model, the ESG Score was used as the dependent variable, while the independent variable was the standard deviation, analyzed separately for two distinct years.

Table 3: Relationship between ESG Score and Volatility in 2022

Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	66,659	,895		74,507	,000
Szórás	-,314	,367	-,086	-,855	,394

a. Dependent Variable: ESG Score

Source: Own computation based on SPSS, 2025

The 2022 regression model did not reveal a significant relationship between the variables. The regression coefficient for standard deviation was -0.314 , which was not statistically significant ($p = 0.394$). This indicates that in that year, volatility had no measurable impact on the ESG score.

Table 4: Relationship between ESG Score and Volatility in 2023

Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	63,811	1,889		33,778	,000
Szórás_A	-1,987	,970	-,203	-2,048	,043

a. Dependent Variable: ESG score

Source: Own computation based on SPSS, 2025

In contrast, by 2023 a statistically significant negative relationship emerged: the regression coefficient for standard deviation was -1.987 , which proved to be significant at a p -value of 0.043 (at the $\alpha = 0.05$ level). This indicates that in 2023, stocks with higher volatility (i.e., greater risk) were associated with lower ESG scores, and this relationship is statistically supported. The results of the regression analysis suggest that the relationship between ESG scores and volatility is not time-invariant. While no measurable effect was observed in 2022, a significant negative association emerged in 2023. This supports the assumption that companies with higher ESG ratings tend to exhibit lower market volatility—meaning they are generally perceived as less risky. However, the strength of this relationship remains moderate, and its explanatory power is not absolute, indicating that other influencing factors cannot be ruled out.

4. CONCLUSIONS

The aim of this research was to explore the relationship between ESG scores and key financial performance indicators of companies—particularly stock return volatility, profitability, and elements of capital structure. The analysis was based on data from the top 100 US-based companies with the highest ESG ratings in the S&P 500 DJI index, using data from 2022 and 2023, processed through

quantitative methods in IBM SPSS. Correlation and regression analyses revealed that ESG scores were not significantly related to the main financial indicators in most cases. The relationships between ESG scores and EPS rating or ROE were weak and statistically insignificant, suggesting that ESG performance alone does not clearly predict financial success. However, a significant negative relationship was found between standard deviation (used as a volatility proxy) and ESG scores in 2023, indicating that companies with higher ESG scores tend to exhibit lower stock price fluctuations and may be perceived as more stable, lower-risk investments. The ANOVA tests showed no significant differences in ESG scores and ROE across sectors, while EPS ratings did show statistically significant differences in 2023, implying that earnings per share are strongly influenced by sectoral characteristics. This highlights the importance of considering industry-specific contexts when interpreting ESG evaluations. In conclusion, ESG scores—especially in terms of reducing volatility—can hold value for investors, but they do not fully explain financial performance on their own. ESG assessments should be interpreted alongside other financial and sector-specific metrics. These findings reinforce the notion in the literature that ESG impacts are mostly indirect, acting through channels such as corporate reputation and investor confidence.

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Author's address

Boda Zsófia

University of Sapientia, Faculty of Economics, Socio-Human Sciences and Engineering
Piața Libertății 1, Miercurea Ciuc

Email: bodazsofia33@gmail.com

BUSINESS APPLICATION OF FRAMING

ATTILA SZŐCS - TIMEA BENCZE

ABSTRACT

As models gradually emerged to describe specific behavioral patterns that classical psychology could not account for, the research of Tversky and Kahneman in the 1970s represented a potential breakthrough. Their work moved beyond the original framework of cognitive psychology, placing increasing emphasis on economic issues. Growing scientific interest in this direction led to the emergence of a new field: behavioral economics.

This new scientific discipline gained wide popularity not only in academic circles, but also in popular science publications. Its findings were frequently cited for providing insights into how people make decisions under uncertainty.

Behavioral economics brought particular value to the field of marketing by explaining why consumers behave irrationally under the influence of emotions, time pressure, and contextual factors in real-world market conditions.

Despite its widespread acclaim and the awarding of two Nobel Prizes, the prospect theory developed by Tversky and Kahneman (1979) has not been widely applied in practice (Barberis, 2013). This article explores the concrete business applications of the theory, with special emphasis on the concepts of nudging, framing, anchoring, and the white mouse strategy.

1. BUSINESS/MARKETING APPLICATIONS

According to traditional economics, prices are determined by supply and demand. This approach assumes that consumers make rational choices and maximize their own utility given the information available to them. In reality, this decision-making is significantly more complex, as people's decisions are often influenced by a few psychological factors, such as emotions, cognitive biases, and mental simplifications, so-called heuristics.

A deeper understanding of these behaviors is made possible by behavioral economics, which explores the laws of actual human decision-making at the interface of psychology and economics. It is not a new system of economics but a complement to it, especially where classical models cannot provide a satisfactory explanation for irrational consumer behavior. This model also offers concrete tools to influence decisions and thus price formation.

Among the best-known proponents of behavioral economics are Daniel Kahneman and Amos Tversky, who established prospect theory, and Richard H. Thaler and Dan Ariely, who studied the practical, economic, and social consequences of biases. Thanks to their work, over the past decades the results of behavioral economics have become increasingly important in marketing, pricing, and influencing consumer decisions. Companies are increasingly using nudge, framing, anchoring, and decoy techniques to not only satisfy consumer needs and choices, but also to manage them.

The aim of this paper is to examine how these behavioral techniques are reflected in business practice, with a particular focus on pricing strategies. The paper presents different decision biases and then analyzes the use of mental accounting, nudge marketing, reference pricing, decoy options, and framing effects in different industries through concrete examples.

1.1. MENTAL ACCOUNTING AND DECISION BIAS

Consumers' decisions are not always driven by rational considerations, as traditional economic models assume. In reality, people do not make perfectly logical, utility-maximizing decisions, but often base their decisions on emotions, experience, and simplistic thought patterns, called heuristics. This insight has provided the basis for the strategy of behavioral economics, which investigates the psychological processes behind consumer decisions.

Three basic principles are of particular importance in price perception and purchasing decisions, and are central concepts of prospect theory:

- **Reference point dependency:** People do not value absolute gains or losses, but the change results from their decision compared to their current situation. In other words, they always evaluate their results against a starting point.
- **Loss aversion:** The psychological impact of losses is stronger than that of gains of the same value. This fundamentally distorts price perception and purchasing decisions.
- **Decreasing sensitivity:** People's sensitivity to change is not linear. A small amount of savings on a cheaper product may seem significant, but the same amount as a decrease in the price of a more expensive product is barely noticeable. For example, a €5 discount has a different effect on a €50 product than on a €500 product.

These principles are closely related to the concept of mental accounting introduced by Richard Thaler. According to mental accounting, people manage financial events using separate "mental accounts", which significantly influences how they evaluate expenses or gains.

This theory is well illustrated by Tversky and Kahneman's 1980 "lost theater ticket" examples:

- *Situation 1:* A person bought a theater ticket for \$40 but lost it before the performance. The question is: would they be willing to buy another ticket?
- *Situation 2:* The person has not yet bought the ticket, but before arriving at the theater, they lose two \$20 bills. The question is the same: would they be willing to buy the ticket?

The results show that most people were not willing to buy a second ticket in the first scenario, as they felt that the experience was not worth a total of \$80. In the second scenario, however, the majority were willing to purchase the ticket, because they did not associate the \$40 loss with the ticket. The interpretation of money thus depends on which "mental account" the loss is allocated to.

A discount and a refund of the same amount have different psychological effects, since a refund presented as a reward often creates a more positive feeling, it appears on a separate account as a gain.

These principles determine how prices should be set, how they should be communicated, and how promotions should be organized. In many cases, customer decisions are not influenced by the actual price level, but by its psychological framing, that is, how the information is "presented".

1.2. NUDGE IN PRICING

The concept of nudge was introduced by Richard Thaler and Cass Sunstein. One of the best-known ideas in behavioral economics refers to the creation of a choice environment that does not restrict

freedom but gently guides people toward options that are more likely to be beneficial or preferred. The aim is not to manipulate the buyer but to influence decisions through subtle psychological mechanisms. A nudge does not prohibit or coerce, it merely steers.

A classic example of nudging is found at Schiphol Airport, where a tiny fly decal was placed under men's urinals. This small visual cue reduces mess by 80%, significantly lowering cleaning costs. The example illustrates how a simple design element can influence behavior without the need for rules or enforcement.

In business, especially in digital environments and pricing strategies, the use of nudging is becoming increasingly widespread. Three common techniques include:

- **Urgency Cues** - Examples include messages like “Only 2 items left.” or “Offer ends at midnight.”. These emphasize time pressure or limited stock, activating a fear of missing out and prompting faster decision-making.
- **Targeted Offers and Goal Activation** - Personalized promotions based on users' past behavior, such as “4 people are currently viewing this product.” or “Only 1 item is stock, free shipping included.”, give the impression that of exclusivity and scarcity. These tactics activate goal/driven motivation and make the deal feel immediate and personal.
- **Default Options** - Many services pre-select the more expensive or “recommended” plan. While customers can manually opt for a cheaper choice, many don't change the default. This leverages inertia and convenience to influence the final decision.

1.2.1. BUSINESS EXAMPLE – UBER

Uber provides a strong real-world example of how nudge techniques can shape behavior while preserving freedom of choice. Since drivers are independent contractors and not employees, Uber cannot dictate their work hours, yet the platform subtly guides behavior through behavioral science.

Key techniques include:

- **Target messages**, such as “You're only \$10 away from your goal.”, play on loss aversion and motivate continued driving to avoid the feeling of missing out on income.
- **Gamification elements**, like progress bars, badges, and animations, offer non-monetary reward and immediate feedback. These maintain engagement even during low-reward periods.
- **Prediction and confirmation**, like “Two more rides and you get a bonus.”, encourages action by emphasizing how close the driver is to a reward, a phenomenon known as the goal gradient effect.
- **Next ride nudging**, where a new ride is offered before the current one ends, reduces idle time and increases the chance that drivers keep going without interruption.
- In all of these, Uber does not issue commands, it simply builds a choice environment in which the option that benefits Uber most also feels like the most obvious and convenient choice for the driver.

1.2.2. BLACK NUDGE - THE FACEBOOK EXAMPLE

While nudging is originally intended to support individuals in making better decisions without limiting their freedom, it can also be misused for manipulative purposes. This darker application of nudging, often called black nudging, exploits cognitive biases not for the benefit of the individual, but to serve corporate or political interests.

A well-known example is a secret Facebook experiment conducted in 2012. In this study, the news feeds nearly 700,000 users were manipulated without their knowledge or consent. Researchers increased the proportion of either positive or negative posts shown to each user to observe how this would affect their behavior.

The results showed that users' own posts reflected the emotional tone of the content they had been exposed to, a phenomenon known as emotional contagion. Importantly, the participants were unaware that they were part of an experiment, raising serious ethical concerns.

Although the study served an academic purpose, it raises critical questions about the power of digital platforms to influence emotions and decisions through hidden algorithms. The Facebook case demonstrates that nudging, when combined with an opaque system, can easily cross the line from guidance to manipulation.

1.2.3. WHERE ARE THE BOUNDARIES OF ETHICS? THE MORAL DIMENSIONS OF DECISIONS AND PRICING.

The concept of black nudge is especially relevant when designing promotional messages, default settings, or pricing models. A marketing tactic is ethical only if it supports autonomous decision making, not if it exploits human cognitive limitations.

In business practice, this means that influencing behavior is not just a strategic issue, but also a moral one. Companies must ensure that their pricing tactics and decisions architectures respect consumers' freedom and psychological integrity. Nudges should guide, not deceive.

1.3. ANCHORING – THE ANCHOR IN PRICE SENSING

Consumer decisions are often influenced not only by the absolute value of a price but by the reference price, the first number they see or expect. This is known as the anchoring effect: people tend to rely heavily on the first piece of information presented (the “anchor”) when making subsequent judgments, even if that information is arbitrary or unrelated.

1.3.1. MISSISSIPPI EXAMPLE – ANCHORING AND ESTIMATION BIAS

One of Kahneman and Tversky's classic demonstrations involved a simple question about the length of the Mississippi River. Participants were split into two groups:

- Group 1 was asked: “Is the Mississippi River longer or shorter than 500 miles?”
- Group 2 was asked: “Is the Mississippi River longer or shorter than 5,000 miles?”

After answering the yes/no questions, both groups were asked to estimate the river's actual length.

- Group 1's median estimate: 1,000 miles
- Group 2's median estimate: 2,000 miles

The striking difference illustrates how even an obviously inaccurate number can “anchor” our thinking and skew our perception. The anchoring effect doesn't just apply to geography or trivia; it plays a powerful role in pricing decisions as well.

1.3.2. WILLINGNESS TO PAY IN CASE OF HOTEL PRICE INCREASES

An empirical study by Smith and colleagues (2016) in a hotel setting showed that the acceptability of price increases is strongly dependent on the communicated reference price. A survey of 415 hotel guests was conducted in three different categories of hotels in the southeastern region of the US. The research was designed to examine the impact of room rate increases and discounts on consumers' willingness to purchase compared to a previously experienced reference price.

Participants were given a situational questionnaire where they were first asked to indicate their own reference price (e.g., how much they had paid for the same room before) and then presented with different prices. Increases of +\$20, +\$40, +\$60 and discounts -\$20, -\$40, -\$60 were compared to the reference price. In each case, they were asked to use a seven-point Likert scale to indicate how willing they would be to book the room.

The results showed that price increases decreased willingness to buy in a linear fashion: the larger the increase, the lower the respondents' willingness to purchase. In contrast, price cuts did not lead to a linear increase in willingness to pay. Only a +\$40 discount had a statistically significant positive effect. The \$20 discount was not considered a meaningful motivator, and the \$60 discount raised suspicion among respondents.

1.3.3. FACEBOOK EXPERIMENT – ANCHORING AND DEFAULT EFFECT

An experiment by Tesary, Lin and Strulov-Shlain (2024) highlights that the anchor effect also introduces bias in the evaluation of personal data. In the study, 5,028 US Facebook users participated and were asked how much they would be willing to share various personal data (e.g., posts, likes, acquaintances, survey responses) for research or advertising purposes.

Two key influencing factors were changed in the experiment:

- automatic sharing, opt-in, or active decision;
- and the price anchor used – low: \$0-50, high: \$50-100.

The results showed that, on average, users gave 37.4% lower data values for the low-price anchor than for the high-price anchor. However, it was also found that when someone had to opt in to sharing, they gave a 22.1% higher value, with an 11.8% increase for active choice compared to automatic sharing.

The data values provided by the participants showed wide variation, with the average willingness to accept (WTA) being \$54.2. While questionnaire responses were valued at an average of \$35.5, data on acquaintances were valued at \$64.6. For at least one type of data, 18.3% of respondents said they would not be willing to share it for any monetary compensation. This attitude was particularly prevalent for acquaintances and contact data, where this proportion researched 31.7%.

A significant finding of the research is that sociodemographic factors strongly influence sensitivity to the anchor effect. In particular, the results illustrate that the combination of the reference (anchor) and the default setting has a significant impact on decision-making. If the choice architecture is solely focused on increasing the amount of data, it may lead to sample selection and a lower representativeness of the dataset. It is therefore clear that it is not sufficient to increase the volume of data collection alone; it is also important to ensure that the data reflects the diversity of the target groups in an unbiased way. This leads to more sustainable decision making, both ethically and commercially.

1.4. DECOY – CHOICE CONTROLLED BY DECOY OPTION

Purchasing decisions are influenced not only by the content of the choices but also by the relationship between values. The decoy effect shows a consciously inserted, seemingly less attractive choice can steer people's decisions in a predetermined direction.

One of the best-known examples of this phenomenon is Dan Ariely's (2008) experiment on Economist subscriptions, the details of which are presented below.

1.4.1. ECONOMIST SUBSCRIPTION EXAMPLE

The subscription included three options:

- Online subscription only: \$59
- Print subscription only: \$125
- Online + print subscription together: also \$125

The second option, the "print only" subscription, seems to be a completely pointless choice, as it costs the same as the combined package but offers less. Nevertheless, its presence had a significant impact on subscribers' decision-making.

Ariely presented the offers to two different groups: the first group could choose from all three options, while the second group had the "print only" subscription removed and could choose between two options.

When all three options were included, the results were:

- Online only: 16%
- Print only: 0%
- Online + print: 84%

When the "print only" option was removed, and only the following two remained:

- Online only: 68%
- Online + print: 32%

The experiment demonstrates that by deliberately building in an illogical "decoy" option, consumers' decision-making can be significantly influenced, as they will tend to choose the option that appears to be a better deal in comparison.

The decoy effect is also a strategy often used in everyday business practice, especially in pricing decisions. We often see in restaurant menus, subscription packages, or the pricing of different products that the use of a middle, less favorable offer artificially increases the attractiveness of a more expensive option. The decoy works most effectively when it is clearly less favorable than one of the alternatives. This partial comparability creates the illusion that the dominant offer is superior, even if the decision is not actually based on an objective comparison.

The technique illustrates that consumer decisions are influenced not only by preferences but also by the structure, order, and comparability of the available options. In other words, the environment in which the choice is made can be just as important as the product itself.

1.5. FRAMING – THE FRAMING OF DECISIONS

The framing effect is that people interpret the same information differently depending on the linguistic or emotional context in which it is placed. One of the major insights of prospect theory is

that decisions are framed not only by the facts communicated but also by their psychological context, i.e., the way information is “presented” influences the perception and behavior of the decision-maker.

Traditional economic models assume that decision-makers respond in the same rational way to equally valued options, regardless of how they are framed. Behavioral economics, however, reveals that changing the context in which decisions are made can fundamentally transform people's choices.

1.5.1. ASIAN DISEASE EXAMPLE – STRICT FRAMING

One of the best-known classic examples is Kahneman and Tversky's 1981 “Asian disease” experiment, in which the same life-and-death dilemma was presented to participants in two different formulations.

Research participants were told that a fatal disease was expected to threaten the lives of 600 people and were given a choice of two possible programs. The program was formulated in two ways:

- Positive context (“rescue”)
 - A: 200 people will definitely be saved.
 - B: 1/3 chance that 600 people will be saved, 2/3 chance that no one will be saved.
- Negative context (“death”)
 - C: 400 people are sure to die.
 - D: 1/3 chance that no one will die, 2/3 chance that everyone will die.

When the response options were framed positively, i.e., “save”, the majority of participants chose option A, the safe choice, even though it only saved 200 people. Here, participants acted in a risk-averse manner.

However, when the same options were expressed in negative terms, i.e., “death”, the majority chose the riskier option D. In this case, participants became more risk-seeking, hoping for a chance to avoid total loss.

We can see that the mathematical structure of the two sets of options is identical, yet people made entirely different choices depending on whether the scenario was framed around saving lives or losing lives. This experiment perfectly illustrates a central principle of prospect theory: people are more sensitive to losses than to gains of equal size. A “gain” frame encourages risk aversion, while “loss” frame triggers risk-taking. Words, emotional tone, and context often outweigh numbers or logic in shaping decisions.

1.5.2. VOLVO – EMOTIONAL FRAMING CAMPAIGN

The effect of framing is most pronounced when a brand not only shares product attributes with customers but also communicates through emotional narratives.

Volvo's “The Volvo Saved My Life Club” campaign is a perfect example of how a car brand can become an emotional message through life stories rather than safety statistics. It tells the stories of people who say Volvo saved their lives. This campaign is a textbook example of positive emotional framing and a story-driven approach.

The focus of the campaign is not on technical details such as “Volvo has 9 airbags” or “the body is 23% stronger”, but on poignant yet uplifting stories where Volvo is presented as a protective companion, almost like family (“Volvo protected my children,” “I survived because I was in a Volvo”). In this way, the car is not just a four-wheeled means of transport but a safety shield

symbolizing the protection of loved ones. The campaign sends a powerful message: “It’s not just a car. It’s a protection system for you and your family.”

Personal stories of survivors evoke empathy, and through affective heuristics, emotions drive the decision, not conscious deliberation. This campaign is a masterful example of positive emotional and narrative framing, showing how a “cold” technical feature can become a “warm”, emotionally relatable experience.

1.5.3. VOLVO E.V.A. CAMPAIGN – ETHICAL FRAMING

Volvo’s E.V.A. (Equal Vehicles for All) campaign is an excellent example of the use of moral framing in marketing communication. The focus of the campaign was not on technical developments in the brand’s products but on raising awareness of social injustice: most car safety tests are carried out with male dummies, putting women and smaller people at greater risk of injury in a crash.

Volvo reframed this problem not only by announcing new testing methods but also by making public its own safety data collected over decades. In doing so, the company clearly demonstrated that it takes responsibility for the safety of all road users, regardless of gender, body shape, or background.

The central message of the campaign is: “Security should not be a privilege. Safety is for everyone.”

The E.V.A. campaign is not just an advertisement but a values-based message that goes beyond product marketing and becomes a moral statement. It is an example of how a brand can enter public discourse without losing its business focus. Volvo placed its message within an ethical framework, declaring that safety is not a privilege but a right for all. This type of ethical framing is especially effective when purchasing decisions are not merely practical but also reflect the consumer’s identity and social values.

1.6. SUMMARY AND CONCLUSION

We can conclude that pricing is not only a mathematical decision but also a cognitive and emotional one. This thesis aims to present tools and situations of particular relevance to behavioral science that go beyond classical cost-based or market-based pricing models. The toolbox of behavioral economics, such as mental accounting, anchoring, decoy options, nudging, and framing, highlights that consumer decisions often follow irrational patterns and that even small changes in the decision environment can significantly affect price-related choices.

Framing plays the most important role in influencing decision situations, as it distorts and restructures the internal logic of consumer choices. Research and case studies, such as Asian disease experiment and Volvo’s campaigns, clearly show that presenting the same information within different frames elicits entirely different behaviors. In such cases, consumer decisions depend on whether the information is perceived as a risk, an opportunity, a moral issue, or part of one’s identity. Framing is also unique in its ability to elevate prices, products, and brand communication to a higher, symbolic level of meaning. Volvo’s E.V.A. campaign, for example, is not only about technological innovation but also about presenting safety as a matter of social equality.

Behavioral pricing techniques also impact brand trust, customer relationships, and the perceived quality of the decision environment. When applied consistently and ethically, tools such as framing, nudging, anchoring, and decoy models contribute to long-term brand building, enhance consumer trust, and create a choice architecture that guides rather than manipulates.

Pricing can no longer be interpreted solely from an accounting or market perspective. Today's effective marketing strategies must consider human perception, emotional reactions, cognitive biases, and the complexity of decision-making patterns. Behavioral science approaches therefore suggest that pricing should incorporate psychological factors in order to align business objectives with consumer decision-making mechanisms, and to create real, effective strategies that work.

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Author's address

Szócs Attila

University of Sapientia, Faculty of Economics, Socio-Human Sciences and Engineering
Piața Libertății 1, Miercurea Ciuc

Email: szocsattila@uni.sapientia.ro

Bencze Tímea

University of Sapientia, Faculty of Economics, Socio-Human Sciences and Engineering
Piața Libertății 1, Miercurea Ciuc

Email: benczetimea@uni.sapientia.ro

THE IMPACT OF GREEN MARKETING ON CONSUMER BEHAVIOUR IN THE COSMETICS INDUSTRY

BECSEK BEATRIX-ERIKÁ

ABSTRACT

Increasing consumer awareness and interest in sustainability has helped green marketing to play a growing role in the lives of companies. The aim of this thesis is to examine the relationship between green marketing and consumer behaviour, as well as the impact of green labelling, greenwashing and the increase in consumer trust and loyalty.

The research shows that credible sustainability credentials contribute to firms' competitive advantage, whereas miscommunication (greenwashing) leads to loss of consumer trust and reputational risks.

The research shows that for companies, demonstrable communication is not only an ethical obligation but also an economic interest. The paper presents possible strategies for preventing greenwashing and creating transparent green communication. These include the use of independent certification, public disclosure of detailed sustainability reports and consumer awareness.

Drawing on relevant literature, case studies and other research, the paper presents the current state of green marketing, its challenges and opportunities, with a focus on the cosmetics industry. The results clearly show that consumers are becoming more aware, more in control of products, more willing to pay more for a sustainable product, so for them credibility is essential to build their loyalty.

Key words: green marketing, greenwashing, sustainability, environmental protection

1. INTRODUCTION

When selecting the topic for my research, I considered it essential to choose a subject that is not only of current relevance but also aligns with my personal interests. I firmly believe that genuine curiosity represents one of the most powerful motivational drivers, which is indispensable for conducting thorough research and producing credible, meaningful results.

I have long been interested in the field of corporate marketing and the strategies underpinning it. At the same time, as a consumer, I place significant importance on making conscious and responsible purchasing decisions, particularly in relation to environmental protection and sustainability. For this reason, my thesis focuses on the impact of green marketing on consumer behavior and explores how this trend is influencing corporate marketing strategies - how these strategies are evolving and what alternatives companies are adopting in response.

Throughout the research process, I had the opportunity to examine the practical implementation of green marketing, with particular attention to its perceived credibility and its influence on consumer decision-making. My objective is to provide a more nuanced understanding of the extent to which corporate green claims are authentic, and how these claims affect purchasing behavior. In today's

market, an increasing number of companies are seeking to capitalize on the rising societal interest in sustainability to enhance their market position and profitability.

The primary aim of this thesis is to investigate the relationship between green marketing and consumer behavior, with a particular focus on the phenomenon of "greenwashing" and its implications for consumer decisions. Based on the findings of an online questionnaire survey I conducted, I seek to analyze consumer responses to green signals and identify the key factors that influence demand for environmentally friendly products. Furthermore, I assess the effectiveness of green marketing from a practical standpoint.

I am convinced that genuine interest and a strong sense of commitment are fundamental to the success of any research endeavor. These qualities help maintain motivation throughout the extended research process and ensure that the final thesis offers valuable academic insight. I sincerely hope that my chosen topic not only reflects my personal engagement but also contributes to the broader dissemination of sustainable thinking and environmental awareness.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1. Sustainability Efforts Among Companies

In recent years, consumers have become more conscious when making purchasing decisions and are increasingly willing to pay higher prices for environmentally friendly products (Interworld, 2021). In response, many companies (e.g., IKEA) have launched sustainability campaigns aimed at reducing their carbon footprint and implementing energy-efficient solutions (Alrawabdeh, 2024). However, the phenomenon of "greenwashing" remains a significant issue, as misleading environmental claims undermine consumer trust. In response, the EU has begun to tighten regulations surrounding green marketing communication. The goal of the European "Green Deal" is to achieve climate neutrality by 2050, providing a new framework for how companies should operate. Alongside this, technological innovations such as renewable energy and digital supply chains further support environmentally conscious and sustainable operations (Czékus, 2023).

2.2. Economic Sustainability and Its Corporate Benefits

From a business perspective, sustainability ensures economic stability and customer loyalty. A model built on the balance of economic, social, and environmental aspects enables more efficient resource utilization. In addition to the "three-pillar" model, the concept of the circular economy has emerged, focusing on waste recycling and closed-loop production systems (GVH, 2020). Sustainability can be interpreted in different ways: as strong sustainability, where natural capital cannot be substituted; as weak sustainability, where it can be replaced by technology; or as a treadmill model, where growth and sustainability are fundamentally contradictory

2.3. The Role of Marketing in the Economy

Marketing plays a key role in the life of a business not only as a tool for advertising, but also as a means for identifying and fulfilling consumer needs, thereby building or strengthening competitive advantage (Kiss, 2016). Green marketing drives innovation by encouraging the development of new products, sustainable, recyclable or biodegradable packaging, vegan ingredients, and digital solutions just to name a few (Alrawabdeh, 2024). Thus, the primary goal of marketing is to build and increase awareness. It not only sells, but also informs, engages, communicates, and fosters consumer loyalty and trust (Interworld, 2021).

2.4. The Significance of Green Marketing in the Modern Corporate Sector

Strategic green marketing models such as circular economy approaches or value chain-based strategies aim to integrate sustainability across all corporate levels. This includes green product development (e.g., energy-efficient technologies, biodegradable materials, recycling), green packaging (e.g., paper, compostable materials, bioplastics, FSC certification), and green pricing (e.g., premium pricing or cost-based models). The key to success is transparency. Verified certifications significantly enhance brand trust and thereby reduce consumers' price sensitivity (Greenly, 2023).

2.5. Greenwashing: The Risks of Sustainable Communication

Greenwashing intentionally misleading consumers about a product's or brand's environmental performance reduces trust and damages brand credibility. Examples include exaggerated claims (e.g., declaring a product as "100% green" without evidence), irrelevant information, and the use of false or misleading labels and certifications.

Prevention requires authentic communication, independent audits, transparent reporting, and active consumer engagement (Horváth, 2024). Social media has become essential in this regard, as consumer feedback is now instant and greatly influences public perception of companies.

3. RESEARCH METHODOLOGY

My research was conducted using a quantitative method, which involves the collection of numerical and statistically analyzable data. I carried out primary research in the form of a questionnaire survey, targeting young people from the Székelyföld region aged between 20 and 30 years. The aim was to assess their awareness of sustainability, their cosmetic purchasing habits, and their knowledge about green products. The data was collected through a self-administered Google Forms questionnaire, which is included in the appendix. The objective of the study was to assess the level of awareness, purchasing behavior, and expectations of young people living in Székely Land. The survey examined the most important factors influencing the purchase of cosmetics, how much more they are willing to pay for natural cosmetics, whether they seek information about products before purchasing, and whether they are familiar with the concepts of green marketing and greenwashing.

A total of 105 responses were received. In terms of gender distribution, 88.7% of respondents were female, while only 11.3% were male. This gender imbalance was expected, as women tend to be more willing to participate in surveys of this nature and show greater interest in the topic.

As for the age distribution, the age of 23 was the most frequently represented. However, due to the predefined age range (20–30 years), the age groups were overall evenly distributed.

In terms of place of residence, the results were nearly balanced: 51.9% of respondents were urban, while 48.1% lived in rural areas.

Respondents with higher levels of education were more represented, suggesting that individuals who have completed more stages of formal education are more likely to participate in such surveys. Given the age group, the majority of participants were students or university attendees.

Based on the research topic, I formulated the following hypotheses:

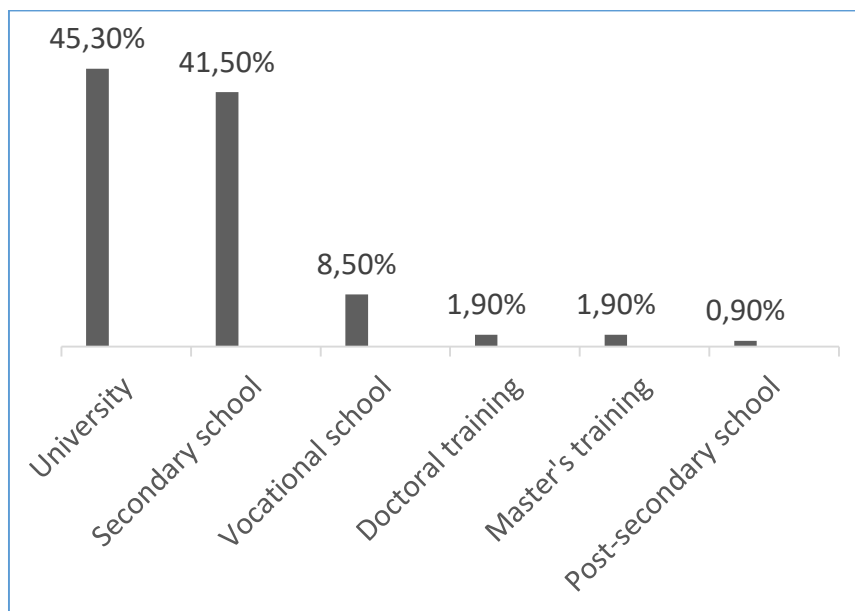
1. Those who purchase cosmetics more frequently are more likely to pay extra for sustainable products.
2. Individuals with personal income are more likely to purchase sustainable cosmetic products than those without income.

3. People living in urban areas are more likely to buy cosmetic products regularly than those in rural areas.
4. Those who consider companies' green claims to be trustworthy are more likely to purchase sustainable cosmetics.
5. The quality of cosmetic products is a more important factor in purchase decisions than brand name or price.

The responses were analyzed using the **SPSS software**, through which I examined relationships between the hypotheses. The findings were presented in the form of **charts and graphs**, which served as the basis for the interpretation and discussion of the results.

4. RESULTS AND DISCUSSION

The chart below shows the educational background of the respondents. As can be easily observed from the figure, the majority were university students, representing 45.3%. They were followed closely by high school students, with 41.5%. After that, there is a significant drop, with vocational school graduates making up 8.5%, while all other categories appeared in only very small percentages.

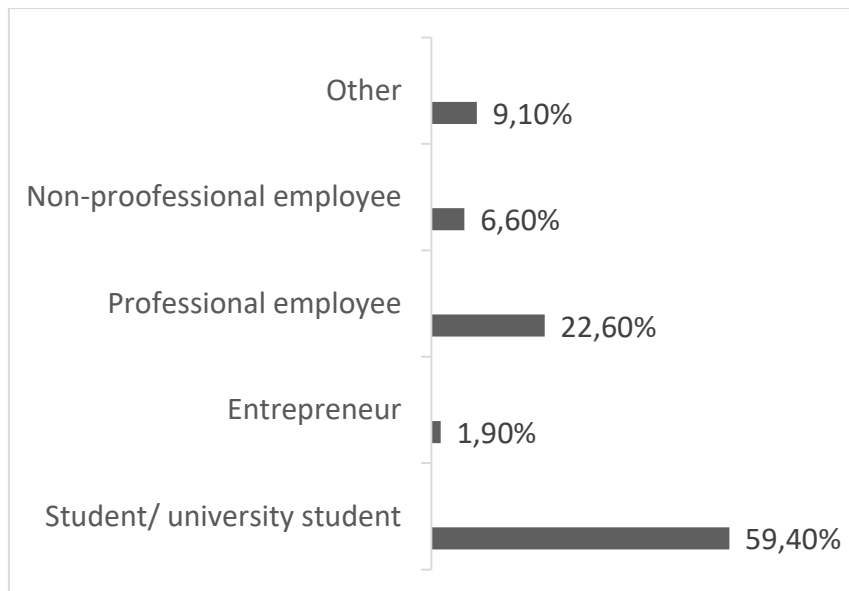


1. Figure: Educational background (Source: Author's own editing)

The following figure shows the current occupation of the respondents.

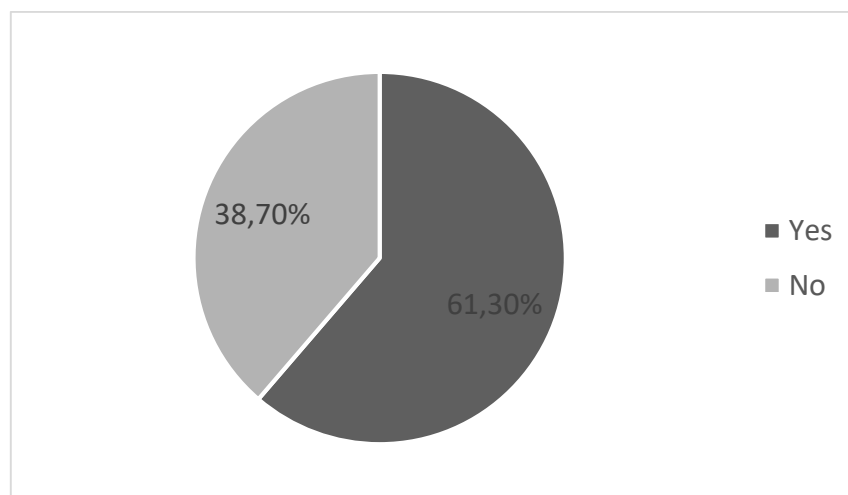
It reveals that more than half (59.4%) are still students. This is followed by profession-related employees (22.6%). 9.1% chose the "Other" category, which includes homemakers, freelancers, etc.

6.6% were employed outside their profession, and finally, only 1.9% identified themselves as entrepreneurs.



2. Figure: Current occupation of respondents (Source: Author's own editing)

At the same time, it can also be observed that the majority of respondents (61.3%) have their own income, which may indicate that even students or university attendees have the opportunity to work alongside their studies.



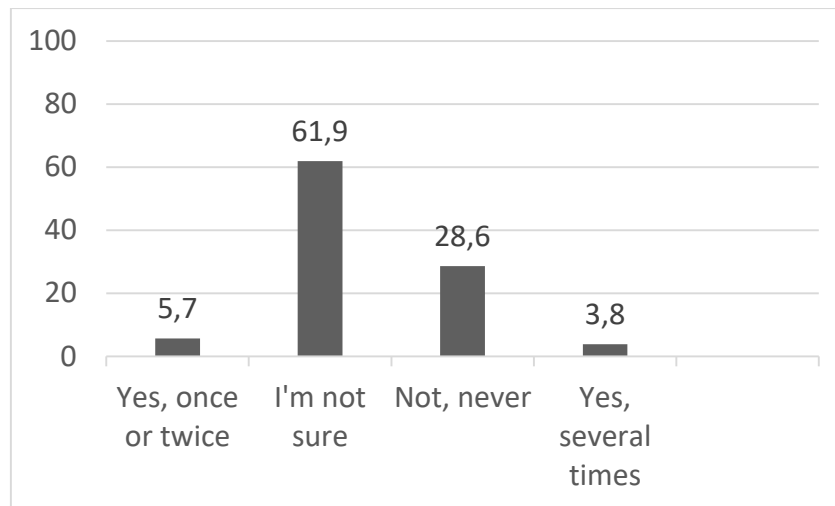
3. Figure: Do you have your own income? (Source: Author's own editing)

This figure examines the frequency of cosmetic product purchases among respondents.

The most common answers were “once a month” and “every few months” (30 respondents each). Together, these two categories account for more than half of all responses, indicating that young people tend to buy cosmetic products once every month or two.

Naturally, there are exceptions — a relatively high number of respondents (26) reported purchasing cosmetics several times a month.

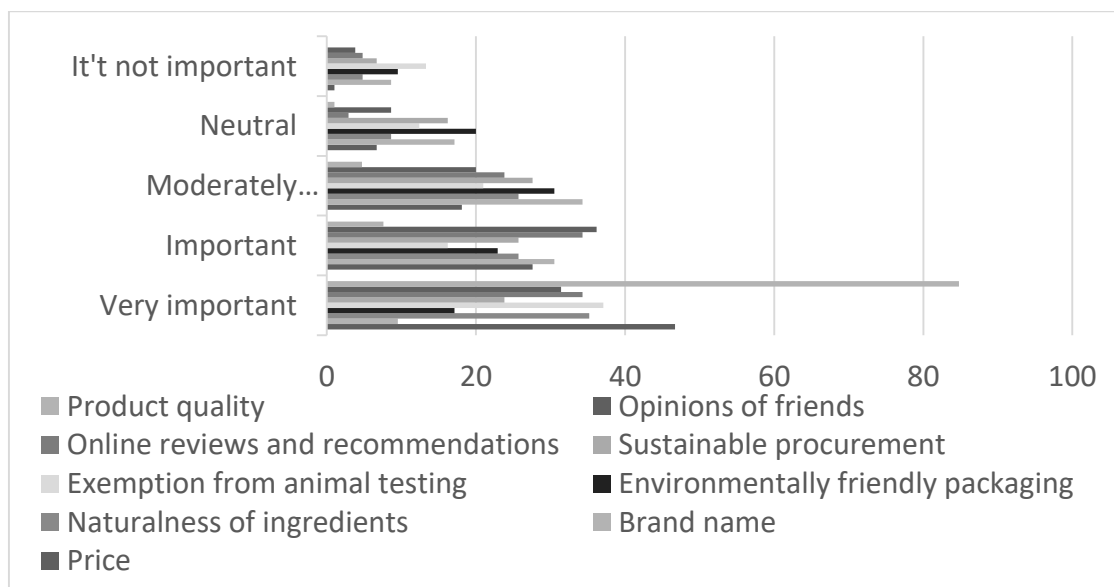
A smaller number indicated that they rarely or only a few times a year purchase cosmetic products.



4. Figure: Frequency of cosmetic product purchases (Source: Author's own editing)

The following figure shows which factors or characteristics influence consumers at the time of purchase. It reveals what they pay attention to and what is most important to them. As can be observed, product quality is considered the most important factor, with 84.8% of respondents selecting it as their top priority. This is followed by price, with 46.7% identifying it as the most important factor. However, price also appeared frequently as a less important but still relevant factor, which means that overall, 80-90% of respondents consider price to be a significant influence on their purchasing decisions. The naturalness of ingredients and cruelty-free production were also rated highly, with 35.2% and 37.5% respectively indicating that these aspects are very important to them.

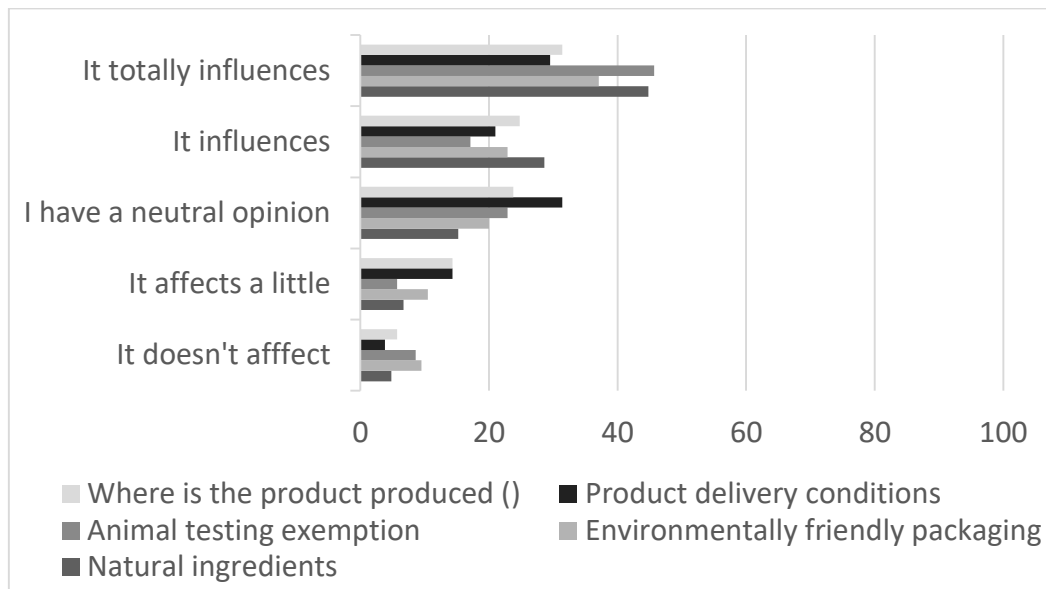
A similarly close result was observed between online reviews and the opinions of friends and acquaintances most respondents considered these important, suggesting that word-of-mouth and recommendations play a key role in their product choices. Surprisingly, brand name was rated as only moderately important almost neutral indicating that most respondents do not necessarily associate branded products with higher quality.



5. Figure: Importance of the following factors during purchase (Source: Author's own editing)

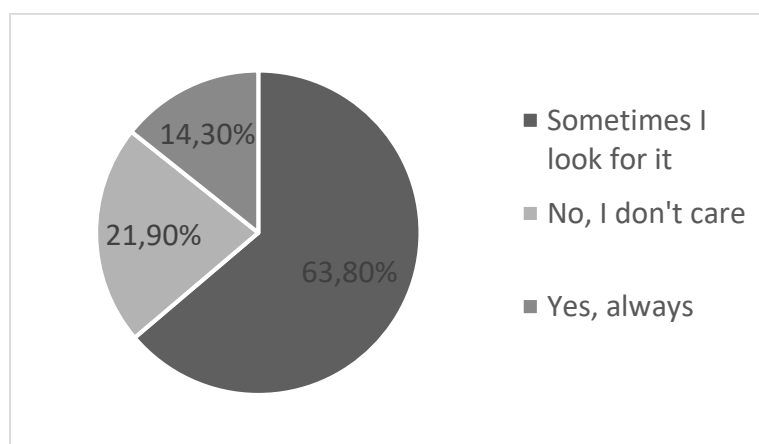
The following figure focuses on the sustainability aspects of cosmetic products.

The goal was to explore which factors, according to the respondents, influence a product's sustainability what they prioritize and consider important. Based on the results, the two most influential factors are natural ingredients and cruelty-free production, both selected by nearly 50% of participants. These are followed by environmentally friendly packaging, chosen by 37.1% of respondents. 31.4% indicated that locally produced products are important to them, suggesting that the origin of the product plays a role in their purchasing decisions. In contrast, transportation conditions received mostly neutral responses, indicating that this aspect is not closely monitored or strongly considered by consumers when evaluating a product's sustainability.



6. Figure: The sustainability factors influencing cosmetic products (Source: Author's own editing)

Naturally, based on the previous figures, the next logical question was whether respondents actually seek information about the sustainability of cosmetic products. The results were somewhat surprising: only 14.3% reported that they regularly and consistently research the sustainability of the products they purchase. Most respondents occasionally look into product details out of curiosity, but do not do so systematically. At the same time, a significant portion (21.9%) of respondents indicated that they never research sustainability, and are simply not interested in the topic. This may suggest a general lack of concern or awareness regarding sustainability and environmental protection.

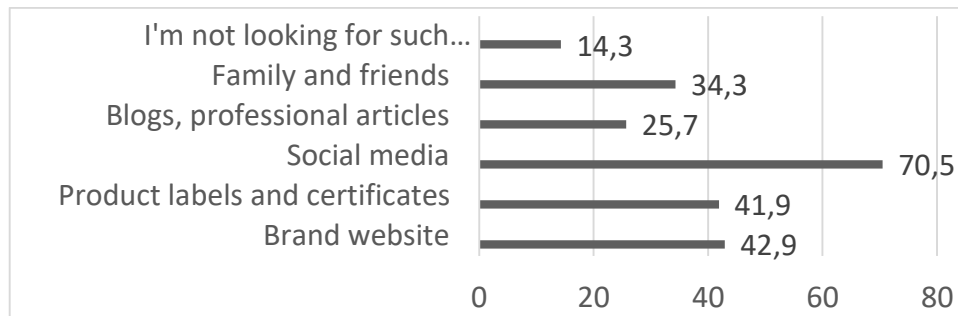


7. Figure: Awareness and research into product sustainability (Source: Author's own editing)

It clearly follows from the previous figure that, even if only occasionally, some respondents do seek out information about product sustainability. Among them, 70.5% obtain their information primarily

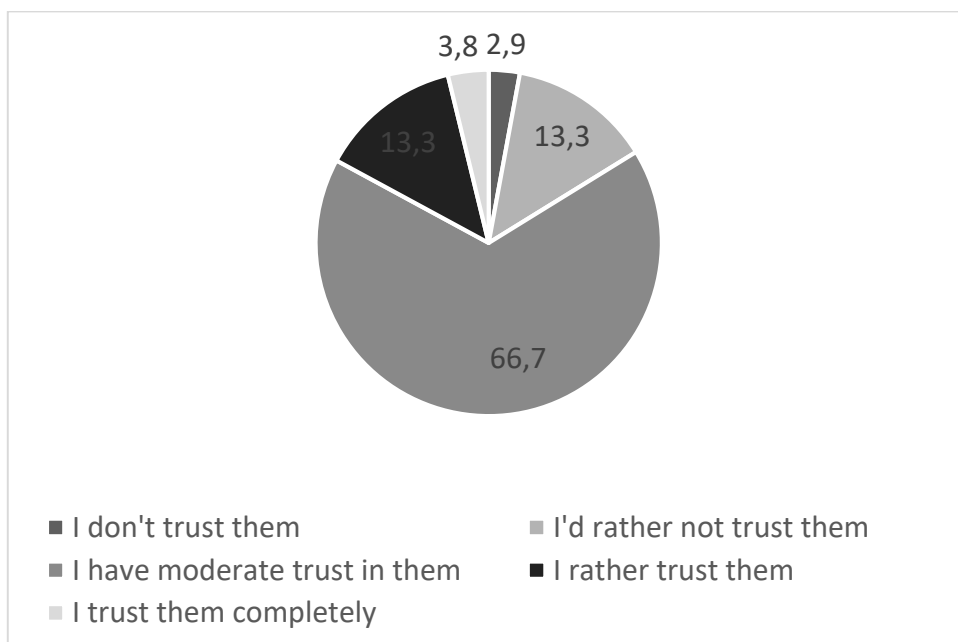
from social media. There is only a 1% difference between those who rely on brand websites (42.9%) and those who refer to product labels and certifications, showing that both channels are almost equally important sources. Given these results, it can be said that the respondents show a fairly high level of awareness and interest in the topic. I am confident that these numbers will continue to rise over time.

Family, friends, and acquaintances also play an important role as sources of information, which is a promising sign it suggests that the respondents are not the only ones engaged, but that those around them also show interest in sustainability-related issues.



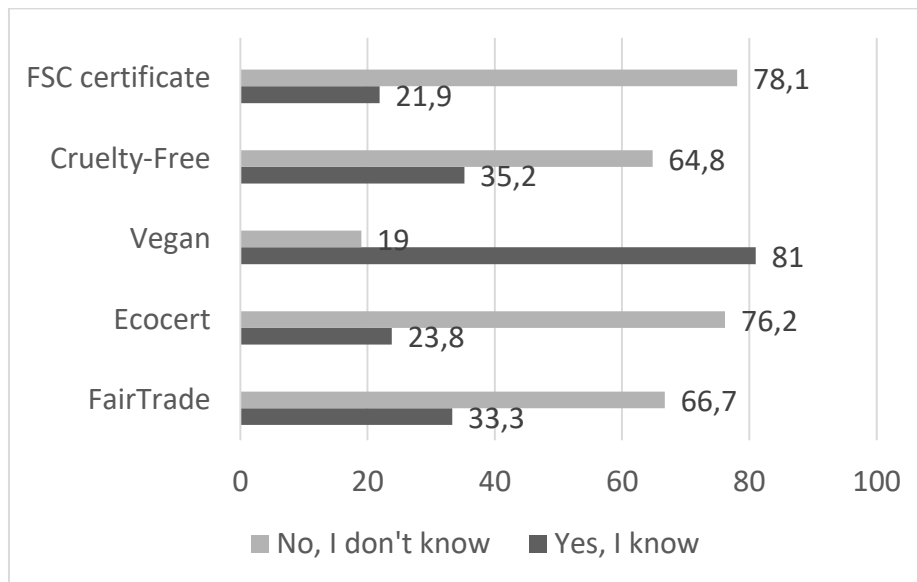
8. Figure: Sources of information about product sustainability (Source: Author's own editing)

We often talk about sustainability, but it's also important to consider how much trust consumers place in products that claim to be sustainable. In the next section, respondents were asked how much they trust the sustainability claims of cosmetic products. More than half (66.7%) indicated a moderate level of trust, which does not necessarily reflect a negative view especially considering that many brands misuse sustainability claims through greenwashing. This level of skepticism may actually be a sign of growing consumer awareness. Interestingly, the results showed an equal proportion (13.3%) of respondents who rather trust and those who rather do not trust such claims. Very few people only 3.8% said they fully trust sustainability claims, while a similarly small 2.9% stated that they do not trust them at all. This highlights the importance of consumer awareness in this area, particularly in recognizing and avoiding greenwashing tactics.



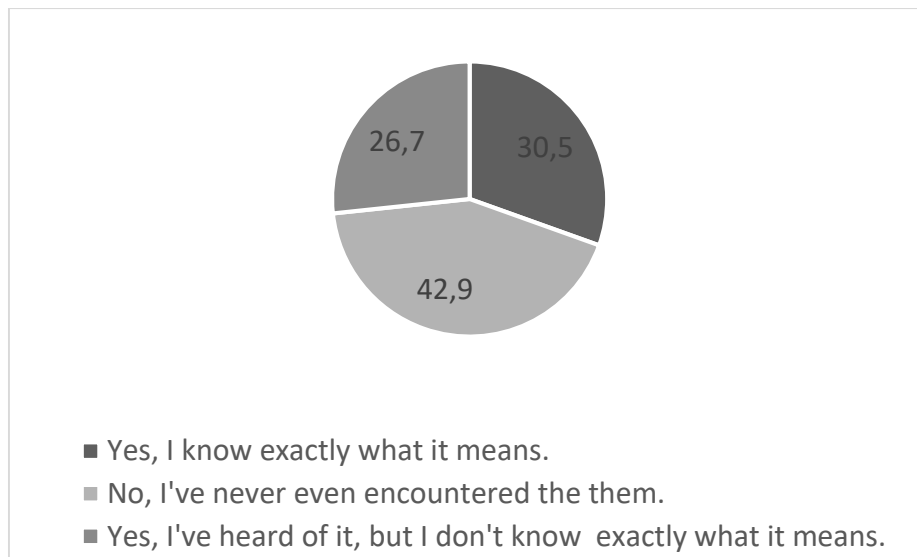
9. Figure: Sustainability of cosmetic products (Source: Author's own editing)

I was also interested in which labels and certifications respondents had encountered on cosmetic product packaging. Surprisingly, very few people pay attention to the labels and certifications displayed on packaging. The most commonly recognized label was the “Vegan” symbol, noticed by 81% of respondents. This was followed by the “Cruelty-Free” certification, at 35.2%, which I personally consider a relatively low figure, as this value should ideally be much higher. As the figure shows, many respondents either had not encountered such labels or simply did not notice them. This highlights the need to improve consumer education and awareness, as many sustainable cosmetic products display multiple certifications though consumers often do not pay enough attention to them.



10. Figure: Awareness of labels and certifications (Source: Author’s own editing)

Whenever sustainability and environmental protection are discussed, it is essential to address the issue of greenwashing as well. This figure illustrates the respondents’ awareness of the greenwashing phenomenon. 42.9% of participants reported that they had never encountered the term “greenwashing” before. 30.5% had heard of it and knew exactly what it meant, while 26.7% had come across the term but were not entirely sure of its exact meaning. My follow-up question also focused on greenwashing: I asked respondents to select the correct definition of the term. This allowed me to assess whether they truly understood it. 55.7% of respondents chose the correct definition, meaning that even some of those who had claimed not to know the term earlier were able to identify its correct meaning. However, 44.3% selected an incorrect option, which suggests that nearly half of the respondents did not fully understand what greenwashing is.



11. Figure: Awareness of greenwashing (Source: Author's own editing)

I also examined several factors related to consumer behavior and attitudes toward sustainability.

First, I investigated whether respondents had ever encountered cosmetic brands that presented themselves as sustainable but later turned out to be misleading. The majority (61.9%) were uncertain, stating that they could not recall a specific case but wouldn't rule out the possibility. 28.6% clearly stated that they had never encountered such brands, while a smaller proportion (5.7% and 3.8%) reported having noticed this phenomenon occasionally or multiple times.

I also asked how much more consumers would be willing to pay for a sustainable cosmetic product. Most respondents (35.2% each) said they would be willing to pay up to 5–10% more. 19% were not willing to pay any extra, prioritizing price above all. Only 4.8% would pay up to 20% more, and just 5.7% said they would pay significantly more for a sustainable product.

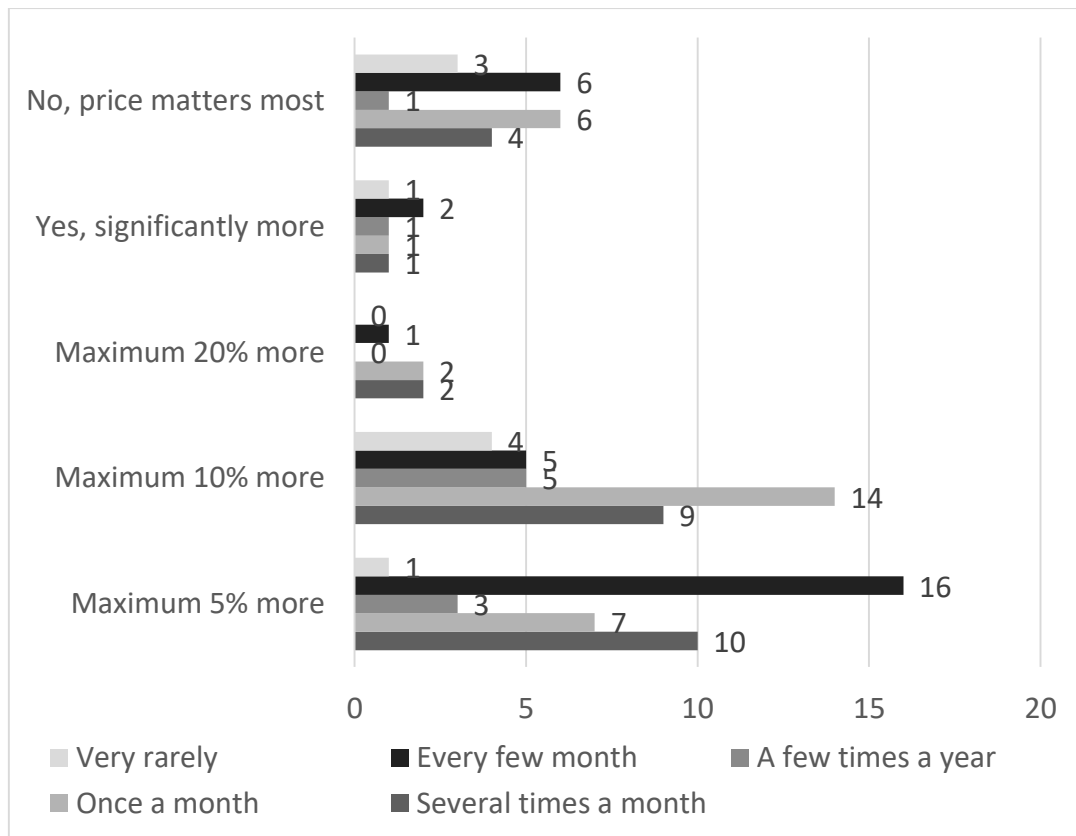
Another question addressed repeated purchase behavior: if a sustainable product proved effective, how likely would respondents be to buy it again? 45.7% said they would very likely repurchase it, while many others indicated they would probably do so, even if not completely certain. 12.4% were undecided, stating they might try something new or switch to a better offer. 2.9% and 1.9% said they would not repurchase, even if satisfied with the product.

Finally, I explored the influence of sustainability on brand loyalty. 46.7% stated that sustainability moderately influences their brand loyalty. 21.9% said it influences them to a small extent, while 15.2% reported a strong influence. 10.5% considered it a decisive factor, and 5.7% said it does not influence their brand loyalty at all.

In the following section, I will analyze my five hypotheses. Regardless of the results, I created charts for each hypothesis and indicated whether they were confirmed or not.

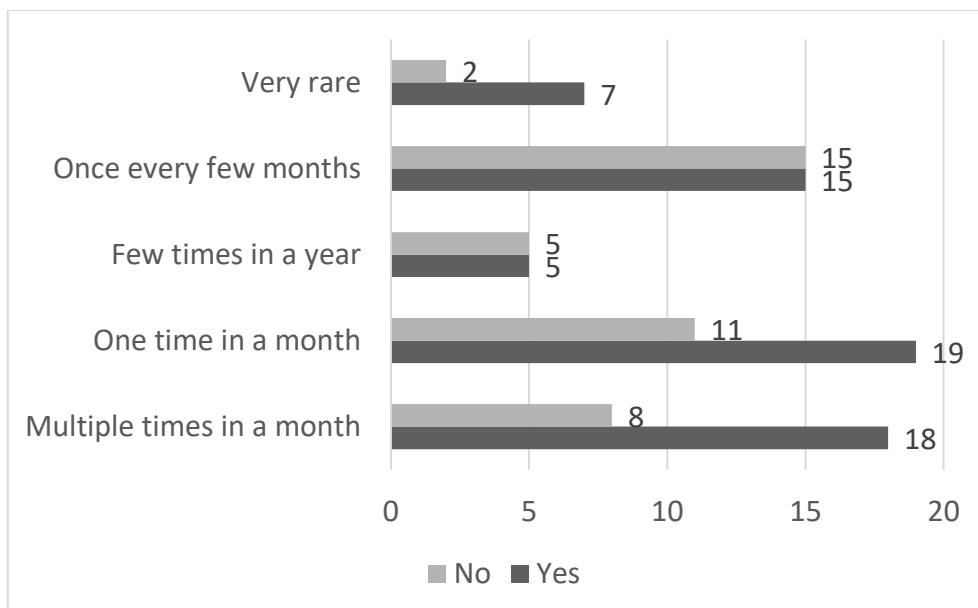
My first hypothesis stated: "Those who purchase cosmetics more frequently are more likely to pay more for sustainable products." In this case, the result was not statistically significant ($p = 0.514$), meaning the hypothesis was not confirmed. However, the figure still revealed an interesting trend:

Respondents who purchase cosmetic products every few months were only willing to pay up to 5% more for a sustainable product, while those who buy cosmetics several times a month were willing to pay up to 10% more.



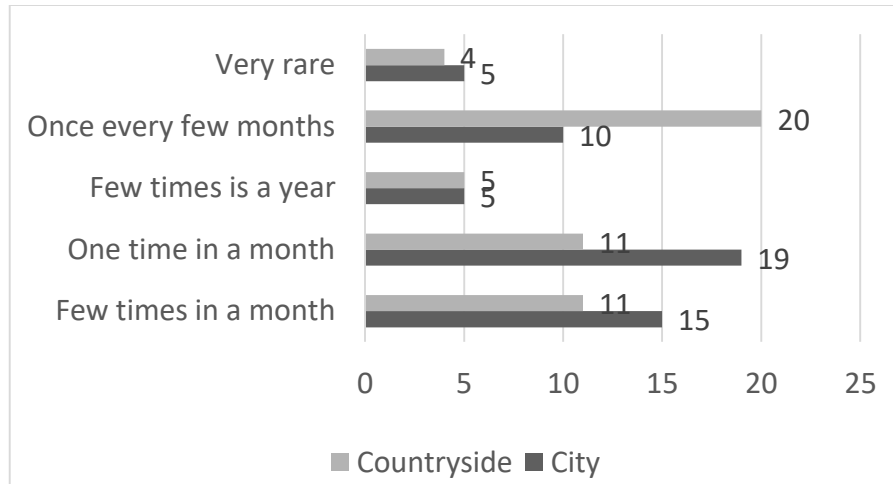
12. Figure: The relationship between willingness to pay more and purchase frequency (Source: Author's own editing)

My second hypothesis was formulated as follows: “Individuals with personal income are more likely to purchase sustainable cosmetic products.” In this case as well, no statistically significant relationship was found ($p = 0.419$), so the hypothesis was not confirmed. However, the data revealed an interesting pattern: those who have their own income tend to go shopping multiple times a month, or at the very least, once a month for cosmetic products.



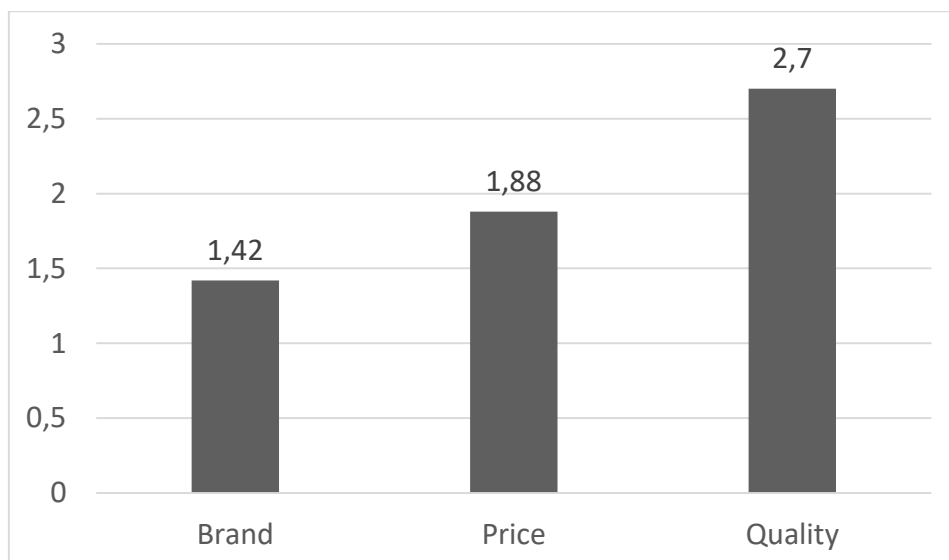
13. Figure: The relationship between income and purchase frequency (Source: Author's own editing)

My third hypothesis was as follows: “People living in urban areas purchase cosmetic products more regularly than those living in rural areas.” Although this hypothesis also did not yield a statistically significant result ($p = 0.191$), the chart still revealed a clear trend. Respondents living in urban areas tend to buy cosmetics more frequently than those in rural areas. Rural respondents mostly reported purchasing cosmetics every few months, while urban residents typically buy them once a month, with a notable number even reporting multiple purchases per month.



14. Figure: The relationship between place of residence and purchase frequency (Source: Author’s own editing)

My fourth hypothesis was also not confirmed. I tested it using correlation analysis, which revealed a very weak negative correlation (correlation coefficient: -0.132). However, the significance level was not acceptable ($p = 0.179$). Since this value is higher than 0.05, the result cannot be considered statistically significant. My fifth hypothesis stated that: “The quality of cosmetic products is a more important factor in purchasing decisions than brand name or price.” The results confirmed this hypothesis. Respondents rated product quality as the most important factor (average rank: 2.7), while brand name was considered the least important (average rank: 1.42).



15. Figure: Importance of product quality (Source: Author’s own editing)

5. CONCLUSIONS

Based on the available data, it can be observed that a significant portion of consumers are interested in conscious purchasing and green products, which indicates an openness to a more environmentally conscious lifestyle. However, it is not always clear to what extent this interest influences their actual purchasing decisions. Although many respondents occasionally pay attention to sustainability-related labels, the data shows that while some actively seek green alternatives, the majority only consider these aspects sporadically. Income is one of the most influential factors in consumer behavior, as it determines what and how much people can afford. Place of residence also plays a role: those living in urban areas and those with personal income are more likely to purchase green products.

Consumer trust plays a key role in the choice of sustainable products. Many people trust labels and claims at face value. The findings suggest that even consumers who try to make conscious decisions are often misled by greenwashing and end up choosing products that do not actually meet environmental standards. This shows that with well-crafted, seemingly credible marketing, nearly any product can be sold as “green,” which ultimately harms truly sustainable products that are not always clearly distinguishable in the marketplace. Overall, it can be concluded that while consumers are interested in organic and sustainable products, their decisions are influenced by a variety of factors. The importance of these factors varies by product category, suggesting that consumers establish individual priorities during the decision-making process. The study also revealed that many consumers choose green products due to their commitment to sustainability, concern for personal and environmental health, or a sense of social responsibility. However, many lack sufficient information to distinguish genuinely sustainable products from misleadingly marketed ones.

In the long run, misleading claims can erode consumer trust not only in specific brands but in the entire green product category. If consumers realize that products they believed to be environmentally friendly do not provide actual benefits, they may turn away from green products entirely and revert to conventional alternatives.

6. RECOMMENDATIONS

With the growing demand for green products, there is an increasing need for measures that support conscious purchasing and foster trust in truly sustainable products. One essential step is to promote credible certification systems. Internationally recognized eco-labels and certifications can help consumers navigate the market, but, as shown in this research, knowledge about them remains limited which underlines the need for broader awareness and even education. This could be achieved through educational programs and awareness campaigns that teach consumers how to recognize truly green products and encourage more conscious shopping behavior. From the corporate side, it is crucial to ensure transparent and clear communication, including detailed and honest information about products’ environmental impact and production processes. In parallel, consumer protection regulations should be tightened to more effectively combat greenwashing and enhance the credibility of sustainability communication. Reaching sustainability goals is not only about providing information, but also about ensuring practical accessibility. Green products should be available in rural areas and small stores, and pricing strategies should allow lower-income consumers to afford them without difficulty.

Finally, the promotion of local, sustainable production is also important. Supporting small businesses and artisanal producers can reduce environmental impact and help expand the range of green product offerings.

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ANALYSIS OF HUNGARY'S AND ROMANIA'S EXTERNAL TRADE

BÁLINT ÁGOTA – KOROSZCZYNÉ DR. PAVLIN RITA

ABSTRACT

The European Union has one of the most open economies in the world and boasts the largest single market, which has a major impact on the external trade of its Member States. The EU's Common Commercial Policy ensures that goods from the 3rd countries are treated with uniform tariffs, rules and procedures, affecting prices, competition and the balance of international trade. In my study, I examine how EU imports have evolved. I analyse the role of China and the United States in their international trade and the likely effects of the current tariff war focused on the data of Hungary and Romania.

KEY WORDS: import, customs union, trade, customs revenue, European Union

1. INTRODUCTION

Hungary and Romania's foreign trade has undergone significant changes over the past decades especially following their accession to the European Union. Strengthening foreign trade relations has become a key factor in the economic development of both countries, contributing to economic growth, job creation, and technological modernization. Accession to the EU's common market and customs union created new opportunities for the free movement of goods and services, but also introduced new challenges in terms of global competition, dependence on external markets, and trade policy adjustments.

The aim of this analysis is to explore in detail the development of the foreign trade structure of the two countries, with particular attention to import dynamics, the ratio of customs revenues to GDP, and the role of key trading partners including China and the United States. It also examines how accession to the customs union and global economic trends have influenced economic openness and integration into international trade in Hungary and Romania. The analysis includes forecasts prepared using the Winter method, which are intended to illustrate the expected trends in foreign trade in the coming years.

2. THEORETICAL FOUNDATIONS OF INTERNATIONAL ECONOMIC INTEGRATION

2.1 INTERNATIONAL TRADE

International trade refers to the cross-border exchange of goods, services, and capital, playing a crucial role in economic growth, industrial development, and the advancement of globalization. The benefits of trade include the utilization of comparative advantages, the expansion of markets, and the faster spread of technological innovations. (Krugman P., & Obstfeld M., 2009) Trade agreements can be economic partnership, free trade, or association agreements. Economic partnerships support developing countries, while free trade and association agreements aim to open markets and promote political cooperation. The EU also concludes non-preferential agreements, such as partnership and cooperation agreements. All negotiations are conducted in accordance with Article 218²⁵ of the Treaty on the Functioning of the European Union. (Council of the European Union, 2025) In recent decades,

²⁵ Article 218 of the Treaty on the Functioning of the European Union sets out the procedures and powers of the EU institutions for negotiating and concluding agreements between the European Union and non-EU countries or international organizations.

globalization has fundamentally transformed international trade by facilitating the integration of markets and expanding economic interactions between countries. China has played a particularly significant role in this process, emerging as one of the world's largest exporters. Its presence in the European market presents both opportunities and challenges. China's economic policy is driven largely by geopolitical considerations rather than purely economic theory, with the country aiming to strengthen its position in global partnerships through increasingly strategic investment and trade policies. (Szabó D. és Trautmann L., 2021) The benefits of international trade are supported by various theories emphasizing more efficient resource use, expanded domestic supply, and increased welfare through free movement of goods. The Ricardo theory highlights productivity differences, the Heckscher-Ohlin model focuses on factor endowments, and growth theory stresses the impact of exports on economic expansion. Comparative advantage is often measured using the Balassa index. These advantages are dynamic, changing with technology, demand, and policy shifts, so companies must continuously monitor them. Indirect benefits of trade include adopting advanced technologies, more efficient production, competitive incentives, and quicker resolution of internal imbalances, all of which strengthen national competitiveness and sustainability. (Dankó L., 2009)

2.2 INTRODUCTION TO THE EUROPEAN UNION CUSTOMS UNION

A customs union is a form of economic integration in which two or more countries eliminate internal tariffs and other trade barriers between each other, while applying a common external tariff to non-member countries. (The Editors of Encyclopaedia Britannica, 2025) Thus, a customs union represents an intermediate stage between free trade areas and common markets, promoting trade among member states while applying a unified trade policy toward outsiders. (Michal O., Ines W., 2019) The customs union offers many benefits but also presents challenges, such as limiting national sovereignty and the uneven impact of common external tariffs on member states. Additionally, the administrative and technical complexity, including the harmonization of customs procedures, is time-consuming and requires ongoing development. The EU's digital customs system is a significant advancement, but differences among national customs authorities still hinder uniform operation. (Angyal Z., 2017) The European Union's customs union is among the most advanced forms of cooperation, ensuring the free movement of goods among EU member states and applying uniform customs procedures. The internal market and common customs system prevent distortions of internal competition and promote global competitiveness. (Bakai K. P., 2022) Customs unions offer several economic benefits. Their most important effect is the stimulation of trade, as the free movement of goods improves their competitiveness and results in lower import costs. The elimination of tariffs boosts trade among member states, while the common external tariff prevents "trade diversion." (Krugman P., & Obstfeld M. 2009) Another important outcome of the customs union is the deepening of economic integration. Increased cooperation among member states and the harmonization of customs procedures help optimize supply chains. Research indicates that the European Union's customs reforms have improved logistics efficiency and reduced administrative burdens. (Gelei A., Gödöny M., Hálám Sz., Nietsch T., Rozgonyi S., Skrák K., Teleki J., Tolnainé Tóth V., Vizsy J., 2020) A customs union provides clear benefits but also poses challenges, including limited national sovereignty, uneven impacts of common external tariffs, and complex, time-consuming administrative and technical demands. Although advances like the EU's electronic customs system have simplified procedures, differences among national customs authorities still hinder uniform operation. (Bakai K. P., 2022) The European Union's customs union is crucial for economic unity, as it allows the free movement of goods and stimulates trade among member states. However, maintaining the customs union and managing external trade involve legal and economic challenges, especially with the evolving global market. Nevertheless, the customs union remains fundamental in global economic relations, strengthening integration and facilitating efficient exchange. (The official website of the European Union, 2025)

3. OVERVIEW OF THE IMPORT STRUCTURE OF HUNGARY AND ROMANIA

Hungary’s and Romania’s import structures clearly reflect the economic composition, industrial hubs, and foreign trade relations of the two countries. Although both nations operate within a similar trade regulatory environment as members of the European Union, the composition of their imports and their main trading partners paint different pictures. The aim of this chapter is to compare the key characteristics of the two countries' imports, identify the dominant product categories, and highlight any similarities or differences between them.

3.1 INTRA- AND EXTRA-EU IMPORT RATIO

Based on the 2024 import data (Figure), both Hungary and Romania primarily rely on trade relations within the European Union. However, Hungary appears to be slightly more open toward non-EU import partners, while Romania is more deeply integrated into the EU’s internal market. Both countries fall into the mid-range when comparing Intra- and Extra-EU import ratios but lag behind member states such as Germany or the Netherlands, which maintain more extensive global trade connections. This suggests that although the economies of Hungary and Romania are closely tied to the EU, Hungary is beginning to show a modest openness toward the global market particularly toward players like China and the United States.

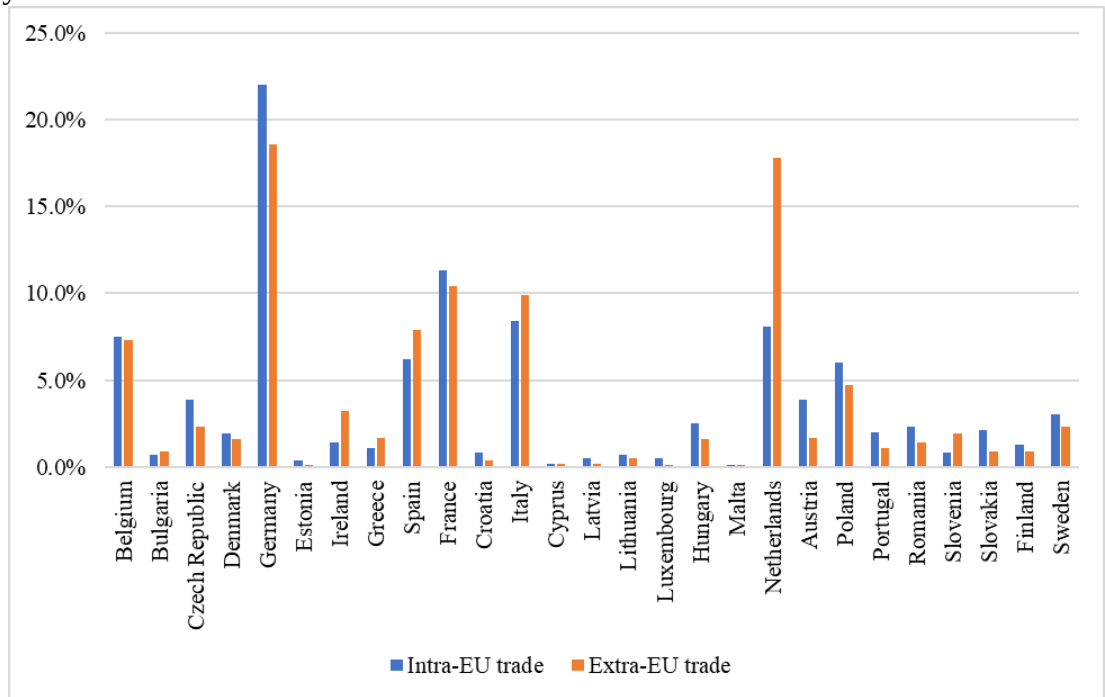


Figure 1: Import Data of EU27 Countries: Analysis of Intra- and Extra-EU Trade Flows in 2024, Percentage Distribution (2025)

Source: Own compilation based on Eurostat data

3.2 THE EVOLUTION OF IMPORT CUSTOMS REVENUE IN HUNGARY AND ROMANIA AFTER ACCESSION TO THE EUROPEAN UNION

Examining the import duty revenues (Figure) of Hungary and Romania, it is clear that EU accession caused a significant decline in the share of customs revenues within the public budget in both countries. In Hungary, import duties accounted for 17% of total revenues in 2003, but this ratio dropped sharply in 2004, the year of accession, and stabilized between 3 - 5% for several years. However, from the 2010s onward, a slow but steady increase began, reaching 7,5% by 2023. This

trend can be partly explained by the expansion of imports from outside the EU and improvements in tax collection efficiency. In Romania, the share of customs revenues fluctuated between 5 - 8% before accession, but after joining the EU in 2007, it dropped dramatically to around 2%. In the following years, customs revenues showed fluctuations but remained generally lower than in Hungary, with a slight increase after 2018, reaching around 4 - 7% in 2023. The differences between the two countries may be due to various economic factors, such as the composition of imports, the share of trade outside the EU, and tax collection efficiency. Overall, EU accession clearly reduced the role of customs revenues in both countries, but Hungary has experienced a stronger and more sustained increase in recent years, while Romania's growth has remained more moderate.

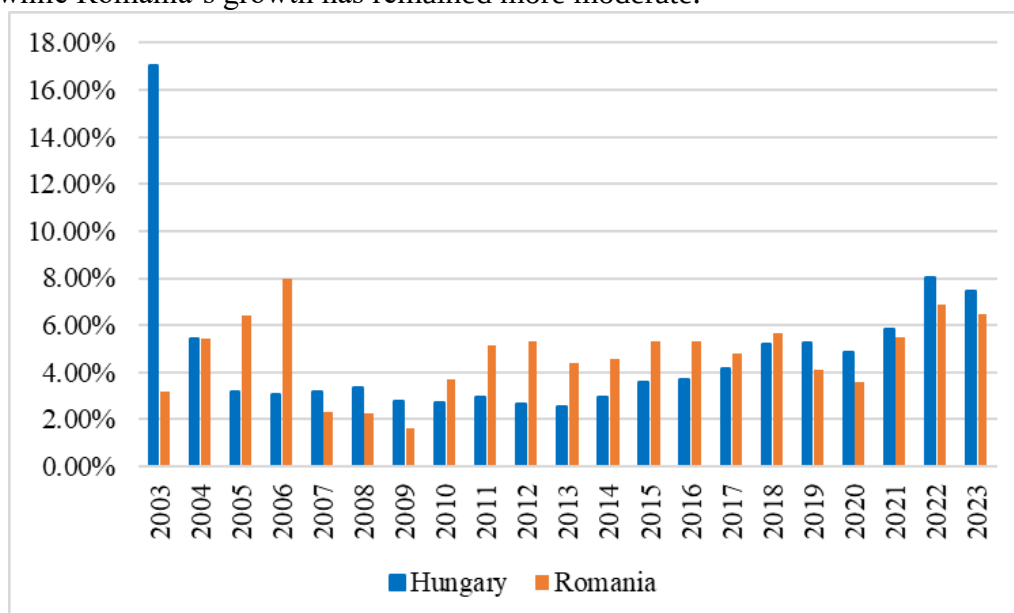


Figure 2: Hungary's and Romania's import duties and fees (excluding VAT) as a percentage share of government and EU institutional revenues between 2003 and 2023 (2025)

Source: Own compilation based on Eurostat data

3.3 THE ROLE OF IMPORTS IN THE ECONOMY: A COMPARISON BETWEEN HUNGARY AND ROMANIA (2014–2024)

Figure illustrates the ratio of imports of goods and services to the gross domestic product (GDP) for Hungary and Romania between 2014 and 2024. The data clearly show that Hungary's import-to-GDP ratio has consistently been significantly higher than Romania's. While Hungary's import ratio generally ranged between 76% and 94% of GDP, Romania's ratio typically remained between 41% and 50%. This indicates that the Hungarian economy is much more dependent on foreign goods and services, suggesting a stronger integration into international trade and global supply chains. In contrast, Romania has a lower import ratio, implying a less open economy that relies more heavily on domestic resources. The differing levels of import dependence between the two countries can be partly explained by structural differences in their economies and the intensity of their trade relationships.

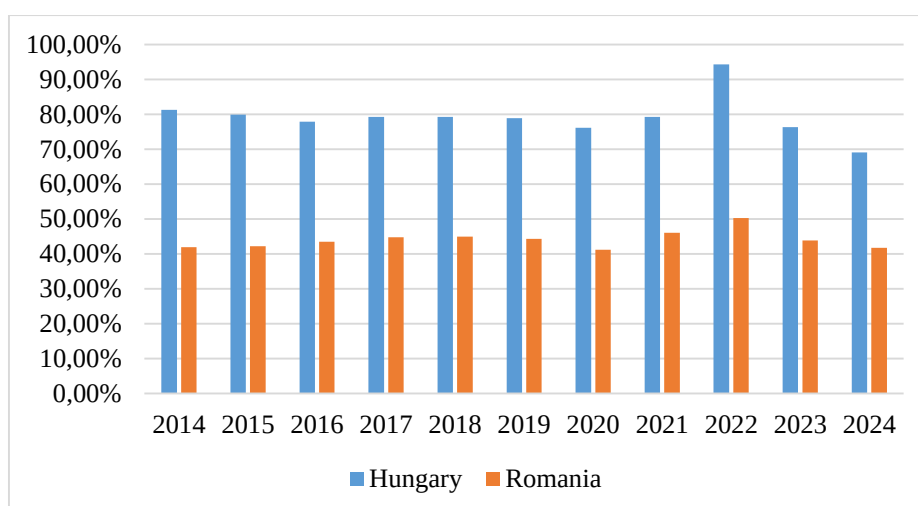


Figure 3: The ratio of Hungary's and Romania's imports to GDP between 2014 and 2024, in percentage terms (2025)

Source: Own compilation based on Eurostat data

3.4 CUSTOMS REVENUES AS A PERCENTAGE OF GDP (2014–2024)

Figure shows the tariff-to-GDP ratio for Hungary and Romania from 2014 to 2024. The chart indicates that tariffs slightly increased in both countries between 2014 and 2019, followed by a more significant rise from 2020 onward. Hungary's tariff rates exceeded those of Romania initially, but from 2019 onwards, Romania gradually caught up and by 2023–2024, it surpassed Hungary, reaching nearly 14% of GDP. Several factors may underlie these changes. On one hand, trade policy decisions and the expansion of trade with non-EU countries could have boosted tariff revenues. On the other hand, the economic recession caused by the COVID-19 pandemic and the subsequent recovery likely influenced the tariff-to-GDP ratios. During the pandemic, GDP may have contracted while tariff revenues declined less sharply, leading to a higher ratio. Additionally, inflation and rising global prices, especially for imported goods, may have contributed to increased tariff revenues.

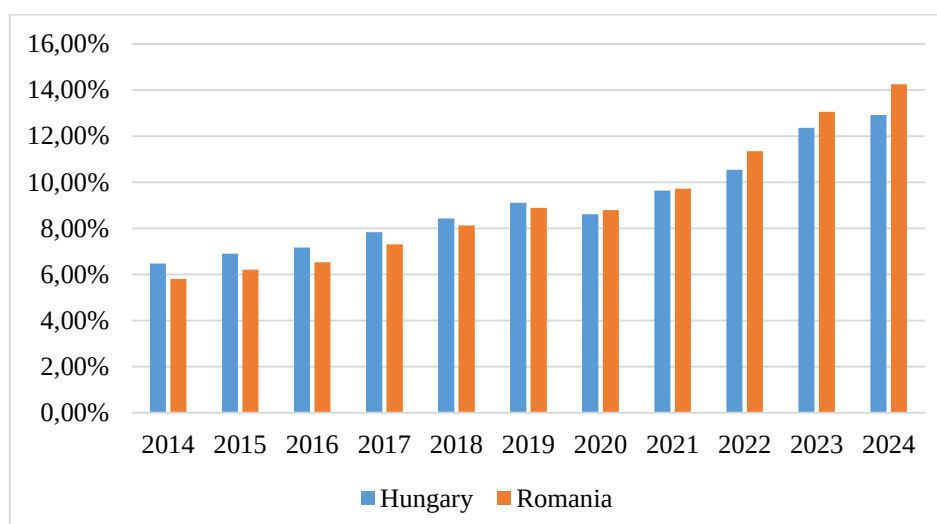


Figure 4: The evolution of Hungary's and Romania's customs revenues as a share of GDP between 2014 and 2024, in percentage terms (2025)

Source: Own compilation based on Eurostat data

3.5 TOP IMPORT PARTNERS IN 2024

According to the 2024 data (Figure), Hungary's largest import partner is China, accounting for more than 23% of total imports. This is followed by Poland, Germany, Austria, Slovakia, and the Czech Republic, each contributing between 4% and 6%. Other countries on the list, such as the Netherlands, South Korea, Italy, France, Romania, and the United States, represent smaller shares ranging from 2% to 4%. The "Other countries" category, which includes all remaining trade partners, makes up approximately 13%, with countries like Denmark, Switzerland, Mexico, and Ukraine among them. China's dominance is primarily due to the significant role of technological, electronic, and machinery imports, as Hungary has integrated into the supply chains of many large Chinese companies, including battery and electronics manufacturers. Additionally, the importance of Central European countries indicates that integrated regional supply chains especially in the automotive sector play an active role in shaping Hungary's import structure.

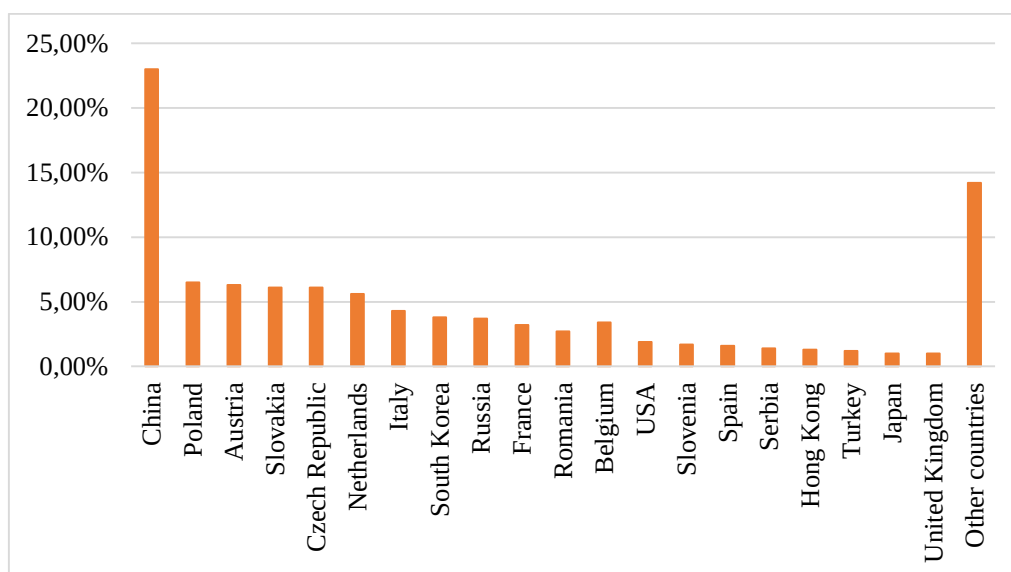


Figure 5: Hungary's largest import partners in 2024, percentage shares (2025)

Source: Own compilation based on Trading Economics data

Romania's main import partners are shown in Figure, with Germany accounting for about 19% of total imports. This is followed by Italy at 8,3%, and Hungary, which holds approximately a 6,7% share. Other significant partners include France, Poland, China, Bulgaria, and Turkey. The "Other countries" category also has a notable share of around 15%, including countries such as Sweden, Iceland, Switzerland, and Ukraine. Romania's import structure is primarily built on trade relationships within the European Union, especially with Germany and Italy, reflecting the strength of its economic integration. Hungary ranks as the third largest import partner, highlighting the close logistical, energy, and industrial cooperation between the two countries.

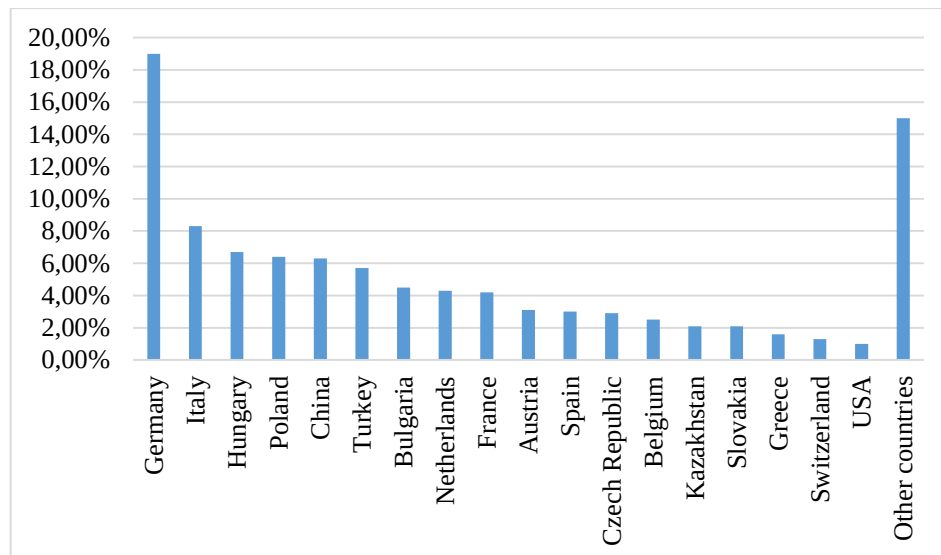


Figure 6: Romania's Largest Import Partners in 2024, Percentage Distribution (2025)
Source: Own compilation based on Trading Economics data

Hungary and Romania have significantly different import structures. Hungary's imports heavily rely on China and other Asian partners, indicating a greater openness to global supply chains, especially in the technology and battery industries. In contrast, Romania's imports primarily come from EU countries, particularly Germany and Italy, reflecting strong traditional Western European industrial ties. This difference also highlights the two countries' distinct trade policies and economic strategies: Hungary actively attracts Asian investors, while Romania focuses more on European integration. For both countries, trade with neighboring countries is important; however, Romania's trade is more regional, whereas Hungary's trade is more global in nature.

3.6 DEVELOPMENT OF IMPORTS FROM CHINA (2014–2024)

Based on the analysis of Figure , both Hungary and Romania showed significant growth in imports from China between 2014 and 2024, though notable differences between the two countries also emerge. In Romania, the import share increased almost continuously, starting at around 4,3% in 2014 and rising to over 14,3% by 2024. This nearly fourfold increase indicates that Romania is becoming increasingly dependent on Chinese goods, particularly in the fields of technology, industrial products, and electronics. The pandemic period, especially post-COVID-19, accelerated this trend due to increased demand for healthcare and IT equipment, much of which originated from China. Although there was a slight decline in 2023, likely caused by economic uncertainties, supply chain disruptions, or regulatory changes, the import share rose again in 2024, reaching record levels. In Hungary, the import share from China also rose significantly, from about 5,5% in 2014 to over 14% by 2022, reflecting a strong increase. This growth is mainly driven by Hungary's advanced industrial base, particularly in the automotive and electronics sectors, which rely heavily on Asian, especially Chinese, components and equipment. The COVID-19 pandemic similarly boosted demand for healthcare and IT products, further increasing imports from China. However, Hungary experienced a slight decrease in 2023, attributed to global economic uncertainties, shipping difficulties, changes in EU trade regulations, and restructuring of supply chains. In 2024, instead of further growth, a slight decline was observed, suggesting efforts to diversify import sources or seek domestic and European alternatives.

Notably, by 2024, Romania's imports from China surpassed Hungary's, indicating that Romania's economy is becoming more reliant on Chinese goods and that its trade structure is shifting, possibly with an increase in electronics, clothing, or products sourced from online platforms. In contrast, the decline in Hungary may reflect adjustments in supply chains, the search for alternative suppliers, or

the impact of regulatory changes. Overall, Chinese imports play a significant role in both countries, but Romania shows a stronger and faster-growing dependence.

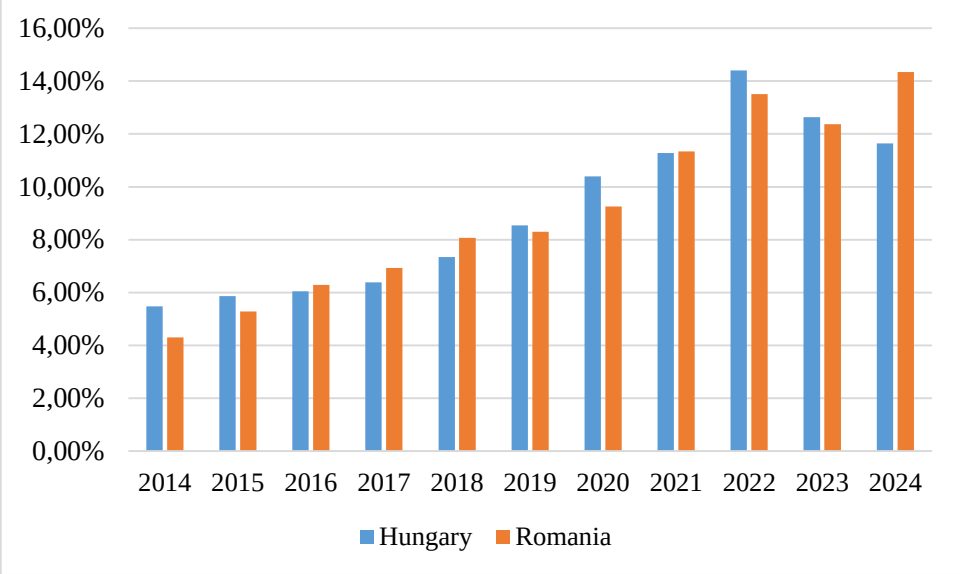


Figure 7: Hungary and Romania's Goods Imports from China Between 2014 and 2024, Percentage Distribution (2025)
Source: Own compilation based on Eurostat data

3.7 TRENDS IN IMPORTS FROM THE USA (2014–2024)

The diagram (Figure) shows the proportion of imports from the United States to Hungary and Romania between 2014 and 2024. For Hungary, the share of imports from the US remained relatively stable over the years, fluctuating between 7% and 10% with minor variations. The highest value was reached in 2023, followed by a slight decline. In contrast, Romania’s imports from the US showed a continuous upward trend, especially after 2019, and from 2022 onwards, Romania’s import share often exceeded that of Hungary. In 2023, Romania’s imports from the US reached 13%, marking a significant increase. This trend suggests that Romania has been intensively expanding its trade relations with the United States in recent years, while Hungary has maintained a more stable but less dynamic relationship.

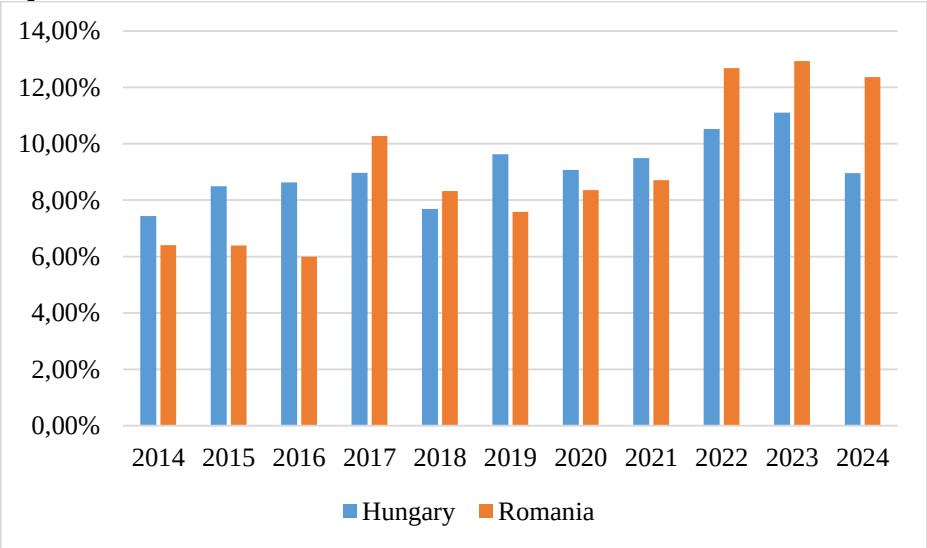


Figure 8: Hungary and Romania's Import Trends with the United States Between 2014 and 2024, Percentage Distribution (2025)
Source: Own compilation based on Eurostat data

3.8 IMPORT FORECAST FOR HUNGARY AND ROMANIA

According to the forecast based on the Winter method (Figure), Hungary's import index was relatively high at the beginning of 2023, fluctuating between 106 and 114. However, by the end of the year, it showed a significant decline, dropping to 90,51 in December 2023. This downward trend continued into 2024, with the import index falling further to 89,04 by January 2025. This trend suggests a continuous decrease in Hungary's total import volume, which may be due to weakening domestic demand, inflation, rising import costs, or structural changes in the economy. In contrast, Romania's import index experienced a slight decline during 2023 but started to rise again toward the end of the year. Throughout 2024, it remained consistently above 110, reaching 125,02 by January 2025. This dynamic growth indicates that Romania's import activity is becoming increasingly vigorous, reflecting economic expansion, increased consumption and investment, and strengthening foreign trade relations.

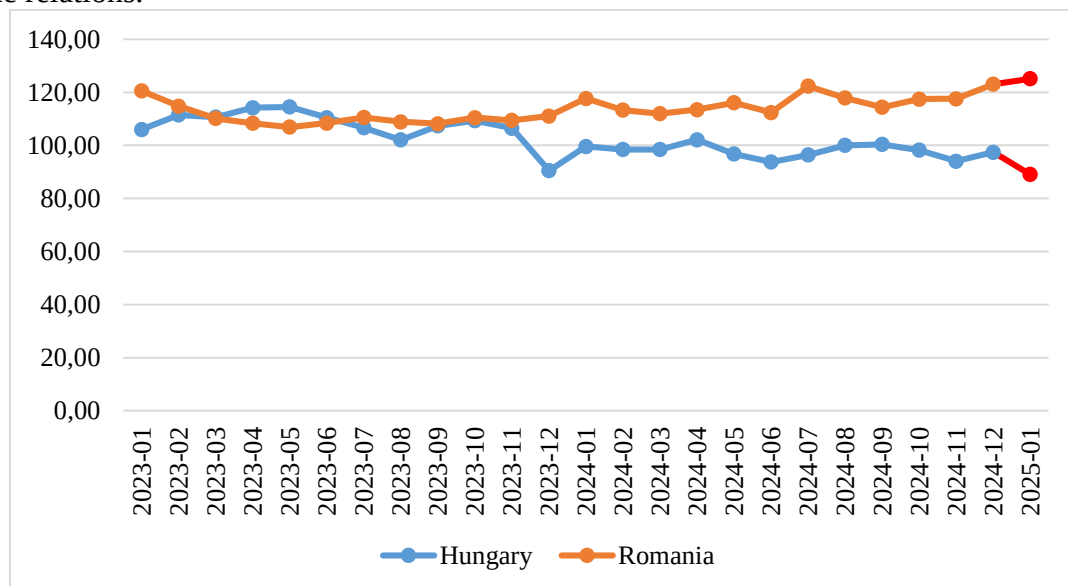


Figure 9: Hungary and Romania Import Forecast Analysis Using the Winter Method (2025)
Source: Own compilation based on Eurostat data

4. RESULTS AND EVALUATION

Based on the analyzed data, it is clear that the foreign trade structures of Hungary and Romania show several similarities, but also significant differences. Both countries rely heavily on trade within the European Union, but Hungary displays greater openness toward external trade partners, particularly in Asia most notably China. This can be attributed in part to Hungary's deeper integration into global supply chains, as well as its targeted investment promotion policies. In contrast, Romania has pursued a more conservative strategy, focusing its economic relations primarily on the industrial centers of Western Europe, reflecting a deeper level of integration within the EU. Its import structure is less globalized but offers a more stable and regionally balanced profile.

It can be concluded that Hungary's export and import policies place greater emphasis on diversification and access to global markets, while Romania aligns more closely with intra-EU economic forces. Looking ahead, this divergence entails different risks and opportunities: Hungary may benefit from stronger global ties, but this also makes it more vulnerable to external market fluctuations. Romania's stable EU orientation offers predictability but may limit the exploitation of broader international economic opportunities.

5. CONCLUSIONS

Both Hungary and Romania exhibit a high ratio of imports relative to their GDP, clearly reflecting economic openness, which is beneficial for international trade and competitiveness. However, this openness also makes the two countries vulnerable to global market fluctuations and external economic shocks. The low ratio of customs revenues to GDP indicates that a large portion of imported goods originates from within the European Union customs union or benefits from preferential tariff treatment, underscoring the close integration of both countries into the EU single market. China's role in imports is steadily strengthening, particularly in the fields of technology and industrial products, which presents significant opportunities for the economic development of both countries. At the same time, this trend poses challenges, as the growing trade with China may require continuous review of internal EU regulations and market mechanisms to preserve the EU's competitiveness and market unity. The United States remains an important but not dominant import source. Imports from the U.S. mainly focus on high value-added, quality technological and industrial products, which holds strategic significance, even if the volume of imports is smaller compared to other main trading partners. Hungary and Romania share similar import structures, but Hungary typically has a larger import volume and higher customs revenues, due to its more developed industrial base and closer economic integration with the EU. This difference highlights the disparities in economic development and structure between the two countries.

Overall, trade with China is expected to continue growing, creating new economic opportunities for both countries. However, this growth may also bring significant challenges to the regulation and cohesion of the EU's internal market, requiring adaptation by both member states and EU institutions. Therefore, it is essential to develop a balanced trade policy that supports economic growth while protecting the unity of the internal market.

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AUTHORS' ADDRESSES

Authors' addresses:

Bálint Ágota

University of Sapientia, Faculty of Economics, Socio-Human Sciences and Engineering
Piața Libertății 1, Miercurea Ciuc

Email: balintkagota@uni.sapientia.ro

Koroseczné Dr. Pavlin Rita

Hungarian University of Agriculture and Life Sciences Kaposvar Campus

[Kaposvár, Guba Sándor u. 40, 7400 Hungary](#)

Email: pavlinrita@uni.sapientia.ro

COMPARATIVE FINANCIAL ANALYSIS OF DOMESTIC, FOREIGN AND INTERNATIONAL OIL COMPANIES

ATTILA BOLDIZSÁR – BÍBORKA-ESZTER BÍRÓ

Abstract

The paper examines and compares the financial performance of four integrated oil companies – OMV Petrom (Romania), MOL (Hungary), Chevron, and ExxonMobil (USA) – over the period 2017–2023. A comprehensive set of financial ratios is used to evaluate liquidity, profitability, efficiency, leverage, and market performance. Quantitative methodology is applied, including CAPM, WACC, and EVA models to estimate risk, cost of capital, and value creation. The results reveal regional differences between Central-Eastern European and North American companies, providing relevant insights for investors and financial analysts.

Keywords: Oil industry, Financial Analysis, Investment decision, CAPM model, WACC, EVA, Regional comparison

1. INTRODUCTION

The oil industry is a key driver of the global economy, with major companies operating under varying conditions across different regions. Despite the sector's shared reliance on fossil fuels, financial performance indicators such as profitability, liquidity, and efficiency often diverge due to differences in economic environments, regulatory systems, and strategic approaches.

This paper aims to compare the financial structure and performance of four integrated oil companies between 2017 and 2023: OMV Petrom (Romania), MOL (Hungary), Chevron, and ExxonMobil (USA). The objective is to evaluate regional financial disparities – particularly between Central-Eastern European and North American companies – through key financial ratios and performance indicators. The research focuses on identifying trends in liquidity, profitability, efficiency, indebtedness, and market valuation, applying models such as the Capital Asset Pricing Model (CAPM), Weighted Average Cost of Capital (WACC), and Economic Value Added (EVA).

The methodology is based on secondary data extracted from audited annual reports, using a comparative financial analysis framework. A self-developed Excel model was employed to ensure consistency and accuracy in cross-company comparison. The results of the analysis may provide useful insights for investors, analysts, and policymakers interested in the oil sector's regional financial characteristics.

2. MATERIAL AND METHODS

This study applies a quantitative financial analysis based on secondary data collected from the audited annual reports of four integrated oil companies: OMV Petrom (Romania), MOL (Hungary), Chevron (USA), and ExxonMobil (USA). The examined period covers seven years, from 2017 to 2023, which allows the identification of trends, structural changes, and performance differences across companies and regions.

The financial performance is evaluated using a set of key financial indicators, grouped into the following categories: liquidity ratios, profitability ratios (ROA, ROE, ROIC), efficiency metrics, leverage indicators, and market valuation ratios (P/E, P/BV, EPS, dividend yield). The analysis also incorporates industry-specific metrics relevant to the oil and gas sector.

To deepen the analysis, the study applies the Capital Asset Pricing Model (CAPM) to estimate expected returns and systematic risk, the Weighted Average Cost of Capital (WACC) to assess financing costs, and the Economic Value Added (EVA) model to evaluate value creation and shareholder return.

A custom-designed Excel model was used to ensure consistency in calculations and comparability between companies. Financial data were harmonized across different accounting standards (IFRS and US GAAP), and benchmark comparisons were made using global and regional averages (e.g. NYU Stern Damodaran datasets).

3. MACROECONOMIC ENVIRONMENT

The profitability and long-term performance of oil companies are strongly influenced by macroeconomic and geopolitical factors (Bodie et al. 1996). Since 2020, the industry has been facing complex global conditions shaped by energy transition, inflation, and geopolitical risks especially in the Middle East and Eastern Europe (World Energy Outlook 2024). The increasing demand for cleaner energy, along with the declining share of fossil fuels, forces companies to adapt both strategically and financially. As Ratti and Vespignani (2016, 2020) show, energy markets are tightly linked to global money supply, industrial output, and inflation. This connection explains why oil investments are highly sensitive to economic cycles.

According to Stevens (2018), the historical and geopolitical context also plays a role in shaping the sector. Countries relying heavily on oil revenues, especially in OPEC, face specific challenges in diversifying their economies and financing investments. Fossil energy projects generally face higher capital costs (8 – 9%) than renewables (4 – 7%), which puts pressure on capital-intensive firms like ExxonMobil and Chevron (World Energy Outlook 2024).

Finally, differences in regional capital access and financing structures must be taken into account when evaluating oil companies from different markets (OPEC 2023). These factors shape how firms invest and how risky their projects appear to investors.

4. RESULTS AND DISCUSSION

When analyzing financial performance, it's not enough to just look at the ratios alone – they need to be placed in the context of the industry (Ulbert et al. 2018; Copland et al. 1999). Oil and gas companies operate under very different conditions depending on their region, so comparing them without considering those differences can be misleading. As Virág et al. (2013) point out, firm-specific features and market environment matter too.

Between 2017 and 2023, both ROIC and ROE increased globally, which suggests better capital efficiency across the industry. U.S. companies performed better overall: the average ROIC was 5.50% compared to 3.61% in Europe, and ROE reached 7.63% vs. 5.76% (based on NYU Stern data). In terms of market valuation, European firms had much higher P/E ratios (75.75 vs. 22.65), possibly because investors expect more growth there. On the other hand, P/BV was more stable and slightly higher in the U.S. (1.63 vs. 1.16).

These results reflect not only financial structure differences but also how investors value future prospects. As Babajide and Lawrence (2023) and Deepikah and Kohli (2023) showed, capital structure and growth expectations can strongly influence valuation.

4.1. ANALYSIS OF THE BALANCE SHEET AND INCOME STATEMENT

The financial structure and performance of the four oil companies show notable regional differences. In 2023, ExxonMobil (XOM) had the largest asset base with USD 376 billion, followed by Chevron (CVX) with USD 262 billion, while MOL and OMV Petrom (SNP) operated with significantly

smaller asset portfolios of USD 21 and 12 billion respectively. Western companies (XOM and CVX) exhibited a strong dominance of fixed assets – averaging 86% and 69% of total assets – reflecting their capital-intensive, long-term investment strategies (ExxonMobil 2024). In contrast, SNP and MOL presented more flexible asset structures, with higher proportions of current assets (32% and 29%) and signs of strategic shifts toward liquidity and adaptability. The impact of COVID-19 in 2020 resulted in negative earnings for XOM and MOL, while CVX and SNP managed to recover more rapidly. By 2022, the industry rebounded, with XOM reaching USD 56 billion in annual profit and CVX USD 33 billion. Revenue and cost trends support this recovery: SNP achieved the highest average growth in revenue (26%) and costs (24%), while MOL followed with 18% and 6%. CVX and XOM posted more modest average revenue growth (12% and 11%) and cost increases of 7% and 6%, respectively (Deloitte 2024).

Capital structure analysis reveals that SNP maintained a high average equity ratio (68%), indicating reliance on internal financing, whereas MOL's equity-to-debt ratio showed a more leveraged position (49% equity, 51% debt). CVX and XOM exhibited the most stable financial structures with balanced capital compositions and lower debt levels, underlining their robust long-term strategies (Basile et al. 2021).

4.2. LIQUIDITY INDICATORS

Liquidity ratios are essential tools for evaluating the short-term solvency and financial responsiveness of oil companies, especially in an industry marked by capital intensity and commodity-driven volatility. The analysis of the 2017–2023 period reveals notable regional distinctions in how firms manage liquidity (Figure 1). OMV Petrom (SNP) stands out with the **highest average current ratio** (2.43) and **cash ratio** (1.27), reflecting a highly conservative approach focused on internal reserves. However, the company's **quick ratio** (0.33) is significantly lower, suggesting that a substantial portion of its liquidity is tied up in inventories raising concerns about true short-term financial agility (Ulbert et al. 2018).

In contrast, Western companies exhibited a more stable and balanced liquidity profile. Chevron (CVX) achieved the **highest quick ratio** (0.99) and maintained a **dynamic liquidity** of 1.00, while ExxonMobil (XOM) also reported consistent performance across all indicators highlighting disciplined working capital policies and effective cash flow control (Zhang 2024b). MOL, on the other hand, had the weakest liquidity position. Its average **cash ratio** of just 0.26 and **dynamic liquidity** of 0.29 underscore a more constrained short-term outlook. These figures are consistent with the company's more leveraged capital structure discussed earlier in the analysis (Basile et al. 2021).

Overall, the data suggest that **U.S. oil majors favor stability and control**, while regional firms like SNP and MOL maintain higher cash reserves and rely more heavily on inventory. These choices reflect structural differences in financial strategy and regional responses to global shocks, such as the COVID-19 crisis (Virág et al. 2013; Copland et al. 1999).

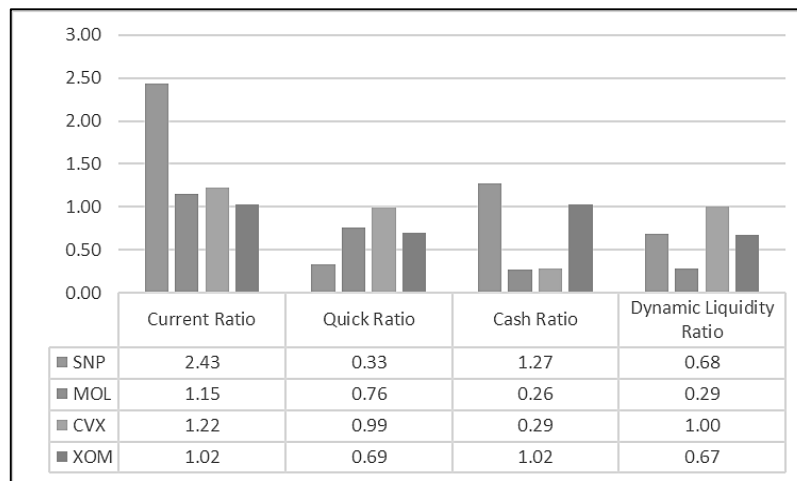


Figure 1. Average liquidity indicators of oil companies (2017–2023)
(Source: Own compilation based on annual reports)

4.3. EFFICIENCY INDICATORS

Efficiency ratios help assess how effectively oil companies use their assets and manage working capital. In a capital-intensive industry like oil and gas, faster turnover and lower working capital needs can significantly improve financial flexibility (Baranyai et al. 2020).

Inventory turnover was much faster at Chevron (CVX) and ExxonMobil (XOM), averaging 16 and 27 days, respectively. In contrast, MOL and OMV Petrom (SNP) needed 38 and 34 days on average, indicating slower cycles and higher capital tied up in inventory (Ulbert et al. 2018; Nyambura 2021). Receivables turnover showed even more striking differences: CVX (4 days) and XOM (2 days) collected payments almost immediately, while MOL and SNP averaged 43 and 38 days. Slower collection can increase liquidity pressure and financing costs (Fejér-Király 2016; Cerna et al. 2022). Accounts payable turnover was longest at XOM (61 days) and SNP (47 days), giving them more time to hold onto cash before settling liabilities—a sign of efficient cash flow management (Ebire et al. 2024).

To capture all this in a single metric, the **Cash Conversion Cycle (CCC)** integrates inventory, receivables, and payables turnover. As shown in **Figure 2**, CVX and XOM operated with negative CCC values throughout the period (averaging –30 and –33 days), meaning they collected cash before paying suppliers. In contrast, MOL and SNP had **positive CCC values** (25–40 days), indicating longer cycles and higher external financing needs (Ulbert et al. 2018; Asman et al. 2023).

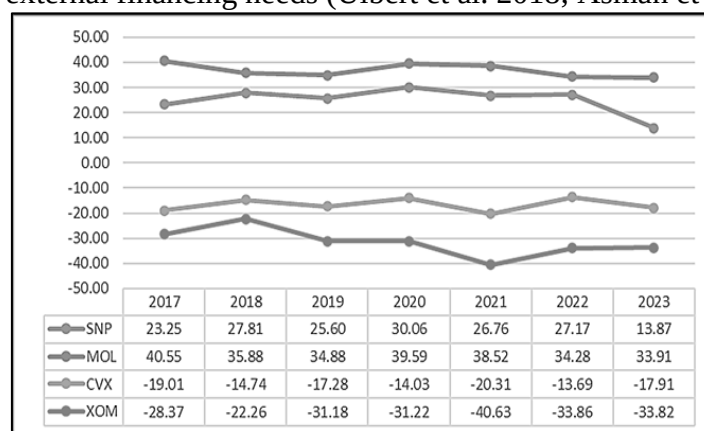


Figure 2. Cash Conversion Cycle (CCC) of oil companies, 2017–2023
(Source: Own compilation based on annual reports)

Finally, labor efficiency also varied widely. XOM and CVX generated USD 4.2M and 3.8M in revenue per employee, far exceeding MOL and SNP (both below USD 0.7M), which reflects differences in automation, productivity, and economies of scale (Virág et al. 2013; McKinsey & Company 2023).

4.4. PROFITABILITY INDICATORS

Profitability indicators reflect how efficiently companies turn resources into profits. In oil and gas, both operational efficiency and capital structure play key roles in driving long-term value creation (Fazakas et al. 2003; Baranyai et al. 2020). According to the results, **OMV Petrom (SNP)** achieved the highest average return on sales (ROS: 15.26%) and asset profitability (ROA: 7.98%), pointing to strong operational efficiency. **MOL** led in return on equity (ROE: 12.83%), while **CVX** and **SNP** shared the highest average return on invested capital (ROIC: 11.96%).

As shown in **Figure 3**, CVX and ExxonMobil (XOM) consistently outperformed the industry average in ROIC between 2017 and 2023. The 2022 spike for SNP (39.21%) is especially notable and likely reflects low cost levels and favorable margins. MOL remained close to the industry trend,

while CVX delivered stable and high values—particularly in 2022 (33.55%). These results highlight the long-term capital efficiency of the U.S. majors (Fazakas et al. 2003; Ulbert et al. 2018). The **EBITDA-based ROA** also confirms operational strength. In 2022, MOL and XOM reported peak values (23.61% and 27.80%, respectively), while CVX improved despite weak traditional ROA results. The 2020 COVID-19 dip affected all firms, but 2021–2022 showed a clear rebound, confirming adaptability (Fejér-Király 2016).

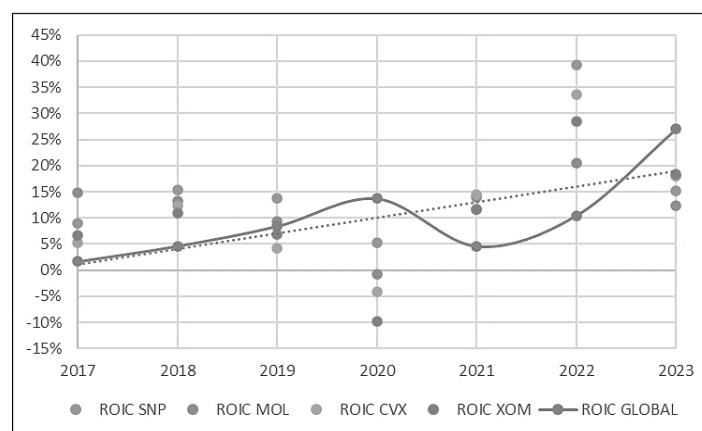


Figure 3. ROIC of oil companies vs. global industry average (2017–2023)
(Source: Own compilation based on financial reports and NYU Stern data)

Overall, the data indicate that **Central-Eastern European firms (SNP, MOL)** perform well on asset-level profitability, while **U.S. firms (CVX, XOM)** dominate in capital returns. Most indicators exceed global benchmarks, suggesting competitiveness and strong investor outlook (Ulbert et al. 2018; Haijiev et al. 2024).

4.5. LEVERAGE INDICATORS

Leverage ratios are fundamental to understanding the capital structure and long-term financial risks of oil companies. They reflect how much external funding firms rely on and signal potential vulnerability or resilience in volatile market conditions (Fazakas et al. 2003; Ulbert et al. 2018). As shown in **Figure 4**, **OMV Petrom (SNP)** consistently reported the lowest **leverage ratio** (debt-to-equity), ranging from 0.31 to 0.39, indicating strong internal financing and minimal reliance on external debt. In contrast, **MOL** exhibited the highest values throughout the period, peaking at **1.36 in 2020** and falling to 0.92 by 2023—reflecting a shift toward more balanced financing (Baidoo 2022).

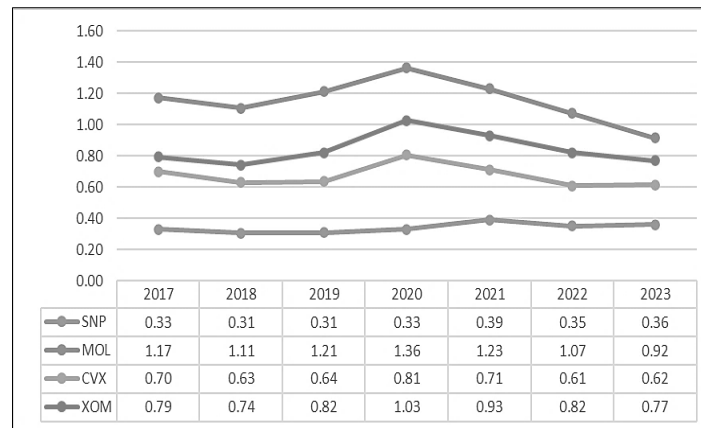


Figure 4. *Leverage ratio (Debt-to-equity) of oil companies, 2017–2023*
(Source: Own compilation based on financial reports)

Chevron (CVX) and **ExxonMobil (XOM)** operated with moderate leverage. Their ratios mostly ranged between 0.60 and 0.85, which is typical for capital-intensive industries where long-term debt supports growth and asset development (Virág et al. 2013; Balli et al. 2023). The sharp rise in MOL’s leverage during the pandemic suggests heightened financing pressure, while SNP’s low values signal superior financial flexibility. High leverage can reduce room for maneuver in turbulent markets, while a lower ratio helps protect liquidity and supports long-term sustainability (Baranyai et al. 2020).

4.6. MARKET INDICATORS

Market indicators provide key insights into how investors perceive the financial value and future performance of oil companies. They include metrics like the price-to-earnings (P/E) ratio, price-to-book (P/BV), market capitalization, dividend payout ratio, and dividend yield—all of which indirectly reflect corporate earnings potential and investor sentiment (Fazakas et al. 2003; Baranyai et al. 2013).

As shown in **Figure 5**, P/E ratios fluctuated significantly during 2017–2023, particularly during the COVID-19 period. Western majors like **Chevron (CVX)** and **ExxonMobil (XOM)** experienced a sharp decline followed by recovery after 2022, while Central-Eastern European companies such as **MOL** and **OMV Petrom (SNP)** saw a steep fall in 2020 but gradually regained value (Deepikah & Kohli 2023). This reflects broader investor expectations and is closely tied to firms’ earnings-per-share (EPS), which also rebounded post-pandemic (Huda & Sabur 2025). P/BV values also revealed regional distinctions. While CVX and XOM mostly stayed above the critical threshold of 1.0, suggesting fair valuation, MOL and SNP hovered below this level—indicating potential undervaluation or weaker market confidence (Brealey & Meyers 2011).

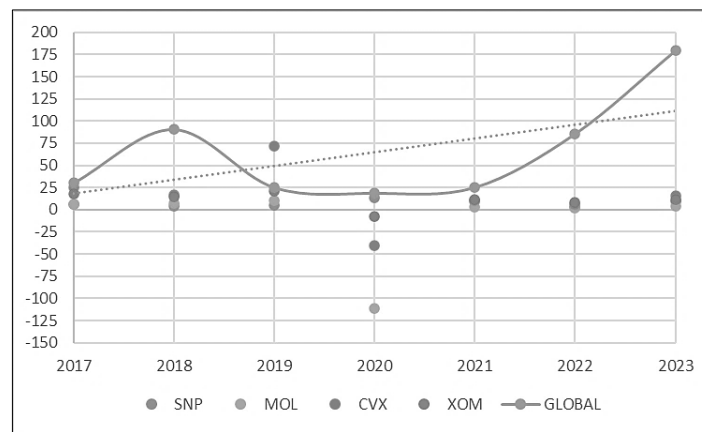


Figure 5. Price-to-Earnings (P/E) ratio of oil companies compared to the global industry average, 2017–2023

(Source: Own compilation based on company reports and NYU Stern data)

Market capitalization data (Table 14) further underscores the gap: CVX and XOM maintained average values of \$237B and \$319B respectively, far above the MOL (\$6B) and SNP (\$5B) averages. These differences stem from global presence, production volumes, and capital intensity (Ulbert et al. 2018). Dividend policy also diverged: U.S. firms maintained stable payout ratios (40–60%), while European counterparts like MOL occasionally reported extreme values (e.g., 143% in 2017), hinting at irregular cash flow distribution or reserve-based payments (Baranyai et al. 2013). Similarly, dividend yields were higher for MOL and SNP (up to 13%), whereas CVX and XOM offered lower but more predictable returns (Brealey & Meyers 2011).

5. SECTOR-SPECIFIC INDICATORS: RLI, RRR, AND OIL SENSITIVITY

In addition to traditional financial ratios, sector-specific indicators provide valuable insights into the sustainability, exploration performance, and market exposure of oil companies. This section focuses on three key metrics: the **Reserve Life Index (RLI)**, the **Reserve Replacement Ratio (RRR)**, and **oil price sensitivity**.

The **RLI** estimates how many years a company can sustain its production using known reserves, assuming constant extraction rates. OMV Petrom (SNP) maintained a stable average RLI of **9.18 years** over the period, rising to 10.25 years in 2023. MOL had the shortest reserve lifespan with an average of **3.27 years**, despite recovering from a low of 2.43 years in 2019. Chevron (CVX) followed a declining trend, averaging **5.25 years** between 2017 and 2023. In contrast, ExxonMobil (XOM) recorded the longest average RLI at **11.46 years**, reflecting consistent reserve expansion (Canacol Energy Ltd. 2025).

The **RRR** indicates how effectively companies replace extracted reserves. A value above 100% suggests that reserves are being replenished or expanded. XOM outperformed all others with an average RRR of **200%**, including a peak of 534% in 2022. CVX and MOL were relatively close, averaging **81%** and **82%**, respectively. SNP displayed considerable volatility: although it reached 206% in 2023, its seven-year average was only **53%** (Situmoarg et al. 2025).

Oil price sensitivity captures how much a firm's revenue is influenced by global oil price changes. SNP exhibited the highest average sensitivity at **113%**, suggesting strong exposure to international market fluctuations. CVX also showed high sensitivity at **100%**. Meanwhile, MOL and XOM had lower average values of **74%** and **79%**, possibly due to regional market regulations and pricing strategies (Considine et al. 2022).

As shown in **Table 1**, U.S. firms maintain longer reserve life cycles, stronger reserve replacement capacity, and higher sensitivity to global price dynamics. In contrast, CEE firms demonstrate more moderate reserves, fluctuating RRR values, and reduced exposure to oil price shocks. Stable and high RRR values—like those of XOM—may contribute to better investor perception and long-term sustainability (World Oil Staff 2024).

Table 1. Key Industry-Specific Indicators (2017–2023 Averages)

Company	Reserve Life Index (RLI, years)	Reserve Replacement Ratio (RRR, %)	Oil Price Sensitivity (%)
OMV Petrom (SNP)	9.18	53	113
MOL	3.27	82	74
Chevron (CVX)	5.25	81	100
ExxonMobil (XOM)	11.46	200	79

Source: Author's calculations based on company reports, Canacol Energy Ltd. (2023, 2025); Situmoarg et al. (2025); Considine et al. (2022); World Oil Staff (2024)

6. APPLICATION OF CAPM, WACC, AND EVA TO THE ANALYZED COMPANIES

The application of CAPM, WACC, and EVA models offers a nuanced picture of the value creation and financing structure of the four analyzed oil companies. Following Damodaran's (2012) framework, the average cost of equity (r_e), weighted average cost of capital (WACC), and economic value added (EVA) were assessed for the 2017–2023 period, as summarized in **Table 2**.

Table 2. Key Capital Cost and Value Creation Indicators (Averages for 2017–2023)

Company	Cost of Equity (r_e , %)	WACC (%)	ROE – r_e (%)	ROA – WACC (%)	EVA Average (B USD)
OMV Petrom (SNP)	16	16	–5	–8	–0.14
MOL	15	10	–2	–4	+0.30
Chevron (CVX)	9	8	0	–3	negative until 2021
ExxonMobil (XOM)	9	8	+3	–2	+31.9 (2022 peak)

Source: Author's calculations based on company reports and NYU Stern database

The results show that Central and Eastern European firms (SNP, MOL) face significantly higher capital costs compared to U.S.-based peers (CVX, XOM), which remained close to the global average across the entire period. According to Ulbert et al. (2018), this disparity may stem from less favorable debt structures and elevated risk perception in CEE markets. The WACC values of SNP and MOL consistently exceeded the industry benchmark (see Figure 27), indicating a structurally higher cost of capital. Meanwhile, the positive EVA trajectory observed for XOM and CVX after 2021 suggests a strong recovery in value creation. XOM's EVA reached a peak of +31.9 billion USD in 2022, while MOL recorded a modest but positive average (+0.30 billion USD), supporting Baranyai et al.'s (2013) argument that firms with lower WACC and disciplined capital use are more likely to achieve economic surplus.

The ROE – r_e and ROA – WACC spreads further confirm these differences. SNP and MOL underperformed with negative gaps (–5% and –2% in ROE – r_e), while XOM outperformed expectations (+3%), reflecting efficient shareholder value creation (see Table 18 and 19 in the appendix). As highlighted by Sudarsono and Harahap (2023), such consistent overperformance signals robust strategic and operational execution in capital-intensive industries.

Overall, the results indicate that Western companies (XOM, CVX) operate with more efficient capital structures and are better positioned to meet or exceed investor expectations. In contrast, CEE firms like SNP and MOL continue to struggle with structurally higher capital costs and weaker excess return indicators—findings that align with Juhász and Szabó’s (2021) observation on the valuation disadvantage of Eastern European oil companies.

7. MULTIVARIATE REGRESSION ANALYSIS: IDENTIFYING KEY VALUE DRIVERS

To deepen the comparative analysis, four multivariate regression models were conducted to identify the most relevant financial drivers behind EPS, ROE, ROIC, and P/BV valuation. **Table 3** summarizes the most important results based on the 2017–2023 dataset.

The **EPS model** reveals a strong positive association with the price-to-book ratio (P/BV) and EVA, with a standardized beta of 0.84 for P/BV ($p < 0.001$), supporting findings from Ulbert et al. (2018) regarding the relevance of market valuation and value creation metrics. The adjusted R^2 of 0.836 indicates excellent model fit.

For **ROE**, the model highlights EBITDA/ROA, EVA, and ROIC_diff as significant predictors. The high standardized beta of 0.77 for EBITDA/ROA ($p < 0.001$) emphasizes internal profitability as a key determinant of shareholder return, in line with Baranyai et al. (2013).

The **ROIC model** is the most parsimonious, driven solely by ROA, yet achieves an adjusted R^2 of 0.884 and a beta of 0.95, underlining the theoretical linkage between asset returns and invested capital (Damodaran, 2012).

Lastly, the **P/BV valuation model** identifies Market Capitalization, WACC_diff, and EPS as key explanatory variables. EPS emerges as the strongest predictor ($\beta = 0.79$, $p < 0.001$), consistent with the investor-oriented valuation literature (Sudarsono & Harahap, 2023).

These models confirm that both profitability and capital efficiency—especially EVA, EPS, and ROA—are central in explaining firm value and investor perception. The differences in predictive power between Western and CEE-based oil firms also suggest regional variations in how market valuation reflects internal performance, as highlighted in **Table 3**.

Table 3. Detailed Summary of Regression Models (2017–2023)

Dependent Variable	Significant Predictors	R^2	Adjusted R^2	F-statistic	p-value (model)	Standardized Beta (key predictor)	Sig. (key predictor)
EPS	P/BV, EVA	0.869	0.836	25.47	<0.001	0.84 (P/BV)	<0.001
ROE	EBITDA/ROA, EVA, ROIC_diff	0.907	0.872	26.89	<0.001	0.77 (EBITDA/ROA)	<0.001
ROIC	ROA	0.896	0.884	75.32	<0.001	0.95 (ROA)	<0.001
P/BV	Market Cap, WACC_diff, EPS	0.928	0.901	33.21	<0.001	0.79 (EPS)	<0.001

Source: Own calculation based on SPSS regression outputs using oil company data from 2017 to 2023.

8. CONCLUSION

The comparative analysis of OMV Petrom, MOL, Chevron, and ExxonMobil between 2017 and 2023 reveals notable regional disparities in financial structure and performance. Central-Eastern European companies, particularly OMV Petrom, exhibit a more conservative capital structure with higher equity ratios and lower debt dependency, which contributes to reduced financial risk exposure. In contrast, U.S.-based companies like Chevron and ExxonMobil demonstrate stronger liquidity, efficient working capital management (evident in negative CCC values), and more significant stock market valuation—reflected in their superior EPS, P/E, and P/BV ratios.

Profitability indicators (ROE, ROA, ROIC) suggest that the CEE firms, despite their smaller scale, utilize their assets and capital more effectively in certain years. Nevertheless, Western companies show stronger long-term value creation capacity, as confirmed by their post-2021 positive EVA values and relatively low WACC rates (~8–9%). The region's players, while offering higher dividend yields, show limitations in sustaining value creation, as seen in OMV Petrom's persistently negative EVA.

Oil industry-specific indicators such as Reserve Life Index (RLI) and Reserve Replacement Ratio (RRR) favor U.S. firms, indicating better long-term strategic positioning. Given these insights, a balanced investment approach would be advisable: overweighting U.S. companies for stability and underweighting riskier yet higher-yielding CEE firms. Despite sector volatility, the oil industry remains a fundamental pillar of the global economy, which ensures its financial relevance for years to come.

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AUTHOR'S ADDRESS

ATTILA BOLDIZSÁR

SAPIENTIA HUNGARIAN UNIVERSITY OF TRANSYLVANIA, Faculty of Economics, Applied
Economics and Finance MSc

Csíkszereda, Romania

Email: boldizsargattila@uni.sapientia.ro

BÍBORKA ESZTER-BÍRÓ

SAPIENTIA HUNGARIAN UNIVERSITY OF TRANSYLVANIA, Faculty of Economics

Department of Business Sciences

Csíkszereda, Romania

E-mail: birobiborka@uni.sapientia.ro

A COMPARATIVE ANALYSIS OF COLLABORATIVE FILTERING AND CONTENT-BASED APPROACHES TOWARD HYBRID SOLUTIONS

CSONGOR KRISTÓ - LÁSZLÓ PÁL

Abstract

Recommendation systems enhance digital experiences by utilizing collaborative filtering (k-nn, matrix factorization) and content-based methods (analysing genres, actors, plot, etc.). Hybrid models integrating both approaches aim to address individual limitations and improve accuracy. The aim of this study is to compare memory-based and model-based algorithms within collaborative filtering, while analysing whether TF-IDF or SBERT performs better at content-based recommendations, ultimately designing an advanced hybrid system through strategic integration.

Keywords: recommendation systems, collaborative filtering, content-based filtering, SBERT

1. Introduction

Recommendation systems are everywhere in today's digital world, helping to suggest products like movies, books, courses, or news based on what users might like. With so much information available online and people wanting to save time, these systems are really helpful because they pick out the most interesting content for each person from huge amounts of data.

Unlike physical stores that can only display a few products in their windows, digital recommendation systems can work with unlimited amounts of information. Big companies like Netflix, Amazon, and Spotify rely heavily on these systems. Netflix even created a competition in 2006, offering a prize to anyone who could build a recommendation system 10% better than their existing one called *Cinematch*.

The task of recommendation systems is usually to produce an item list that may be of interest and relevant to the user. The term *item* (Ricci et al. 2022) refers to everything that a recommendation system can offer. These systems define product listings using some kind of user interactions, and there are two types of feedback: *explicit* and *implicit* (Jannach et al. 2010). Implicit feedback includes events like page views or purchase patterns, indicating preferences indirectly. Explicit feedback refers to direct user input carrying more information, such as ratings or written descriptions. The most popular and used systems include collaborative filtering systems, content-based systems, hybrid systems mixing the previous two, and neural network-based systems. Collaborative filtering systems are based on the assumption that users whose preferences are similar in the past will be similar in the future (Jannach et al. 2010). These algorithms can be divided into two main categories, memory-based and *model-based* systems (Gruiter 2021). The most common memory-based algorithms are the *k-nearest neighbor* type algorithms (Schafer et al. 2007), which compile the item list to be recommended by applying similarity metrics to users or items. Model-based algorithms use dimension-reduction techniques (Goldberg et al. 2001), such as matrix factorization algorithms, which train a model on the entire dataset to calculate recommendations.

Content-based systems (Wang et al. 2018) are based on the principle that items with similar properties will also receive similar ratings from users. A common technique for comparing the content of items is the TF-IDF vectorizer, and more recently BERT, and its further developed version, SBERT (Reimers and Gurevych 2019).

Hybrid systems (Lokesh 2019) combine collaborative filtering and content-based systems, and were originally created to eliminate the shortcomings and limitations of the previous recommendation systems.

In recent years, neural networks have become trending in various topics such as speech and image recognition, photo search, and language translations. In the case of recommender systems, it primarily

improves the disadvantages of collaborative filtering-based algorithms, and generally improves the performance of recommendation systems (Ko et al. 2022). The examination of neural network-based recommendation systems is omitted in this thesis due to their high resource requirements.

2. Material and Methods

2.1 Dataset

To test the recommendation algorithms, we used the movie data of MovieLens (Harper and Konstan 2015). We worked with a smaller version of the dataset specifically recommended for education and research, mainly due to the use of resources. The dataset includes 100836 reviews, 9742 movies and 610 users. When the dataset was created, it was a disqualifying criterion that it could contain users only who had at least 20 different movies that were rated.

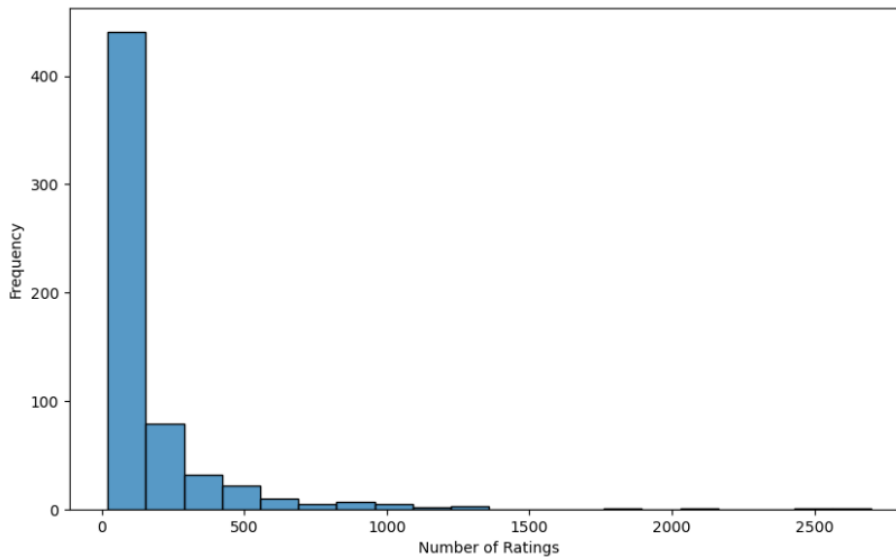


Figure 1. Distribution of ratings by user

Most of the user-item matrices are sparse matrices in practice, which means that there are many more blank cells in the matrix than there are ratings. In our case, the dimensions of the matrix are the number of users and movies, i.e. 610×9742 , which means 5942620 cells, of which only 100836 has a value, which means that our matrix is 98.3% empty. Figure 1 shows that we have a so-called *long-tail* type of data, which supports the fact that our matrix is rare. Furthermore, the figure shows that most users rated between 0 and 250 different movies, but it also shows that there are users who rated more than 2500 movies based on the data.

2.2 Used Methods

2.2.1 Recommendation algorithms

There are three popular, major types of recommendation algorithms: collaborative filtering, content-based, and hybrid recommendation algorithms.

Algorithms *based on collaborative filtering* (Schafer et al. 2007) are based on collaborative similarity, i.e. recommendations are calculated based on similarities between users and between items, and these similarities can be calculated based on previous interactions. These methods can be divided into two broad categories: memory-based and model-based algorithms.

Memory-based algorithms (Ko et al. 2022) are commonly referred to as *neighbourhood-based collaborative filtering algorithms* (or k-nearest neighbour algorithms). These were one of the earliest

collaborative filtering-based algorithms, where the ratings of user-item pairs are estimated based on their neighbourhood.

Model-based algorithms are algorithms that reduce, compress, and break down large, but otherwise sparse, user-item matrices, thereby improving temporal and spatial performance. These include, for example, *matrix factorization* (Ko et al. 2022) algorithms.

Content-based recommendation algorithms make recommendations based on the content of the items, for example, in the case of movies, various characteristics can be taken into account, such as the director of the film, actors, year of release, and a short description of the film. Two important methods should be mentioned here, TF-IDF (Term Frequency - Inverse Document Frequency) (Ni et al. 2021) and SBERT (Sentence - BERT) (Reimers and Gurevych 2019). The final value of TF-IDF is the product of TF and IDF. TF measures the frequency of words in a given document, and IDF shows how specific a word is to a given document based on all available documents.

BERT (Bidirectional Encoder Representations from Transformers) is a neural network-based model that, similar to the TF-IDF method, is able to represent words with vectors, and this method is also able to take into account semantic similarities (for example, the word *good* and *positive* can refer to the same thing), while the TF-IDF vectorizer is not able to do so. SBERT (Sentence-BERT), on the other hand, can represent not only words, but entire sentences as vectors.

Hybrid recommendation systems (Parthasarathy and Devi 2023) usually combine collaborative filtering and content-based recommendation algorithms to eliminate the various disadvantages of recommendation algorithms and increase the performance of the system.

2.2.2 Similarity metrics

Similarity metrics are an important component of certain recommendation systems. These can be used to calculate the similarity between two users or two items based on user interactions, ratings, and item features. The cosine similarity, the Pearson correlation coefficient and the Pearson baseline coefficient were used in the analysis.

2.2.3 Accuracy metrics

RMSE (Root Mean Square Error) and MAE (Mean Absolute Error) are statistical metrics that are used to evaluate regression models. These show how accurate our forecasts and estimates are. Obviously, the lower the value of RMSE or MAE, the better and more accurate our estimates. Furthermore, we used the method of cross-validation to measure the performance of the models.

2.2.4 Classification metrics

Precision, recall, and *F1* are the metrics that are often used in machine learning, such as classification tasks. These metrics are typically calculated based on datasets that include both estimates and real-world values, as this condition is also true in our case. Furthermore, we used the values of the ROC curve and AUC.

2.3 Environment

The development environment was built around Python, utilizing data science libraries like numpy and pandas for data manipulation, with Jupyter Notebook and Google Colab providing interactive platforms for experimentation and visualization.

For implementing the algorithms, the project employed the Surprise library (Hug 2020) for collaborative filtering systems, scikit-learn for content-based and hybrid models, and the Sentence-BERT model (Reimers and Gurevych 2019) for computing semantic similarities in content-based recommendations.

3. Results and Discussion

3.1 User and item-based collaborative filtering comparison

The recommendation algorithms written in the Surprise package are tested in two cases, for collaborative filtering by user and item with the accuracy metrics (RMSE, MAE) and by measuring runtime.

For the user-based experiment, 5 different algorithms will be tested, the *KNNBasic*, *KNNWithMeans*, *KNNBaseline* k-nearest neighbour type, and the *SVD* and *NMF* matrix factorization algorithms. For the item-based experiment, only the three k-nearest neighbour algorithms mentioned above will be tested.

During the experiment, a 5-fold cross-validation is performed with each algorithm, which return the average RMSE, MAE, testing time, training time values, their standard deviations, and the total runtime. Testing, training and total run times are measured in seconds.

3.1.1 User-based collaborative filtering

Table 1 shows that the *KNNBaseline* algorithm performed the best in terms of accuracy among the k-nearest neighbour type algorithms, since the average of RMSE and MAE is the lowest of this algorithm and the *SVD* performs better among the matrix factorization algorithms.

Table 1. Result of user-based collaborative filtering comparison

Algorithm name	rmse mean	mae mean	rmse std	mae std	test time mean	fit time mean	test time std	fit time std	total time
KNNBasic	0.9730	0.7512	0.0049	0.0029	2.13	0.65	0.13	0.04	14
KNNWithMeans	0.8969	0.6827	0.0074	0.0048	2.37	0.64	0.1	0.02	16
KNNBaseline	0.8769	0.6694	0.0069	0.0038	2.62	0.83	0.16	0.02	18
SVD	0.8743	0.6717	0.0052	0.0040	0.31	1.76	0.08	0.11	11
NMF	0.9239	0.7069	0.0060	0.0038	0.21	3.35	0.09	0.19	18

The stronger performance of the *SVD* and *KNNBaseline* algorithms can be seen from the fact that *SVD* as a model-based algorithm is capable of better performance than memory-based algorithms, and the baseline method used in the *KNNBaseline* algorithm is the most sophisticated method of establishing similarities between users.

3.1.2 Item-based collaborative filtering

In the course of the item-based collaborative filtering comparison, we can conclude in Table 2 that the *KNNBaseline* algorithm produced the best results both in terms of statistical accuracy and speed.

Table 2. Item-based collaborative filtering comparison result

Algorithm name	rmse mean	mae mean	rmse std	mae std	test time mean	fit time mean	test time std	fit time std	total time
KNNBasic	0.9688	0.7527	0.0068	0.0054	10.15	13.48	0.73	0.51	119
KNNWithMeans	0.9037	0.6872	0.0056	0.0038	10.83	13.10	0.56	0.63	120
KNNBaseline	0.8790	0.6757	0.0057	0.0039	10.60	12.27	0.38	0.39	115

We can notice that the algorithms show very close, similar results in terms of accuracy compared to user-based testing. In terms of speed, however, there is a huge difference, the average testing time, the average fitting time and thus the total run time are many times higher than user-based collaborative filtering.

The difference in speed between user-based and item-based algorithms is given by the data set itself, as there are only 610 users and 9742 movies, so calculating similarities between items is a much more time-consuming task than calculating similarities between users. In reality, it's the other way around, as there are many more users than items, so item-based algorithms run faster, in our case this difference is caused by the dataset we use.

3.2 Search for optimal parameters

In this experiment, we work with the two algorithms that have proven to be the best based on the tests so far, SVD and KNNBaseline, but in two cases, for user-based and item-based collaborative filtering. Some of the most important parameters of the KNNBaseline algorithm within the Surprise package include the *k* parameter, which specifies the maximum number of neighbors for estimation, the *sim_options*, which contains additional parameters in a dictionary data type, such as *name*, which specifies the similarity metric to use. The *min_support* determines the minimum number of neighbors for estimation, and the *user_based* logical value, which determines whether it calculates similarities based on user-based or item-based collaborative filtering. Also worth mentioning is the *bsl_options* parameter, which defines the method of baseline estimation.

The most important parameters of the SVD matrix factorization algorithm include *lr_all*, which controls the learning rate of parameters, *reg_all*, which determines the regularization of parameters, *n_factors*, which specifies the number of latent factors for factorization, and *n_epochs*, which specifies the number of times the SGD procedure is iterated.

SGD (Stochastic Gradient Descent) and ALS (Alternating Least Squares) are algorithms that are often used to solve machine learning-related tasks. Within the scope of recommendation algorithms, they play a major role in the calculation of the baseline.

The aim of the experiment is to generate optimal parameters for the algorithms, and then to test the algorithms with the optimal parameters using different precision (RMSE) and classification (precision, recall, F1) metrics.

The search for optimal parameters is carried out using the so-called *Hyperparameter tuning* technique. There are several versions of this, we use a variant called *grid search*, which is a simple method of search, where we specify different intervals for a number of parameters for the algorithms, and this tests all the permutations of the parameters when it runs, and then returns the optimal parameters, based on which parameter combination is the best for a given accuracy metric (e.g. RMSE) for the given algorithm during a k-fold-based cross validation.

During the experiment, we determine the optimal parameters of the algorithms, then insert the optimal parameters into the algorithms, and test them against the RMSE accuracy metric and the classification metrics.

Figure 2 shows that the most accurate estimates are made by the SVD algorithm based on RMSE, and the most inaccurate estimates are made by the user-based KNNBaseline algorithm.

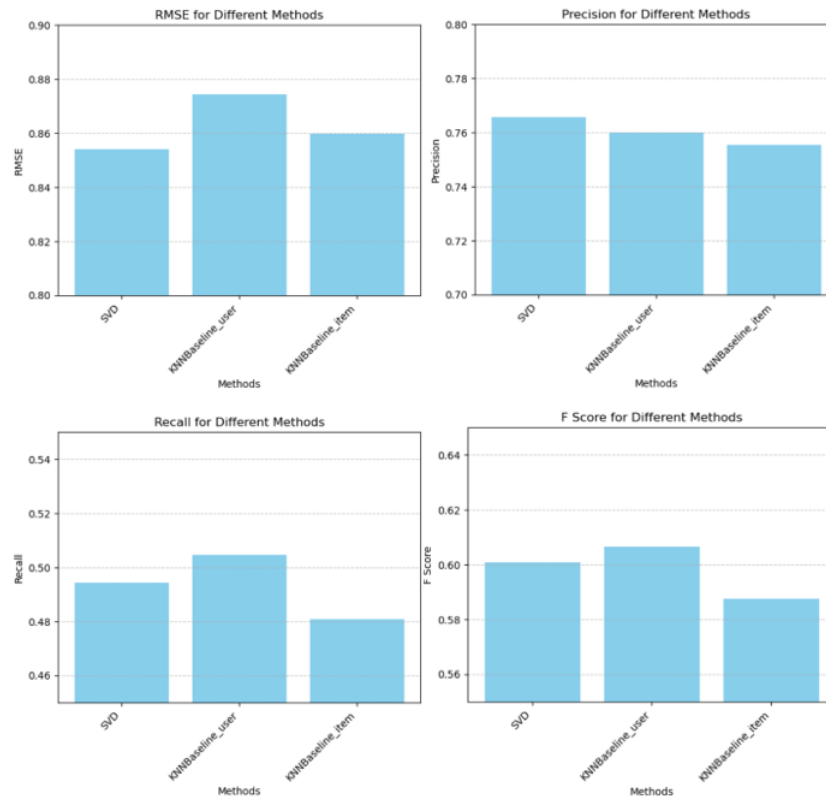


Figure 2. Algorithm performance with optimal parameters based on accuracy and classification metrics

Furthermore, in the case of classification metrics, we can see that SVD is also the most precise, but here the item-based KNNBaseline algorithm performs the weakest. In terms of recall and F1, the user-based KNNBaseline performs best, while its item-based version performs the worst. We can say that if we need accurate and precise estimates, we can choose the SVD algorithm in the first place, or if wider coverage and better classification performance are more important, we can choose the user-based KNNBaseline algorithm.

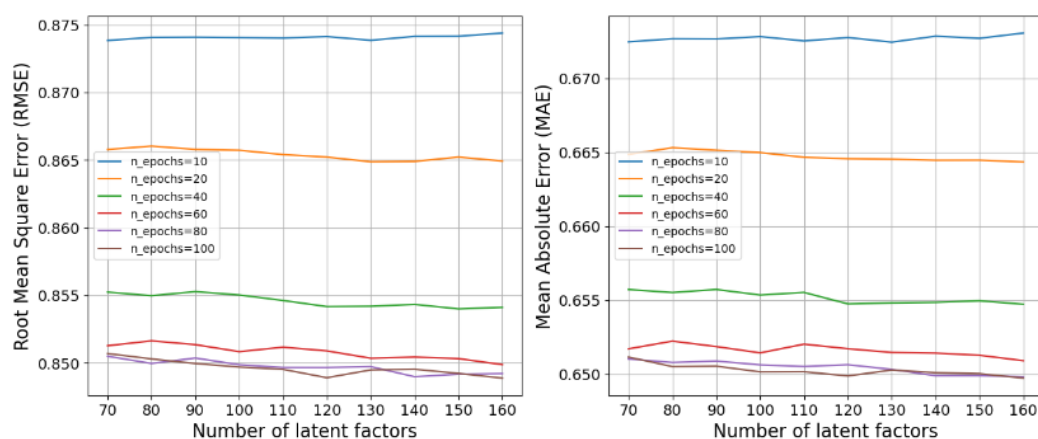


Figure 3. For different parameters of SVD, distributions of accuracy metrics

Figure 3 shows the search for the optimal parameters of the SVD taking into account the accuracy metrics. Looking primarily at the RMSE accuracy metric, the optimal parameters of the SVD algorithm were the following: n_factors: 160, n_epochs: 100, reg_all: 0.1, lr_all: 0.008. It can be

clearly seen in the figure above that the higher the parameters of the iteration and latent factors (n_epochs , $n\_factors$), the better the RMSE and MAE values are obtained.

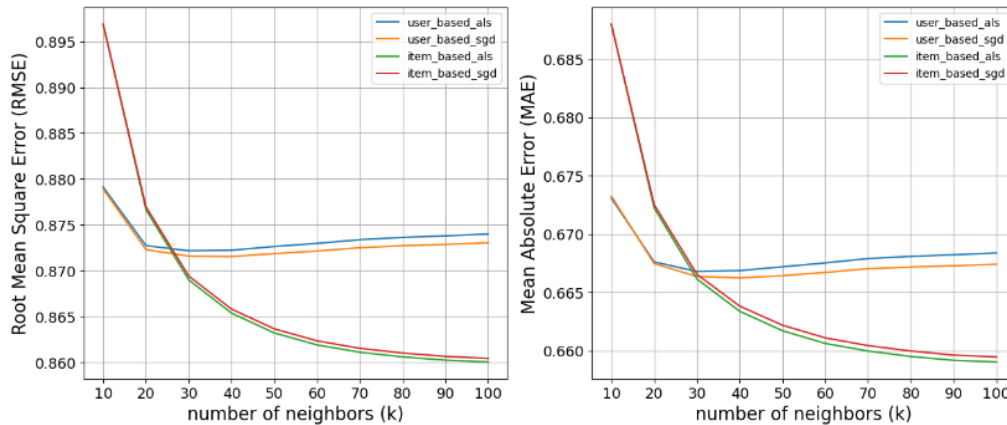


Figure 4. Distribution of KNNBaseline algorithm accuracy values for different neighbourhood values (k)

Figure 4 shows that the most accurate estimates are obtained with the KNNBaseline algorithm if we use the ALS method with item-based collaborative filtering and taking into account the largest possible number of neighbours, in our case taking into account 100, and in the case of user-based collaborative filtering, taking into account the ALS method and 40 neighbours.

The difference between the optimal k values of user-based and item-based algorithms can also be seen as a result of the specificity of our data set, that the number of items greatly exceeds the number of users, thus, a larger size of the neighborhood gives optimal estimates for the items, while a relatively smaller neighborhood is needed for users.

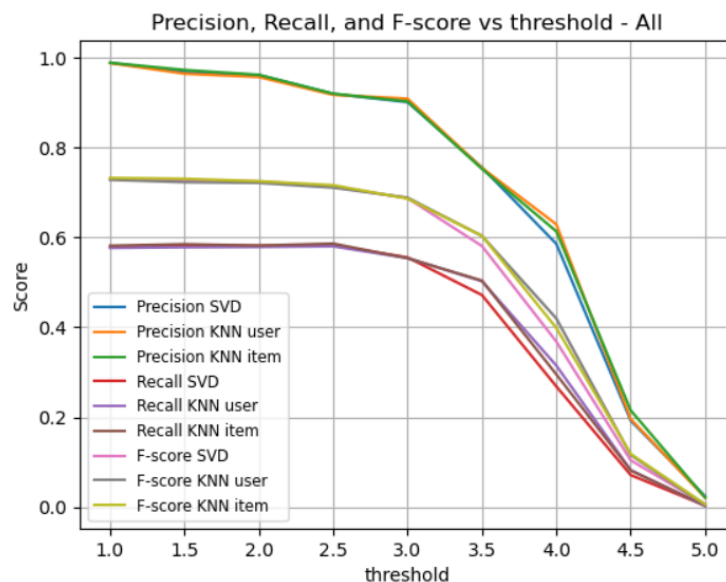


Figure 5. Comparison of classification metrics and threshold

Figure 5 shows the values of the classification metrics for different thresholds. Classification metrics take their highest value when the threshold is only 1, but the threshold should be set at the highest possible level, as it is not worth recommending a film whose rating is low, as there is a good chance that the user will not like it.

Instead, we can choose the threshold value at 3, as the metrics are still very close to their own maximum, but at a threshold higher than 3, the values of the metrics start to decrease rapidly.

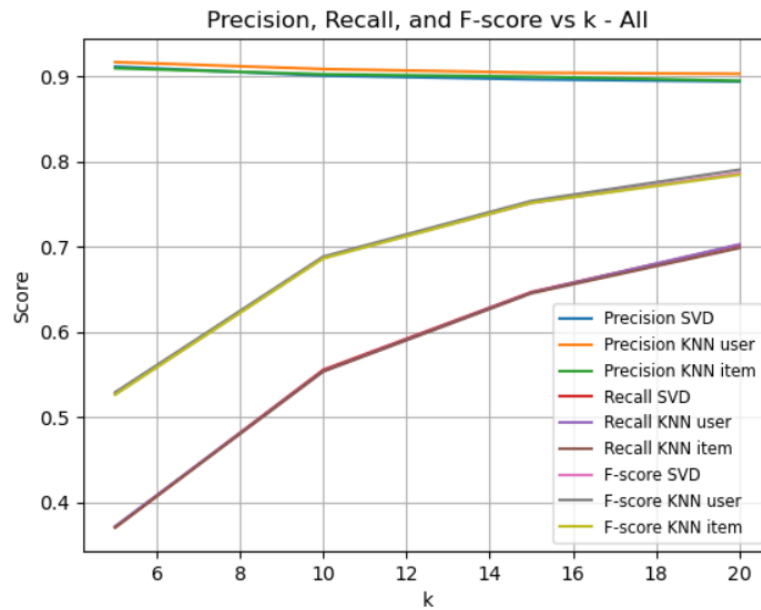


Figure 6. Comparison of classification metrics and k

In Figure 6 we can see the classification metrics for different k values, and we can clearly see that as k increases, precision decreases very slightly, almost stays constant, but recall and F1 increase rapidly, so 20 is a logical choice for k .

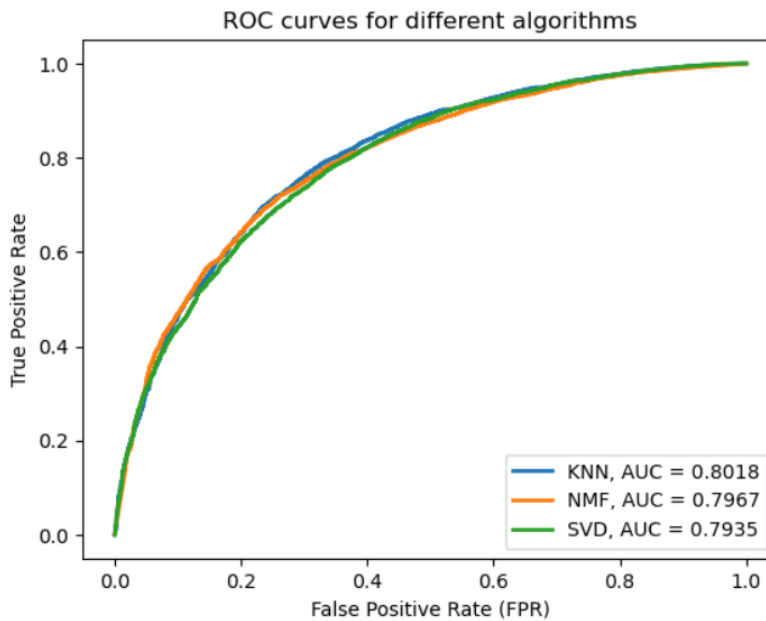


Figure 7. ROC curve, AUC values.

Figure 7 shows the ROC curve, where the threshold is 3, and the AUC values for the labels measured for the KNNBaseline, NMF and SVD algorithms. We can read that for all three algorithms, AUC values came out very close to each other, around 0.8, where KNNBaseline performs best, with the highest AUC value.

3.3 Content-based recommendation system

For content-based recommendations, we test the TF-IDF vectorization method with different movie properties. We compare the recommendations it gives for a given, well-known movie, firstly if we recommend a movie based only on the genres of the films, then if we recommend a movie based on genres and actors, and finally if we recommend a movie based on genres, actors and movie descriptions.

Finally, we will also test the recommendation with the SBERT model, here we can compare the recommendations with the third case of the previous experiment, since the description of the movie contains sentences that, in theory, the SBERT model handles very well.

The selected movie is *Star Wars: Episode III - Revenge of the Sith*, as there are several Star Wars films in our data set, and it is easy to illustrate the similarities between the films, and thus the accuracy and relevance of the content-based recommendations.

It is important to note that just because a film is completely similar to the film we have chosen based on certain criteria, it does not mean that the given user will like it, so there is more emphasis on subjective judgment and evaluation than on numerical similarity.

3.3.1 Content-based recommendation - based on genres

The following recommendations for our selected movie are calculated based on the genres of the movies. The genres of our selected movie are: action, adventure, sci-fi. Since the similarities between movies are calculated by the TF-IDF method only by genres, we can expect that films that also belong to action, adventure and science fiction films will be at the top of the recommended list.

Table 3. Recommendations based on genres

Title	Genres	Similarity
Waterworld	Action, Adventure, SciFi	1.00
Star Wars: Episode IV - A New Hope	Action, Adventure, SciFi	1.00
Stargate	Action, Adventure, SciFi	1.00
Demolition Man	Action, Adventure, SciFi	1.00
Star Wars: Episode V - The Empire Strikes Back	Action, Adventure, SciFi	1.00
Star Wars: Episode VI - Return of The Jedi	Action, Adventure, SciFi	1.00
Star Trek III: The Search For Spock	Action, Adventure, SciFi	1.00

In Table 3 we can see that all the recommended films belong to the same genres as the Star Wars movie to which we compare, so each film has been rated with maximum similarity.

3.3.2 Content-based recommendation - based on genres and actors

The following recommendation is based on the genres of the films and the actors added compared to the previous recommendation. The cast of our selected Star Wars movie in our dataset are: Hayden Christensen, Natalie Portman, and Ewan McGregor. Since we are already using more information, we can expect to get more relevant recommended films.

Table 4. Recommendations based on genres and actors

Title	Genres	Actors
Star Wars: Episode II - Attack of the Clones	Action, Adventure, Sci-Fi, IMAX	Hayden Christensen, Natalie Portman, Ewan McGregor
Star Wars: Episode I - The Phantom Menace	Action, Adventure, Sci-Fi, Thriller	Ewan McGregor, Liam Neeson, Natalie Portman
Jumper	Action, Adventure, Drama, Sci-Fi, Thriller	Hayden Christensen, Samuel L. Jackson, Jamie Bell
American Heist	Action	Hayden Christensen, Earl Minor, Adrien Brody
Six-String Samurai	Action, Adventure, Sci-Fi	Jeffrey Falcon, Justin McGuire, Kim DeAngelo
20,000 Leagues Under The Sea	Action, Adventure, Sci-Fi	Allen Holubar, Dan Hanlon, Edna Pendleton
Annihilation	Adventure, Mystery, Sci-Fi, Thriller	Natalie Portman, Jennifer Jason Leigh, Tessa Thompson

Table 4 shows that compared to the previous experiment, where we only made comparisons and recommendations based on genres, we came up with different recommendations. It may be deceptive that fewer Star Wars movies are shown here than in the previous attempt, but here a real order is formed based on the similarities, as the similarities between the films are different compared to our film, unlike the previous experiment, where each shown film is assigned the same similarity, so the order displayed there is completely random, however we would like to shape it.

Looking at the rest of the films, we can also say that the recommendations are more relevant, since not only the genres are found, but there are also matches between the actors.

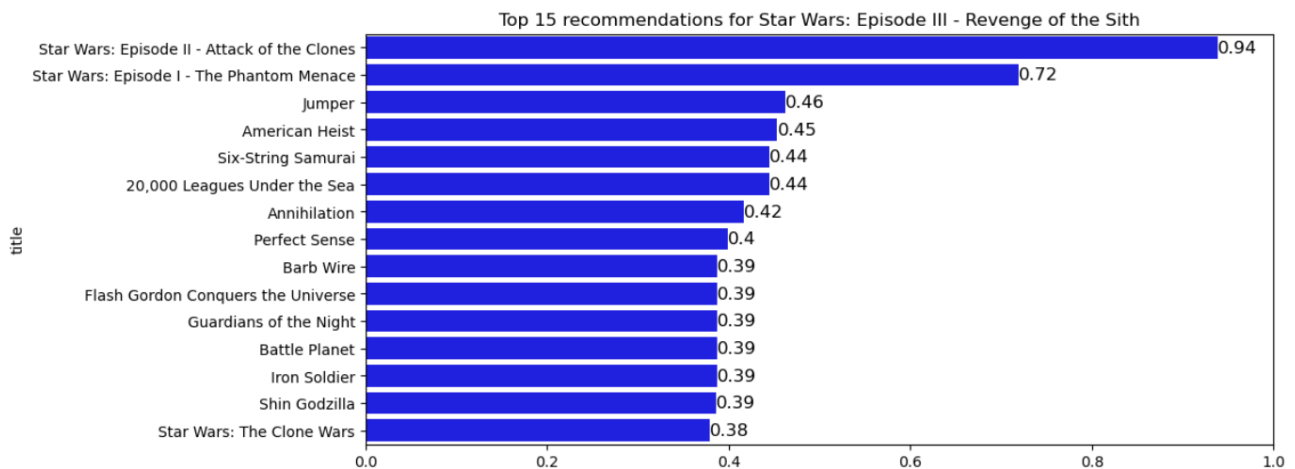


Figure 8. Similarity values of recommendations by genre and actor

However, in Figure 8, we can see that the Star Wars movies in the first two places are the most similar to our chosen movie, as the genres and actors are largely the same.

3.3.3 Content-based recommendation - based on genres, actors and movie descriptions

We introduce another factor to the recommendation, the descriptions of the films. The genres and actors together make up about 10 words, but most of the film descriptions are around 500 words (Figure 9), so it is expected that the algorithm will recommend several films that contain genres or actors that are not part of the selected film.

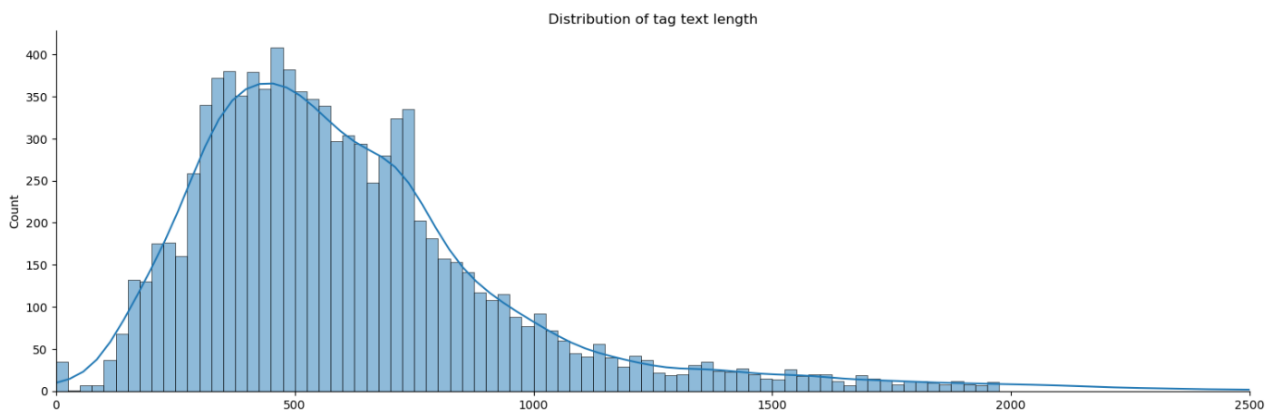


Figure 9. Movie description length distribution

In Table 5 we can see the recommendations received based on genres, actors and descriptions. We can read that Star Wars movies are being shown as before, but it is also noticeable that there are also films whose genres or actors do not match our chosen film at all.

Table 5. Recommendations based on genres, actors and movie descriptions

Title	Genres	Actors
Star Wars: Episode II - Attack of the Clones	Action, Adventure, Sci-Fi, IMAX	Hayden Christensen, Natalie Portman, Ewan McGregor
Havoc in Heaven	Animation	Yue-Feng Qiu, Run-Sheng Fu, Hans Alfredson
Star Wars: The Clone Wars	Action, Adventure, Animation, Sci-Fi	Matt Lanter, Nika Futterman, Tom Kane
Star Wars: Episode I - The Phantom Menace	Action, Adventure, Sci-Fi, Thriller	Ewan McGregor, Liam Neeson, Natalie Portman
Puppet Master 5	Horror, Sci-Fi, Thriller	Gordon Currie, Chandra West, Ian Ogilvy, Teresa Hill
Star Wars: Episode VIII - The Last Jedi	Action, Adventure, Fantasy, Sci-Fi	Daisy Ridley, John Boyega, Mark Hamill
2046	Drama, Fantasy, Romance, Sci-Fi	Tony Leung Chiu-wai, Ziyi Zhang, FayeWong

3.3.4 Comparison of TF-IDF and SBERT

In this experiment, the previous recommendation, where we generated recommendations based on genres, actors, and descriptions using the TF-IDF vectorization method, is compared with the SBERT model for the same data.

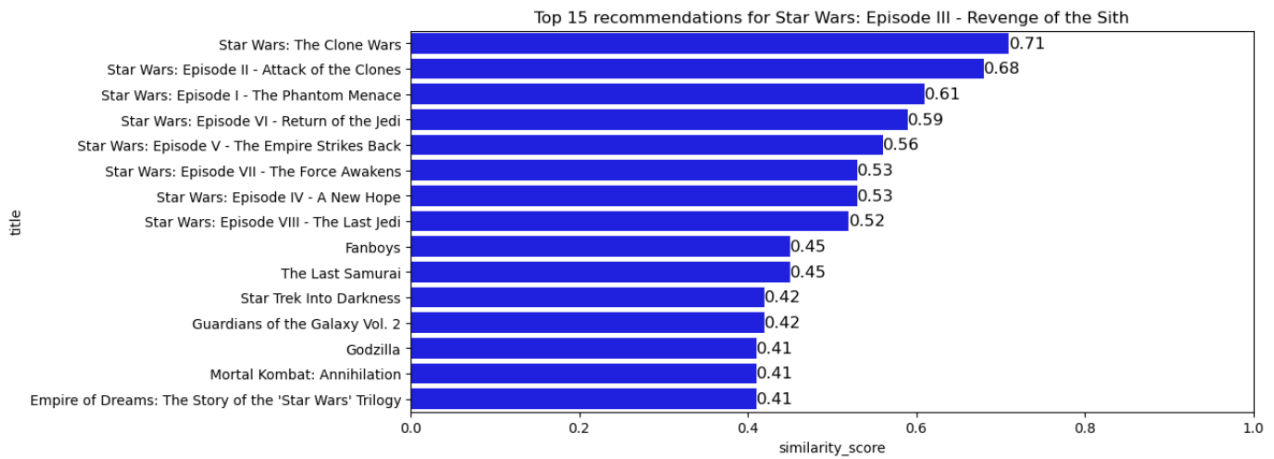


Figure 10. Recommendations with the SBERT model based on genres, actors and descriptions

The SBERT method should theoretically provide much better, more relevant recommendations, because while the TF-IDF vectorizer can only characterize the importance of words, but cannot draw similarities between synonyms, the SBERT model can not only take into account the similarity between synonyms, but even detects the intellectual similarity of sentences, and in this case, when we also take into account the descriptions, this is very much in the hands of SBERT in theory. This difference is clearly visible in Figure 10, as almost all of the Star Wars-themed movies in our dataset occupy the very first places, and from the genres and actors of the other films it can be read on Table 6 that there are matches with the selected film in them as well.

Table 6. Recommendations with the SBERT model based on genres, actors and descriptions

Title	Genres	Actors
Star Wars: The Clone Wars	Action, Adventure, Animation, Sci-Fi	Matt Lanter, Nika Futterman, Tom Kane
Star Wars: Episode II - Attack of the Clones	Action, Adventure, Sci-Fi, IMAX	Hayden Christensen, Natalie Portman, Ewan McGregor
Star Wars: Episode I - The Phantom Menace	Action, Adventure, Sci-Fi, Thriller	Ewan McGregor, Liam Neeson, Natalie Portman
Star Wars: Episode VI - Return of The Jedi	Action, Adventure, Sci-Fi	Mark Hamill, Harrison Ford, Carrie Fisher
Star Wars: Episode V - The Empire Strikes Back	Action, Adventure, Sci-Fi	Mark Hamill, Harrison Ford, Carrie Fisher
Star Wars: Episode VII - The Force Awakens	Action, Adventure, Fantasy, Sci-Fi, IMAX	Daisy Ridley, John Boyega, Oscar Isaac
Star Wars: Episode IV - A New Hope	Action, Adventure, Sci-Fi	Mark Hamill, Harrison Ford, Carrie Fisher
Star Wars: Episode VIII - The Last Jedi	Action, Adventure, Fantasy, Sic-Fi	Daisy Ridley, John Boyega, Mark Hamill
Fanboys	Adventure, Comedy, Drama	Dan Fogler, Jay Baruchel, Kristen Bell
The Last Samurai	Action, Adventure, Drama, War	Tom Cruise, Ken Watanabe, Billy Connolly
Star Trek Into Darkness	Action, Adventure, Sci-Fi, IMAX	Chris Pine, Zachary Quinto, Zoe Saldana

Guardians of the Galaxy Vol. 2	Action, Adventure, Sci-Fi	Chris Pratt, Zoe Saldana, Dave Bautista

3.4 Comparison of hybrid, collaborative and content-based recommendation systems

Content-based recommendation systems can generate recommendations for a given movie without any additional user information, but we cannot say or estimate it numerically, whether the recommendation will appeal to a selected user.

Collaborative filtering recommendation systems can generate movies for a given user, but they cannot give accurate, correct estimates based on a single movie.

The hybrid system, on the other hand, eliminates these shortcomings, as it initially generates a recommendation based on the given film based on the content-based algorithm, then it assesses all the recommendations received with the help of collaborative filtering to see what kind of rating the given user would give it, and it forms the final movie list based on these data.

In the hybrid system we created, we introduced a weight, which gives the evaluation weight between the estimation value calculated by the collaborative filtering and the similarity values calculated by the content-based recommendation. The weight ranges from 0 to 1, for example, if the weight is 0.8, then 80% of the weighted rating is given by the estimated value and 20% by the similarity value.

Table 7. Recommendation of a content-based system based on genres using the TF-IDF method

Title	Similarity value	Genres
Star Wars: Episode IV - A New Hope	1.0	Action, Adventure, Sci-Fi
Stargate	1.0	Action, Adventure, Sci-Fi
Demolition Man	1.0	Action, Adventure, Sci-Fi
Star Wars: Episode V - The Empire Strikes Back	1.0	Action, Adventure, Sci-Fi
Star Wars VI - Return of the Jedi	1.0	Action, Adventure, Sci-Fi
Star Trek III: The Search for Spock	1.0	Action, Adventure, Sci-Fi
Lost in Space	1.0	Action, Adventure, Sci-Fi

Table 7 shows the genre-based content-based recommendation for the previously selected Star Wars movie.

Table 8. Recommended hybrid system with a weight of 0.8.

Title	Similarity value	Estimated value	Weighted value
Star Wars: Episode V - The Empire Strikes Back	1.0	4.27	4.42
Bulletproof Monk	1.0	4.14	4.31
Escape from New York	0.87	4.17	4.24
Serenity	1.0	3.91	4.13
Godzilla 2000	1.0	3.89	4.11

Spacehunter: Adventures in the Forbidden Zone	1.0	3.88	4.11
Star Wars: Episode VI - Return of the Jedi	1.0	3.77	4.02

In Table 8, we can see the recommendation of the hybrid system with a weight of 0.8 to user 2, from our dataset, based on our selected film, we can read that here we were able to generate better recommendations based on the estimated value, other films are also coming in that represent not only the genres of our selected film.

Table 9. Recommended hybrid system with a weight of 0.8.

Title	Similarity value	Estimated value	Weighted value
Star Wars: Episode V - The Empire Strikes Back	1.0	4.27	4.85
Bulletproof Monk	1.0	4.14	4.82
Serenity	1.0	3.91	4.78
Godzilla 2000	1.0	3.89	4.77
Spacehunter: Adventures in the Forbidden Zone	1.0	3.88	4.77
Star Wars: Episode VI - Return of the Jedi	1.0	3.77	4.75

In Table 9, we can see the recommendation of the hybrid system with a weight of 0.8, where due to the greater emphasis placed on the similarity value, all recommended movies have genres fully aligned with the selected movie's genres.

Overall, we can say that the hybrid system gives better recommendations than collaborative filtering and content-based recommendation, because here we can take into account both similarity values and estimated values. The choice of weight in our case depends on the use of the content-based method, as we used the TF-IDF method for genres, so we can achieve greater coverage, if we use more weight, we prefer the estimated value.

4. Conclusion

When comparing user-based and content-based collaborative filtering, we could notice interesting things, such as the fact that, contrary to general expectations, user-based algorithms performed much better than item-based algorithms at runtime. This can be seen as a uniqueness of the data set used, because while in a live situation there are many more users than items, in our data set it is exactly the opposite, there are many more movies than users.

When searching for the optimal parameters, we could see that the classification metrics divide when and which algorithm is better to apply, if precise estimates are needed, SVD is recommended, but if better coverage is needed, KNNBaseline should be chosen. Furthermore, we have seen that it is very important to use optimal parameters, as the accuracy indicators show very well that there is a big difference between optimal and non-optimal parameters, which greatly affect the performance of the algorithm and the accuracy of the recommendations.

In the case of content-based recommendation systems, the assessment of results is more subjective, as we cannot represent them perfectly numerically. Using the TF-IDF technique, we can practically say that the more characteristics we take into account, the better, the more relevant recommendations it generates. The SBERT model works very well, it's better than TF-IDF, and we can see from the results that it listed practically all the relevant films at the very top of the list.

In the case of the hybrid recommendation system, we have identified the advantages over collaborative filtering and content-based recommendation, and this can be enhanced by further optimization by using different content-based recommendation methods, such as the SBERT model. Further research on the topic includes the implementation and comparison of different hybrid systems, as well as the introduction and testing of new metrics for them.

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Authors' addresses

Csongor Kristó

Sapientia Hungarian University of Transylvania, kristolcsongor@uni.sapientia.ro

László Pál

Sapientia Hungarian University of Transylvania, pallaszlo@uni.sapientia.ro

EXAMINATION OF CORPORATE INCOME TAX BURDENS BASED ON THE ACCOUNTING REPORTS OF MULTINATIONAL COMPANIES OPERATING IN HUNGARY

OLTI KINGA- KOROSZCZAK DR. PAVLIN RITA

Abstract

Taxes are a fundamental part of our everyday lives — whether we consider them from an individual or corporate perspective. In both cases, there is an obligation toward the state: taxes must be paid by a given deadline to ensure that the state can function properly and, in return, provide support and services to its citizens and businesses. Thanks to the taxation system, companies receive various forms of support from the state, which can be used to develop, modernize, or even expand their operations.

I chose the topic “Examining the Corporate Income Tax Burden Based on the Financial Reports of Multinational Companies Operating in Hungary” because I’ve always been interested in how taxes work and how they are reflected in the performance of individual companies.

In the course of my research, I formulated three hypotheses:

1. The COVID-19 pandemic had a significant impact on companies in the year 2020.
2. The Russia-Ukraine war did not noticeably affect companies’ pre-tax profits.
3. Over the years, companies have shown growth in terms of their pre-tax earnings.

A summary and discussion of these hypotheses will be presented in the “Conclusions” chapter, based on the analyses from the following sections.

1. TAXATION OF HUNGARIAN COMPANIES

1.1. Corporate Income Tax

As the name suggests, corporate income tax applies to business entities. These include cooperatives, business associations, and even sole proprietorships registered as individual companies—regardless of whether only one person is involved. Therefore, all economic entities are subject to corporate income tax, regardless of their legal form, with the exception of sole proprietors. Since January 1, 2017, the corporate income tax rate has been 9% of the tax base. Tax allowances may reduce the payable amount. (Budapest Chamber of Commerce and Industry, 2023a)

The basis of corporate income tax is determined primarily according to the rules set out in accounting legislation. It is based on the pre-tax profit shown in the income statement, adjusted in accordance with the tax law. In this context, “adjusted” means that the accounting result can be increased or decreased by various items. Ideally, these adjustments reduce the tax base and thus the amount payable. In other cases, however, they may increase the base, leading to higher taxes.

These adjustments are necessary because certain types of income increase the accounting result but are not subject to taxation—so they are excluded from the tax base. Conversely, there are expenditures that are not recognized as deductible under the law, and these must be added back to the base, thereby increasing it. In some cases, only a portion of the expenditure is deductible, or a fixed (normative) amount is allowed.

Additionally, there are tax base reduction incentives that companies can take advantage of. These include training apprentices, increasing the number of employees within the company, engaging in activities such as research and development, employing individuals who are unemployed, or hiring people with reduced work capacity. (Budapest Chamber of Commerce and Industry, 2023b)

In relation to corporate income tax, it is also important to mention the concept of the minimum income or profit threshold. This means that if neither the tax base nor the corporate income tax reaches a

legally defined minimum, the taxpayer is still required to pay tax based on a presumed minimum profit. This minimum is calculated as 2% of the company's revenue. In order to comply with this rule, the taxpayer must complete a specific declaration form, confirming that the low income is genuine and not intended as a means of tax evasion. (Budapest Chamber of Commerce and Industry, 2023c)

1.2. Innovation Contribution

The rules concerning the innovation contribution, which supports development and scientific research, are set out in Act LXXVI of 2014. This legislation applies to all business entities with a registered office in Hungary. However, the following are exempt from this obligation: Micro and small enterprises as defined in Sections 3(2) and (3) of the SME Act, The Hungarian National Bank, The Hungarian National Asset Management Inc. (MNV Zrt.), State-owned companies under the supervision of the minister responsible for prisons and created for the compulsory employment of inmates, Companies founded without legal predecessors in the year of registration, including their preliminary forms, Public benefit nonprofit business entities, Companies under liquidation or forced deletion proceedings. (National Tax and Customs Administration of Hungary, 2022)

Eligibility for exemption is determined based on the company's classification as of the first day of the business year. The rate of the innovation contribution is 0.3% of the tax base.

1.3. Local Business Tax

The local business tax (commonly abbreviated as HIPA) is one of the most frequently applied local taxes by municipalities in Hungary. It is payable by entrepreneurs to the local government of the municipality where the business activity is carried out—whether partially or entirely. The tax is only applicable if the company engages in income-generating activities.

The standard rate of this tax is 2% of the tax base, although municipalities have the authority to set different rates based on their own local regulations. (Budapest Chamber of Commerce and Industry, 2023a)

The tax base for local business tax is calculated using the following formula:

+ Net sales revenue
– Cost of goods sold and mediated services
– Subcontractor expenses
– Cost of raw materials
– Direct costs of basic research, applied research, and experimental development
= Tax base

(Budapest Chamber of Commerce and Industry, 2023b)

If a business operates in multiple municipalities, the total amount payable must be divided proportionally among the municipalities based on the company's presence and activity in each location. (Budapest Chamber of Commerce and Industry, 2023c)

In the case of the Simplified Local Business Tax, businesses are only required to fulfill their tax obligations once a year. This taxation method can be chosen for a full tax year, and it remains in effect until the taxpayer decides to revoke it. However, this simplified scheme also has a notable drawback: If a business has multiple premises—for example, both a registered office and additional business locations—the tax must be calculated separately for each location. In such cases, it is not possible to apply different taxation methods for different premises. The same simplified method must apply uniformly across all locations. (Budapest Chamber of Commerce and Industry, 2023e)

2. TAXATION OF THE SELECTED COMPANIES

2.1. Materials and Methodology

As the practical part of my thesis, I selected five companies for analysis: Lidl Hungary Commercial Betting Company, LOTTE Chemical Hungary Limited Liability Company, TESCO-GLOBAL Stores is a Closed Joint Stock Company, Mercedes-Benz Credit Financial Services Hungary Private Limited Company, MOL Hungarian Public Limited Company for Oil and Gas.

I conducted a statistical analysis based on data obtained from each company's e-reporting records, published by the Ministry of Justice's Company Information and Electronic Company Registration Service over various years. For MOL, I also relied on the reports published on the company's official website.

Each chapter contains only brief descriptions of the companies, as the focus is primarily on examining their tax liabilities and pre-tax profits over the past ten years. Based on this data, I calculated each company's tax burden for each year by dividing their tax liability by their pre-tax profit.

Where unusual values appeared, I analyzed the underlying reasons—looking into the circumstances that led to a particular year showing a significantly higher or lower tax liability, pre-tax profit, or tax burden compared to the average.

2.2. Lidl Hungary Commercial Betting Company

2.2.1. About the Company:

Lidl Hungary Commercial Betting Company operates in the retail trade of mixed groceries. The company is part of the Schwarz Group, headquartered in Neckarsulm, Germany, and is among the leading food retailers both in Europe and globally. Lidl operates multiple stores across various regions of Hungary.

The company was founded in 2003, and its first store in Hungary opened in Nagykanizsa in 2005. (Ministry of Justice: Company Information and Electronic Company Registration Service: Lidl)

As of February 2025, the company employs 9,547 people nationwide, operates under the leadership of 61 managers, and has 2 registered owners (Céginformáció.hu, 2024).

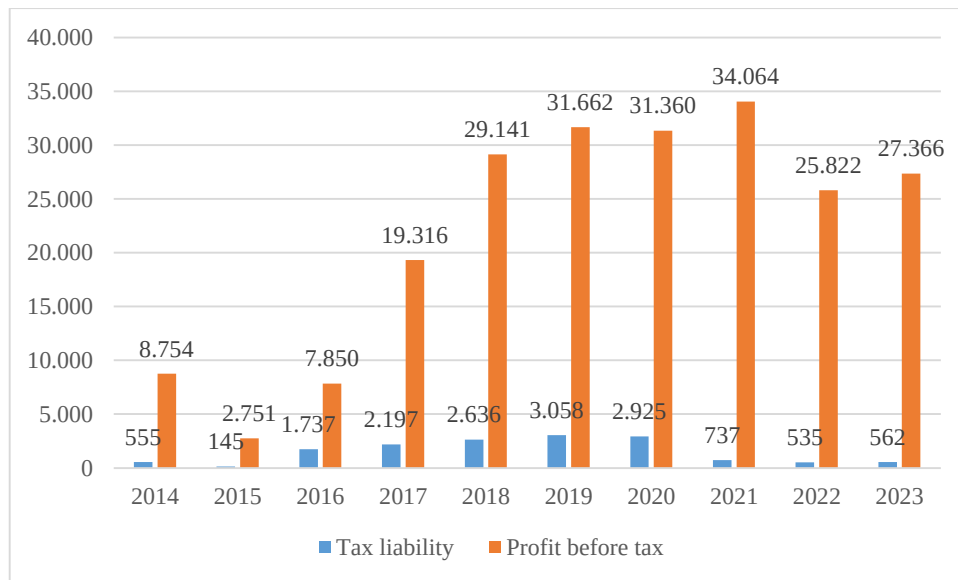
2.2.2. Analysis of the Company's Taxation

I examined the company's data over a period of ten years, from 2014 to 2023. My analysis focused on the tax liability and pre-tax profit of Lidl Hungary Commercial Betting Company during this time frame. The breakdown of these two indicators across the ten-year period is presented below.

The company achieved its highest pre-tax profit in 2021, exceeding 34 billion HUF. This significant profit is primarily attributable to an increase in inventory and goods available for sale, which allowed the company to generate higher sales compared to previous or subsequent years. For instance, in 2021, the company's inventory was valued at 40.933 billion HUF, while in 2020, it amounted to only 31.601 billion HUF.

Additionally, a clear difference can be seen in the total revenue of each year. In 2020, Lidl generated 668.298 billion HUF in revenue, while in 2021, this figure rose to 748.075 billion HUF—an 11.94% increase year over year.

Over the ten-year period, Lidl's tax liability did not show any extraordinary fluctuations. As the pre-tax profit increased, the tax liability grew proportionally, following a relatively stable trend.



(Figure 1: Tax liability and pre-tax profit of Lidl over the past 10 years (in million HUF))
(Own compilation)

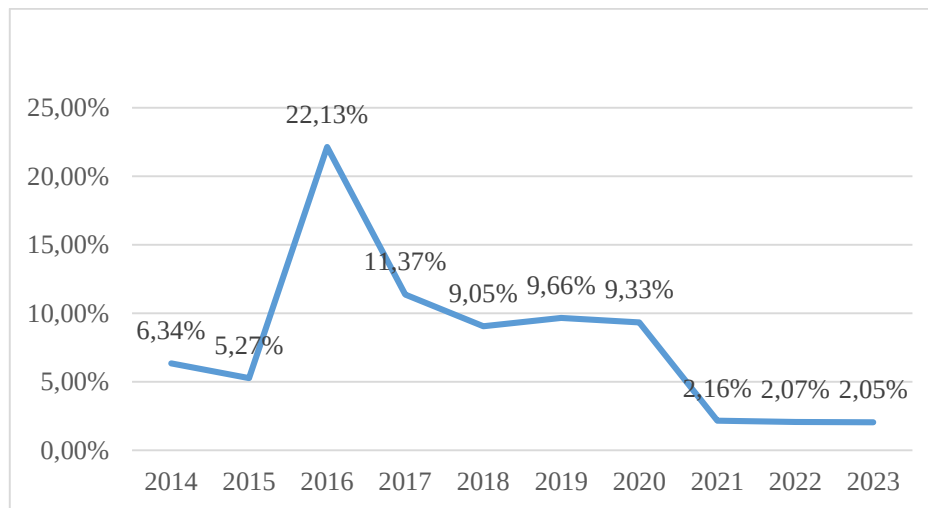


Figure 2: Tax burden of Lidl Hungary Commercial Betting Company over the past 10 years
(Own compilation)

Over the years, 2016 marked the highest tax burden for Lidl, which was the result of a relatively high tax liability combined with a low pre-tax profit. In 2021, 2022, and 2023, the company's tax burden remained fairly consistent, holding slightly above 2%. The years 2018, 2019, and 2020 showed a similar pattern; however, during this period, the tax burden exceeded 9%. Starting from 2016, Lidl's tax burden has exhibited a decreasing trend.

2.3. LOTTE Chemical Hungary Limited Liability Company (Samsung)

2.3.1. About the Company:

LOTTE Chemical Hungary Limited Liability Company, better known as Samsung, is a company specializing in phones and electronic products. Globally, Samsung Electronics Co. LTD has been a part of everyday life since 1969.

By 2023, the company's brand value, developed through continuous efforts, reached \$91.4 billion. Moreover, Samsung has been ranked among the world's top five brands for four consecutive years. The company has consistently expanded its innovations, including the development of the Net Zero Home, an energy-neutral housing project in a Swedish community. Additionally, Samsung introduced

its Gauss generative AI model, and launched the Samsung Gaming Hub service on smart monitors and TVs (Samsung.com).

2.3.2. Corporate Taxation:

Similar to the previous company, I collected data on the pre-tax profit and tax liability of Samsung (LOTTE Chemical Hungary Limited Liability Company) for the period between 2014 and 2023. The results are presented in Figure 4.

During my analysis, the data for LOTTE Chemical Hungary Limited Liability Company were available in euro.

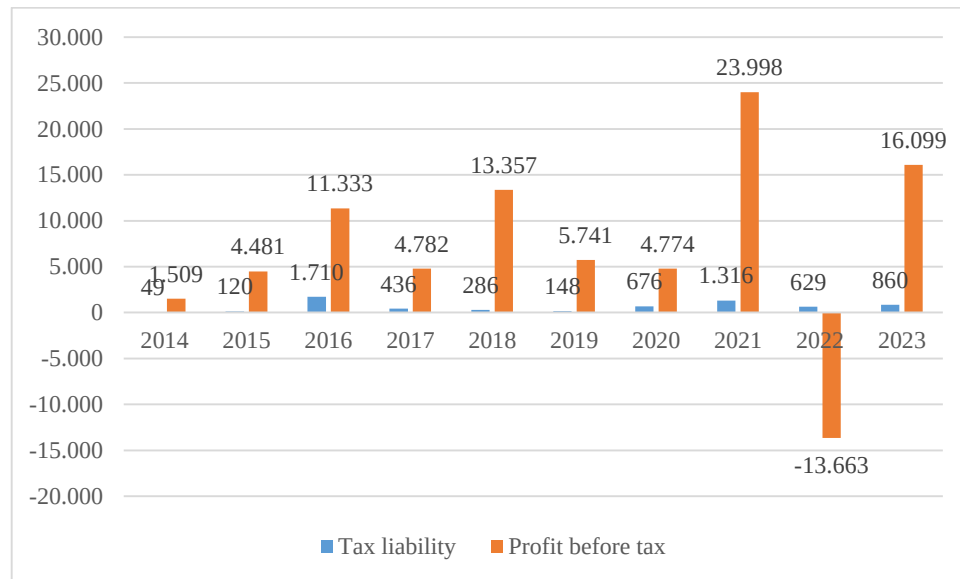


*Figure 3: Tax liability and pre-tax profit LOTTE Chemical Hungary Limited Liability Company over the past 10 years (in million euros)
(Own compilation)*

The tax liability for this company remained relatively low throughout the years. The only year with a somewhat higher tax liability compared to previous years was 2016.

The pre-tax profit peaked in 2021, reaching exactly €23,998,365. That year, the company's net sales revenue exceeded €239 million. However, in 2023, Samsung experienced a significant drop in sales, causing the pre-tax profit to fall sharply to €611,067 compared to 2021.

In 2022, the company also had tax liabilities and pre-tax profits, but the values were so small relative to other years that they barely show up on the graph. Specifically, the tax liability was €13,863, and the pre-tax profit was €2,599. Notably, the company had no corporate tax payment obligation (TAO) in 2022.

The low figures in 2022 can be attributed to decreased sales compared to previous years and a significant increase of 252% in short-term liabilities compared to the previous year. In my opinion, these effects are largely consequences of the Ukraine-Russia war. Additionally, in 2022, the company had to pay €991,743 in value-added tax (VAT) compared to 2021.

Furthermore, the decrease might also be related to a major investment made by the company, as they purchased a new plot of land. The Ukraine-Russia war also had a significant impact on the company's performance that year.

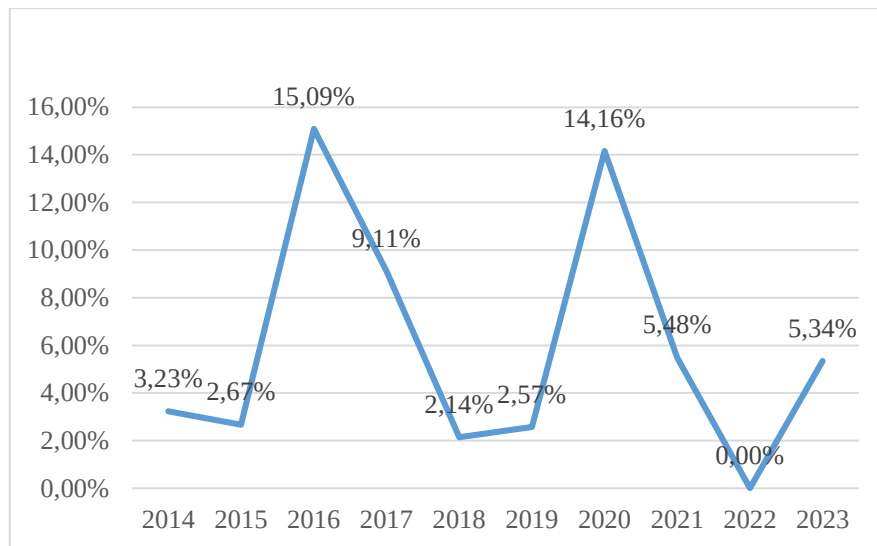


*Figure 4: Tax burden over the past 10 years for LOTTE Chemical Hungary Limited Liability Company
(Own compilation)*

The company's highest tax burdens were in 2016 and 2020, with rates of approximately 15.09% and 14.16%, respectively. These values, visible in the above figure, resulted from the combination of low pre-tax profits and higher tax liabilities in those years. In 2022, the company had no tax burden due to a negative pre-tax profit. The elevated tax burden in 2020 can partly be attributed to the impacts of COVID-19, which led to changes in taxation rules as well as reduced consumer spending due to restrictions. In 2016, the high corporate tax liability, along with depreciation exceeding 1 million euros that year, also influenced the increased tax burden.

2.4. TESCO-GLOBAL Stores is a Closed Joint Stock Company

2.4.1. About the company:

TESCO-GLOBAL Stores is a Closed Joint Stock Company is a British multinational company primarily engaged in the retail sale of a wide range of food products. The company was founded in 1919 in the United Kingdom, and its headquarters is located in Welwyn Garden City, England. The company was founded by Jack Cohen (Tesco.hu).

TESCO first entered the Hungarian market in 1994, opening its first store in Szombathely. Over the following years, the company expanded rapidly and soon started opening hypermarkets across the country. Today, it operates more than 110 hypermarkets in Hungary alone, along with over 90 smaller stores of various formats. Over time, the company has grown to lease space to nearly 1,800 tenants nationwide and still offers around 150 locations for rent across Hungary (Tesco.hu).

2.4.2. Taxation of the Company:

The following figure illustrates the tax liability and pre-tax profit of TESCO-GLOBAL Stores is a Closed Joint Stock Company over the past ten years. As shown in the chart, the pre-tax profit in 2014 was very low, at -67,717 million forints. This decline can be attributed to reduced revenues during that year, alongside an increase in tax payments compared to previous years. Additionally, the company utilized its provisions.

In 2014, the company paid corporate tax amounting to 1,114 million forints and environmental product fees of 262 million forints. It also paid local taxes and deposits, though the corporate tax and environmental fees were notably higher than in other years. However, since the company had no

income that year, it had no tax debt to the state. The company also recorded impairment losses of 7,564 million forints in 2014, which further contributed to the drop in pre-tax profit. In 2020, Tesco had a negative tax liability, likely due to the impact of the COVID-19 pandemic. However, this did not significantly affect the following year, as both its pre-tax profit (13.62 billion HUF) and tax liability (733 million HUF) increased in 2021.

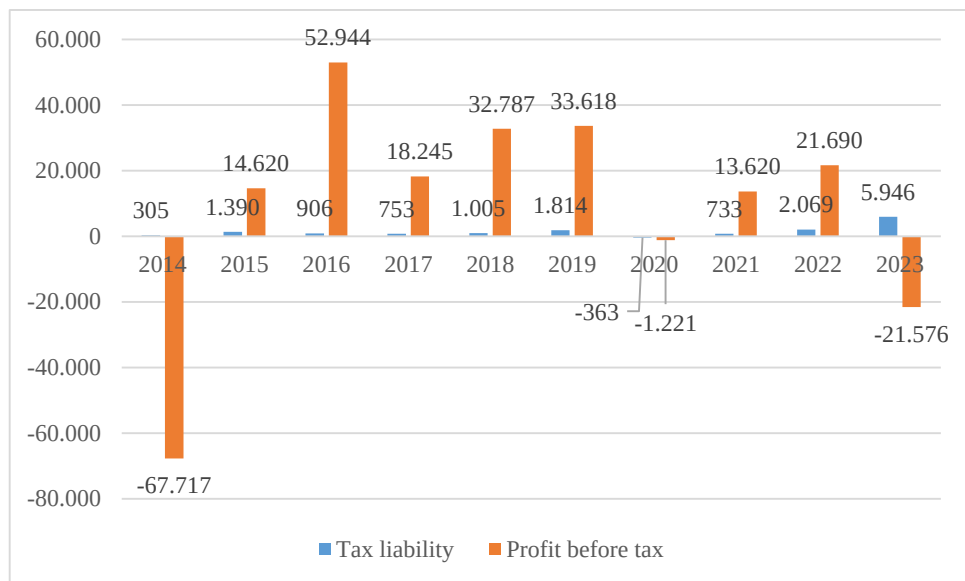


*Figure 5: Tax liability and profit after tax for TESCO-GLOBAL Stores is a Closed Joint Stock Company between 2014 and 2023 (in million HUF)
(Own compilation)*

In 2023, the company's profit before tax once again showed a negative value, amounting to -21,576 million HUF. That year, the company experienced a significant depreciation expense, similar to 2014. Compared to 2022, both the cash provisions and the impairment loss on receivables decreased. However, the value of extraordinary depreciation and the fines imposed by official rulings increased.

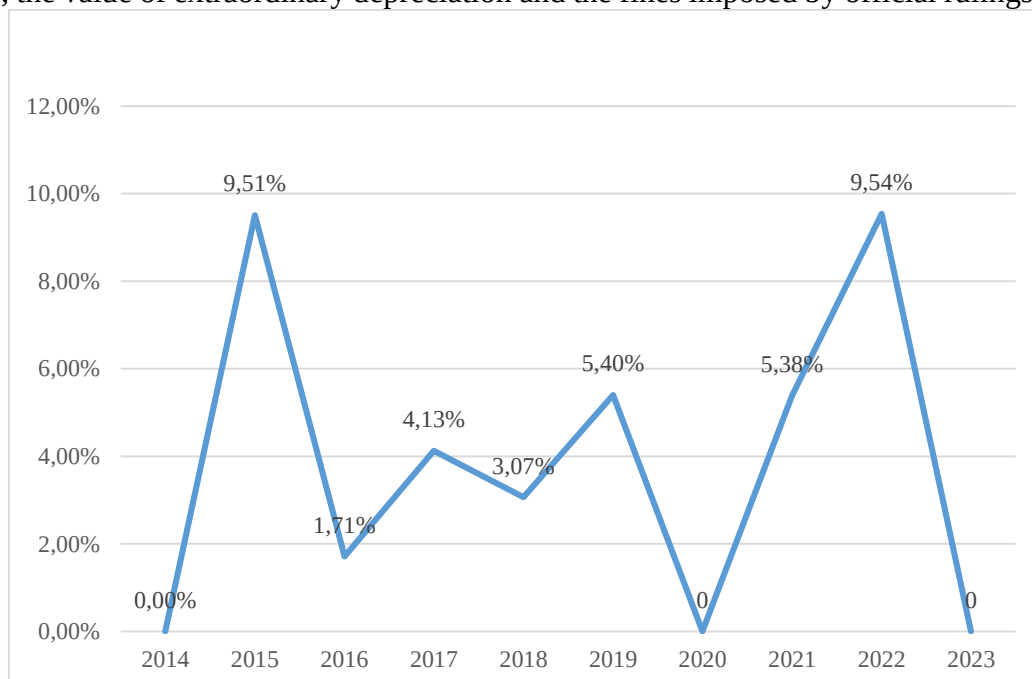


*Figure 6: Tax burden of TESCO-GLOBAL Stores is a Closed Joint Stock Company between 2014 and 2023
(Own compilation)*

From a tax burden perspective over the past ten years, the company recorded a 0% tax rate in 2014, 2020, and 2023 due to either negative pre-tax earnings or negative tax liabilities. Despite the fact that recent years were marked by negative values, the tax burden in 2022 rose significantly to 9.54%. This was the result of relatively low pre-tax profit (21.69 billion HUF) combined with a comparatively high tax liability (2.07 billion HUF). The sharp increase may also be partially attributed to the outbreak of the Russia–Ukraine war, which began in February of that year. In the years prior to 2020, the company's tax burden remained relatively stable.

2.5. Mercedes-Benz Manufacturing Hungary Limited Liability Company

2.5.1. About the company:

Mercedes-Benz Manufacturing Hungary Ltd. is a company based in Kecskemét, which began its operations in Hungary on January 1, 1999. Globally, the brand has been present since 1925, symbolized by the iconic three-pointed star surrounded by a laurel wreath. The company's main activity is car manufacturing. The company describes itself as follows: “The Mercedes star is more than just a brand symbol. Mercedes-Benz embodies a world of experiences driven by emotions, based on timeless design, cutting-edge technology, and meticulous attention to detail.” (Mercedes-Benz.hu).

For this company, it all started with the goal “to play a pioneering role in mobility: on land, on water, and in the air. Today, we apply this to all the elements that the star has always represented.” (Mercedes-Benz.hu).

2.5.2. Taxation of Mercedes-Benz Manufacturing Hungary Ltd.:

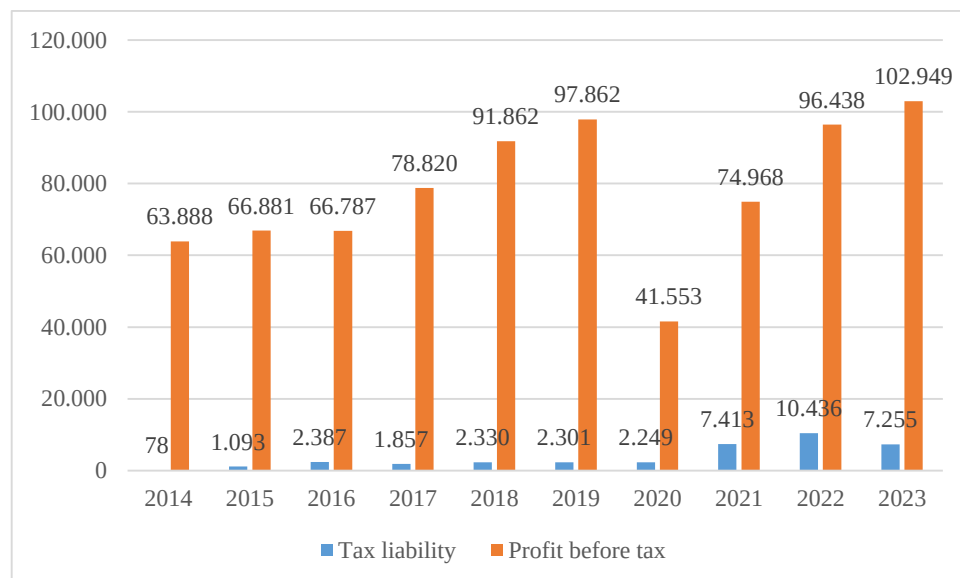


*Figure 7: Tax obligations and pre-tax profit of Mercedes-Benz Manufacturing Hungary Ltd. between 2014 and 2023 (in million euros)
(Own compilation)*

Figure 7 shows the tax obligations and pre-tax profit of the limited liability company over the past ten years, similar to the analyses conducted for the previous companies. Over the years, the company's tax obligations have generally shown a gradual upward trend. A notable spike occurred in 2021, with tax obligations reaching €7,412,786. Like with the other companies, this can be attributed to the effects of the COVID-19 pandemic, as restrictions during that year negatively impacted businesses worldwide. This impact is also clearly visible in the pre-tax profit, which dropped sharply in 2020 compared to previous years but began to steadily recover in the following

years. Additionally, the Russian-Ukrainian war that began in 2022 may have influenced the company's tax obligations as well.

Regarding pre-tax profit, 2023 marked the highest value in the ten-year period, reaching nearly €103 million. That year, the company completed a €1 billion upgrade of its production line aimed at making the operations more sustainable, further digitalizing processes where possible, and increasing flexibility across the manufacturing lines. Compared to the previous year, there was an increase in donated funds and asset depreciation recognized upon disposal according to tax laws, with a growth of over €91 million between the two years. Labor accommodation costs also rose, and the company increased its provisions by more than €8 million.

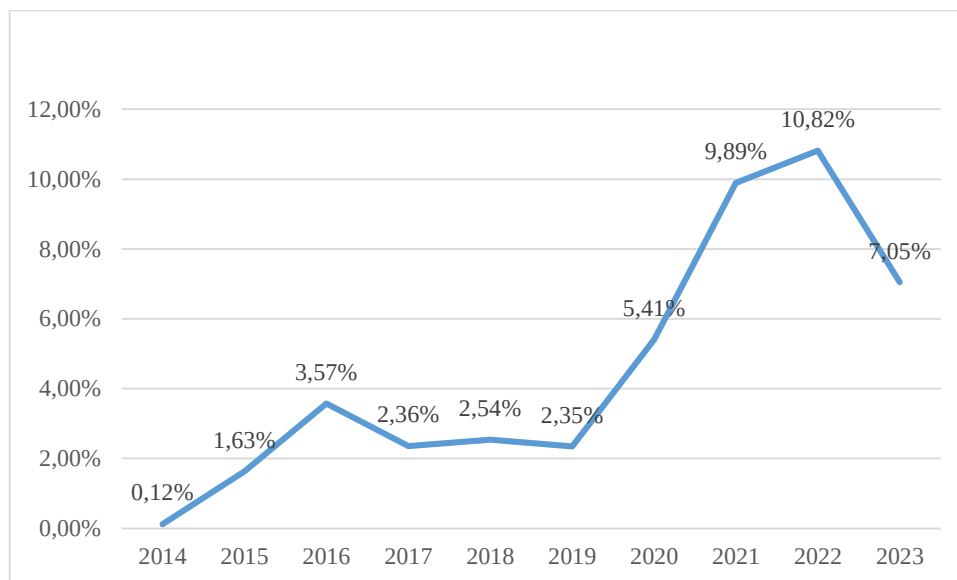


*Figure 8: Tax burden of Mercedes-Benz Manufacturing Hungary Ltd. between 2014 and 2023
(Own elaboration)*

Figure 10 shows the tax burden of Mercedes-Benz Manufacturing Hungary from 2014 to 2023. Over the years, we can observe a generally increasing trend with some minor declines. The most notable peak occurred in 2021, when the tax burden reached 9.89%. That year, the company had to pay higher taxes related to impairment losses (€410,059), provisions (€5,830,251), and depreciation of assets (€92,971,631), all calculated according to accounting regulations at the time of derecognition. The company also faced a penalty payment obligation, although it was minimal compared to the others, amounting to just €323. Considering the company's pre-tax profit and tax liabilities, the net profit after tax in 2021 was €67,554,862.

2.6. MOL Hungarian Oil and Gas Public Limited Company

2.6.1. About MOL:

MOL is a multinational company headquartered in Hungary, specializing in the oil and gas industry. In both 2021 and 2022, MOL was the largest company by revenue in Hungary and ranked third in terms of turnover across Central and Eastern Europe. The company independently carries out exploration, fuel production and refining, distribution, trading, and energy generation.

Today, MOL operates in more than 30 countries with an international workforce of around 25,000 employees and has an 80-year history within the industry. The group owns two petrochemical plants and three refineries. As a publicly traded company, the majority of its shares are held by foreign investors, predominantly institutional ones, who own 29.11% of the company. Over 10% of MOL is owned by the MOL-New Europe Foundation, and the Mathias Corvinus Collegium Foundation also holds a 10% stake. Other notable shareholders include OTP Bank Plc, ING Bank N.V., UniCredit Bank AG, and Commerzbank AG, as well as private Hungarian investors. MOL also retains treasury shares, while about 10% of its shares are held by domestic institutional investors (Molgroup.info).

2.6.2. The Company's Taxation:

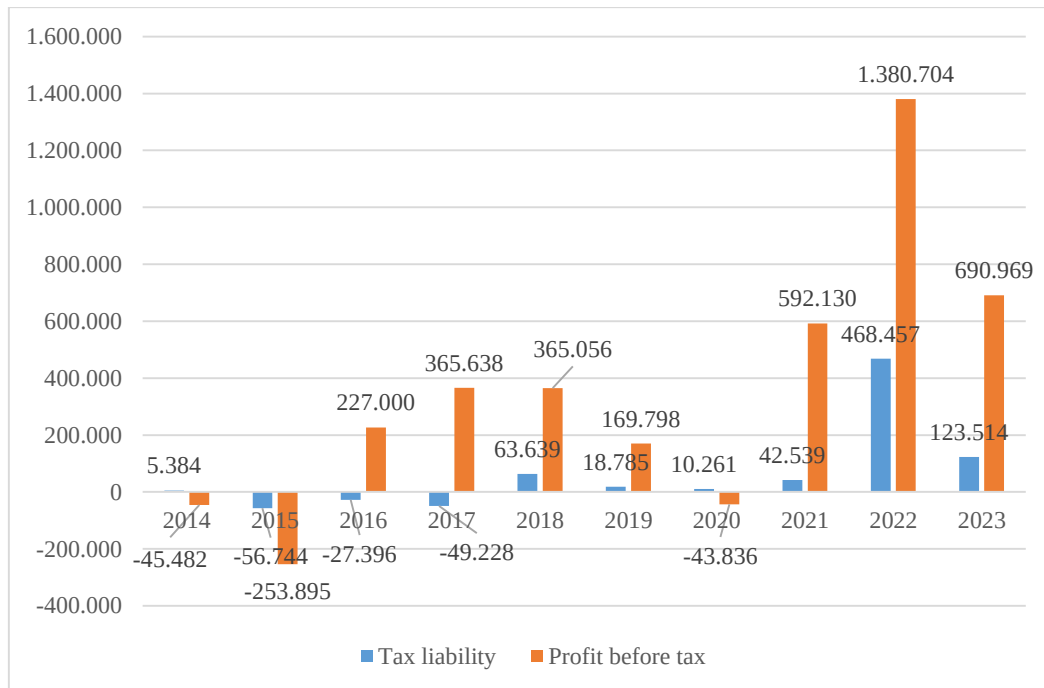


*Figure 9: MOL Plc.'s Tax Liability and Pre-Tax Profit Between 2014 and 2023 (Million HUF)
(Own compilation)*

Figure 9 shows the tax liabilities and pre-tax profits of MOL Hungarian Oil and Gas Public Limited Company over the past 10 years. The company recorded negative tax liabilities in three of those years, and similarly, its pre-tax profit was negative in three years as well. I believe the negative pre-tax result in 2020 can be attributed to the Covid-19 pandemic. Due to lockdown restrictions, people were not allowed to leave their homes, which caused a significant drop in fuel station sales, affecting both fuel purchases and the cafeterias at the stations.

For MOL Plc., I would consider the years 2017, 2018, and the period between 2021 and 2023 to be successful. These years stand out because the company's pre-tax profit exceeded 365 million forints. In 2014 and 2015, the company made significant investments by acquiring fuel stations, which likely reduced their pre-tax profit. Additionally, in 2015 and 2016, companies operating in the oil and gas sector were subject to a 21% corporate tax rate on their profits.

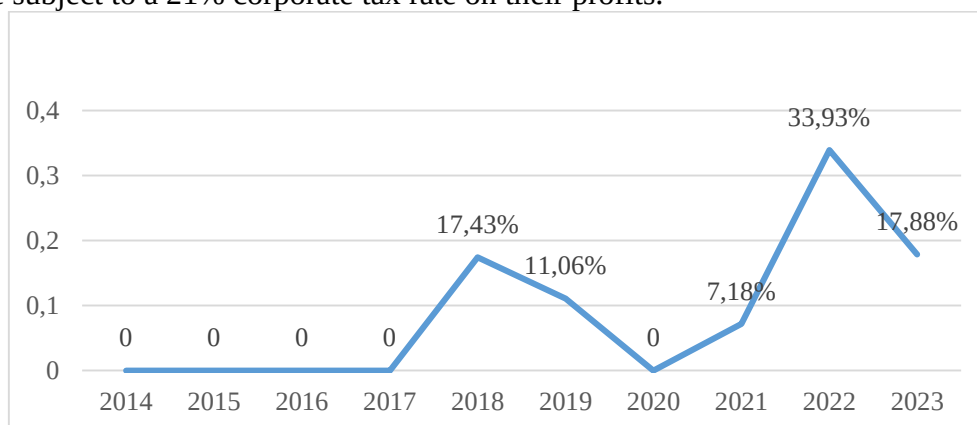


*Figure 10: Tax burden of MOL Hungarian Oil and Gas Public Limited Company between 2014 and 2023
(Own compilation)*

As shown in Figure 12, the company recorded no tax burden in 2014, 2015, 2016, as well as in 2017 and 2020, due to negative tax liabilities and negative pre-tax earnings. The highest tax burden was observed in 2022, reaching 33.93%. This increase in tax liability was driven by a high pre-tax profit. Additionally, the Russia–Ukraine war had an impact on the company as well. The resulting energy crisis prompted the government to implement various measures, some of which affected the MOL Group directly.

Conclusions

Of the three hypotheses I presented in the introduction, the first was that the COVID-19 pandemic had a visible impact on companies — and this was confirmed. All five companies I analyzed showed a decline in pre-tax profits in 2020.

My second hypothesis was that the Russia-Ukraine war had no noticeable effect on companies' pre-tax earnings. However, this turned out to be incorrect, especially in the cases of Lidl and Samsung, where the impact was evident.

The third hypothesis suggested that companies' pre-tax profits increased over the years. This assumption was also confirmed: while some companies showed slow and steady growth, others experienced more rapid increases in pre-tax profits over the 10-year period.

Overall, any global event—regardless of its scale—leaves a mark on a company's financial data, whether it's a smaller or a larger enterprise. This was also evident in the case of the selected Hungarian companies. For example, the Russia-Ukraine war resulted in increased income for MOL, while for the other companies it primarily led to additional costs.

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THE ECONOMIC IMPACTS OF ARTIFICIAL INTELLIGENCE

GÁBOR SILVIA - DR. BÍRÓ BÍBORKA ESZTER

Abstract

This article offers a comprehensive overview of the economic impacts of Artificial Intelligence (AI). It examines AI's conceptual foundations, historical development, and the technologies it includes. The study investigates AI's influence across financial sectors, supply chains, and labor markets, along with its macroeconomic implications, regulatory challenges, and ethical concerns. Through case studies featuring Amazon and FinTech companies, the research demonstrates how AI transforms business models, reshapes global competition, and redefines human roles in economic systems. The findings conclude that AI is not merely a tool but a structural force with transformative power that requires strategic planning, regulatory foresight, and societal adaptation.

Keywords:

Artificial Intelligence, Economic Impact, Labor Market, Financial Technology

1. Introduction

Artificial Intelligence has emerged as one of the most transformative forces in the 21st-century economy. Once limited to theoretical research in computer science and logic, AI has now infiltrated nearly every sector — from healthcare and education to finance and logistics. Similar to how the steam engine lowered the cost of physical labor during the Industrial Revolution, AI today decreases the cost of prediction, optimization, and decision-making (Agrawal, Gans, & Goldfarb, 2018).

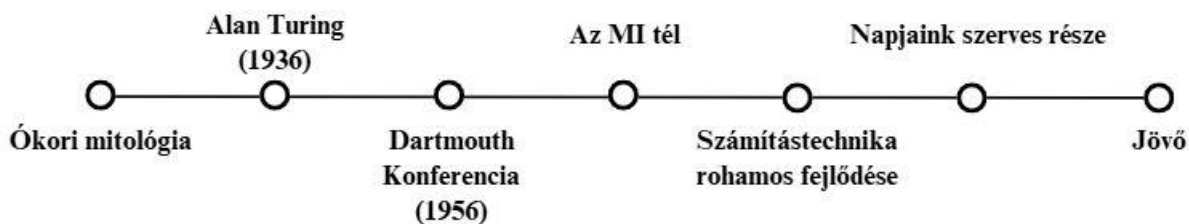
2. Definitions and theoretical background methodology

Artificial Intelligence lacks a universally accepted definition, largely because of its multidisciplinary nature. It exists at the intersection of technology, philosophy, economics, and sociology. Broadly, AI refers to machines or systems capable of performing tasks that typically require human intelligence, such as reasoning, problem-solving, learning, and adapting (Copeland, 2025).

Some definitions emphasize autonomy and environmental awareness — machines that can analyze situations and act to achieve specific goals without human intervention. Others focus on learning and adaptation, framing AI as a system that evolves over time based on data inputs. The main components of AI include machine learning, deep learning, computer vision, natural language processing, and robotics. Each contributes to the system's capacity to understand, process, and interact with its environment (Jordan, 2019).

The challenge of defining AI is compounded by the complexity of human intelligence itself. As long as the nature of human thought remains partially unknown, creating its artificial equivalent will remain equally complex.

3. Historical evolution of artificial intelligence



1. Figure: Historical timeline (Source: own editing)

The concept of creating artificial beings endowed with human-like intelligence predates the advent of modern technology. In ancient Greek mythology, figures like Talos and Pandora represented early imaginings of artificial life. Later, philosophers such as Aristotle laid logical foundations that would influence computational reasoning centuries later.

Alan Turing, a British mathematician, is often credited with initiating the modern AI era through his 1936 paper on computable numbers and the Turing Test, which aimed to assess a machine's ability to exhibit human-like behavior. The term "Artificial Intelligence" was coined in 1956 at the Dartmouth Conference, marking the formal beginning of AI as a research field. Initial optimism led to inflated expectations, which, when unmet, triggered the first "AI winter" — a period marked by reduced funding and interest. The resurgence in the 2000s was enabled by exponential growth in computing power, the availability of big data, and algorithmic advances. Today, AI is embedded in smartphones, online platforms, and industrial systems, becoming a cornerstone of modern economic activity (Copeland, 2025).

4. Key AI technologies and fields of application

Artificial Intelligence is not a single technology but rather a broad array of interrelated systems that allow machines to perform increasingly complex tasks. At the forefront is Machine Learning (ML), a foundational approach where algorithms learn from data patterns and improve over time without explicit programming. ML is widely used in areas such as fraud detection, spam filtering, and recommendation engines (Amazon Web Services, 2025). A more advanced subset of ML is Deep Learning, which employs multilayered neural networks to excel in tasks like image recognition and natural language translation. Computer Vision enables machines to interpret and make decisions based on visual data—ranging from static photographs to real-time video—making it crucial in fields like autonomous driving, medical diagnostics, and surveillance. Natural Language Processing (NLP) provides machines with the ability to understand and generate human language, enabling applications such as virtual assistants, chatbots, and sentiment analysis tools (Tran, 2019). Closely related is Speech Recognition, which converts spoken words into text and supports voice-controlled technologies like Siri, Alexa, and other smart assistant platforms. Robotics represents the tangible manifestation of AI, where intelligent systems manage mechanical devices that can operate autonomously or semi-autonomously, as seen in warehouse logistics, precision agriculture, and surgical automation. These technologies are rapidly evolving and continuously extending their influence across a growing range of sectors, including manufacturing, education, public administration, and entertainment—demonstrating the pervasive and cross-disciplinary nature of AI innovation (Manasa & Devi, 2022).

5. Economic impact on finance and supply chains

In the financial sector, AI has revolutionized risk management, fraud detection, algorithmic trading, and credit scoring. Predictive analytics powered by AI allow institutions to identify patterns and make informed decisions in real time (Manasa & Devi, 2022). Automated systems have enhanced efficiency, cut operational costs, and improved customer experiences.

In supply chain management, AI supports demand forecasting, route optimization, and inventory control. Companies can automate logistics processes and dynamically respond to fluctuations in

demand. AI-based systems can analyze consumer behavior, monitor real-time stock levels, and adjust supply parameters accordingly (Amazon Web Services, 2025).

However, these benefits come with risks. The use of AI in high-frequency trading can amplify market volatility. Algorithmic biases in credit scoring and hiring may perpetuate inequalities. There is also growing concern about deepfake fraud and cyber manipulation, which could destabilize financial systems.

6. Labor market transformation

The impact of Artificial Intelligence on the labor market is complex and multifaceted. While it undeniably leads to the automation of many routine and repetitive tasks—particularly in sectors such as manufacturing, logistics, and basic customer service—it also creates new opportunities by augmenting human capabilities. Rather than causing a simple substitution of human labor, AI is reshaping the nature of work itself, demanding new skills and redefining occupational structures (Copeland, 2025).

Jobs that require uniquely human attributes such as emotional intelligence, empathy, critical thinking, and interpersonal communication remain largely resistant to automation. Roles in caregiving, education, negotiation, and mental health services, for instance, are inherently human-centric and thus unlikely to be fully replaced by machines in the foreseeable future. In contrast, tasks involving data entry, process monitoring, and basic client interaction are increasingly handled by AI-powered systems. These changes necessitate significant investments in upskilling and reskilling programs to ensure that workers are not left behind in the evolving labor market. The transformation of labor markets is not occurring evenly across countries or sectors. In Hungary, as of 2024, only 12% of enterprises with more than 20 employees reported the implementation of AI technologies. Adoption rates were somewhat higher among large corporations, reaching 21%, yet this still indicates a relatively cautious integration of AI. One of the most significant determinants of AI adoption appears to be leadership: companies where senior managers actively engage with AI tools are significantly more likely to apply AI across their operations. This highlights the role of organizational culture and managerial openness in driving technological change (Agerpres, 2024).

In Romania, the trend is somewhat different. AI is being actively integrated into public administration, supported by government-led initiatives aimed at accelerating digital transformation. This includes efforts to modernize bureaucratic processes, improve public service delivery, and increase efficiency through data-driven governance. However, the benefits of these initiatives remain unevenly distributed. A pronounced digital divide exists both between and within regions, largely shaped by disparities in financial resources, digital literacy, and local policy implementation. As emphasized in the thesis, the key challenge is not merely technological but structural and educational. Preparing the workforce for an AI-driven economy requires a proactive approach: integrating digital competencies into national education systems, supporting lifelong learning, and fostering cross-sectoral collaboration between governments, academia, and industry. Only through such coordinated efforts can societies fully harness the potential of AI while ensuring that economic progress translates into inclusive and sustainable labor market outcomes (Jordan, 2019).

7. Regulatory and ethical challenges

As Artificial Intelligence becomes increasingly integrated into economic, governmental, and social systems, it raises critical regulatory and ethical challenges. These concerns are not merely technical but touch upon core societal values, legal frameworks, and public trust. The rapid pace of AI development often outpaces the capacity of existing institutions to regulate its use effectively, thereby creating a governance gap that demands urgent attention. One of the most pressing concerns is data privacy. AI systems rely on vast amounts of data to function effectively, often including sensitive personal information such as health records, financial transactions, or behavioral patterns. Without robust data protection frameworks, there is a heightened risk of misuse, surveillance, and breaches of individual privacy rights. The need for transparent data collection, consent mechanisms, and secure storage protocols is paramount (European Commission, 2021).

A related issue is algorithmic bias, which occurs when AI models trained on biased or incomplete data produce discriminatory outcomes. Such bias can manifest in hiring algorithms, credit scoring systems, facial recognition tools, and more—potentially reinforcing systemic inequalities. Addressing algorithmic fairness requires not only technical solutions but also interdisciplinary collaboration involving ethicists, social scientists, and legal experts (Copeland, 2025).

Transparency and accountability are also central concerns. Many AI systems function as “black boxes,” meaning that their internal decision-making processes are opaque even to their developers. This lack of explainability complicates efforts to audit systems, assign responsibility, or contest unfair decisions. Establishing mechanisms for explainable AI (XAI) is critical to ensure public confidence and institutional oversight. Another emerging threat is related to security. AI systems are vulnerable to adversarial attacks, where seemingly minor changes in input data can cause serious errors in output. Moreover, AI can be exploited for malicious purposes, such as spreading disinformation, enabling deepfakes, or automating cyberattacks. As AI becomes more autonomous, the stakes for securing such systems increase significantly (European Commission, 2021).

The European Union (EU) has taken a proactive approach to addressing these challenges. In 2021, the European Commission proposed the Artificial Intelligence Act, the world’s first comprehensive regulatory framework for AI. This legislation adopts a risk-based approach, classifying AI applications into four categories: unacceptable risk (e.g., social scoring), high-risk (e.g., biometric surveillance, medical devices), limited risk (e.g., chatbots), and minimal risk. High-risk systems are subject to strict requirements regarding data governance, transparency, human oversight, and robustness. This framework aims to ensure that AI systems are safe, transparent, and aligned with fundamental rights, while also preserving space for innovation and economic growth. Despite these efforts, implementation remains a challenge. National authorities must ensure harmonized enforcement across EU member states, while also investing in capacity building and digital literacy. Furthermore, global coordination is needed, as AI technologies often cross jurisdictional boundaries. Without international collaboration, regulatory fragmentation may hinder both innovation and ethical standards (European Commission, 2021).

In conclusion, governing AI is not solely a matter of regulation—it is about shaping the kind of society we wish to build with this technology. Ethical AI requires a multidimensional approach that balances innovation with responsibility, competitiveness with fairness, and efficiency with human dignity (European Commission, 2021).

8. Case studies: Amazon and FinTech innovation

The transformative capabilities of Artificial Intelligence (AI) are most compellingly demonstrated through real-world applications. Amazon and various FinTech startups exemplify how AI can be leveraged not only to optimize operations and reduce costs but also to redefine entire industries and customer experiences (Manasa & Devi, 2022; Amazon Web Services, 2025).

Amazon, founded in 1994 as a modest online bookstore, has grown into a global technology leader. Central to its meteoric rise is the strategic integration of AI across virtually all facets of its business model. From logistics and supply chain optimization to personalized marketing and cloud infrastructure, AI is the invisible engine powering Amazon’s dominance. For instance, Amazon’s sophisticated recommendation engine, which suggests products based on user behavior and preferences, is responsible for approximately 35% of the company’s sales. This level of personalization, made possible through machine learning algorithms and big data analytics, enhances customer satisfaction and loyalty, while simultaneously driving revenue (Manasa & Devi, 2022; Amazon Web Services, 2025).

One of the most innovative applications of AI within Amazon’s ecosystem is Amazon Go, a chain of cashier-less convenience stores. These stores utilize a combination of computer vision, sensor fusion, and deep learning technologies to track customer purchases in real-time. Shoppers can simply walk in, take what they need, and leave—without passing through a traditional checkout process. The system automatically detects the items taken and charges the customer’s Amazon account. This frictionless retail model not only exemplifies the potential of AI in physical spaces but also sets a new

standard for convenience and efficiency in the retail sector (Manasa & Devi, 2022; Amazon Web Services, 2025).



2. Figure: AI-powered consumer journey of Amazon.com (adapted from Hackernoon, 2018)

Beyond its consumer-facing innovations, Amazon also empowers other organizations through Amazon Web Services (AWS), its cloud computing subsidiary. AWS offers a wide range of AI and machine learning tools, democratizing access to powerful computational resources and enabling startups and enterprises alike to integrate AI into their own operations. Services like Amazon SageMaker allow users to build, train, and deploy machine learning models at scale, lowering the entry barriers for innovation across industries (Amazon Web Services, 2025).

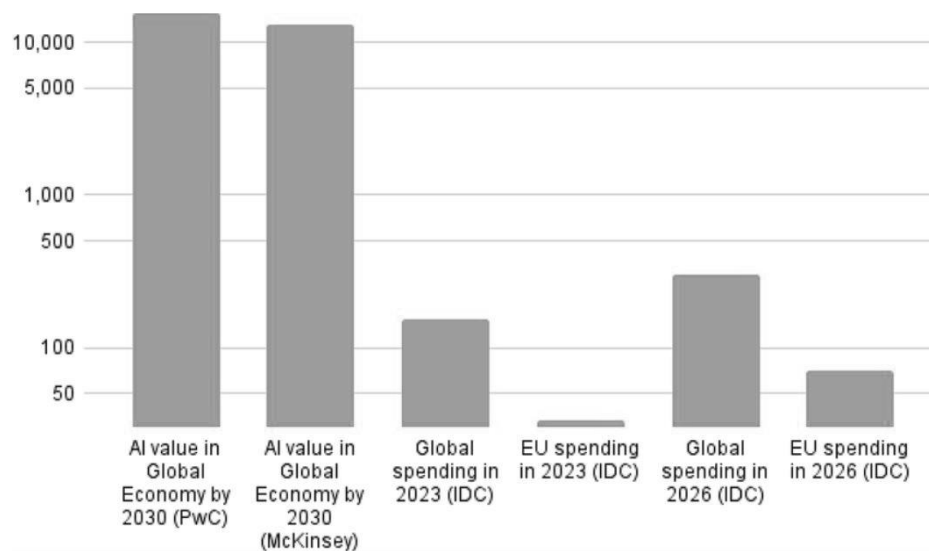
In parallel, the FinTech sector has emerged as a fertile ground for AI-driven disruption. Startups such as Revolut, Klarna, and N26 are redefining the financial services landscape by embedding AI into the core of their platforms. These companies offer digital banking solutions that are not only more accessible but also smarter. AI-driven features include real-time fraud detection, automated budgeting tools, personalized financial advice, and intelligent customer service via chatbots. By automating routine processes and reducing overhead, FinTech firms can offer lower-cost services, reaching previously underserved populations and promoting financial inclusion (Amazon Web Services, 2025).

Moreover, AI enables FinTech firms to assess creditworthiness more accurately by analyzing alternative data sources such as transaction history, social behavior, and device usage. This allows them to extend credit to individuals and small businesses who might otherwise be excluded from traditional financial systems (Revolut, 2024). As a result, AI is not merely a tool for operational efficiency but a catalyst for systemic change within the financial sector (Tran, 2019).

In conclusion, both Amazon and the FinTech industry illustrate the vast potential of AI to transform business models, enhance user experiences, and drive innovation. Through strategic application of intelligent technologies, these case studies demonstrate how AI can be harnessed to generate value, increase accessibility, and shape the future of commerce and finance.

9. Macroeconomic impacts

At the macroeconomic level, Artificial Intelligence (AI) serves as a powerful driver of structural transformation, economic growth, and productivity enhancement. It acts as a general-purpose technology, influencing multiple sectors simultaneously through improved decision-making, automation, and optimized resource allocation. As noted in the thesis, AI lowers the cost of prediction, just like the steam engine once reduced the cost of physical labor, thus transforming the fundamental mechanisms of economic production (Agrawal, Gans, & Goldfarb, 2018).



3. Figure: Projected contribution of AI to the global economy by 2030 and expected AI spending globally and in Europe in 2023 and 2026 (logarithmic scale) (Source: Journal of Innovation and Entrepreneurship, 2025)

AI contributes to GDP growth by enhancing productivity across industries. Companies that adopt AI technologies tend to achieve higher levels of efficiency, innovation, and market responsiveness. Countries that invest in AI—especially those with robust digital infrastructure, skilled labor forces, and innovation ecosystems—see faster technological diffusion and economic returns. The United States and China remain global leaders in AI investment and deployment, while the European Union is advancing through coordinated initiatives like the Digital Europe Programme and the Coordinated Plan on AI. (European Commission, 2021)

However, this transformation is not evenly distributed. Emerging economies face significant barriers to fully leveraging AI, including insufficient funding, low digital literacy, and weak regulatory frameworks. Nevertheless, some are finding success in targeted applications, such as smart agriculture, telemedicine, and e-governance. These localized implementations highlight the adaptive potential of AI in varied socio-economic contexts (Agerpres, 2024).

Moreover, AI is accelerating globalization by reshaping supply chains, enhancing data-driven trade, and intensifying international competition. Over 60 countries have adopted national AI strategies, which reflect not only economic objectives but also ethical, security, and geopolitical considerations. These strategies underscore AI's importance as a source of national competitive advantage (Tran, 2019).

As highlighted in the thesis, the integration of AI at scale may also alter capital flows and investment priorities globally. Venture capital is increasingly directed towards AI-focused startups, particularly in sectors such as fintech, healthtech, and logistics (Revolut, 2024). Consequently, countries and companies that lead in AI development are likely to attract disproportionate shares of global capital, amplifying existing economic disparities.

10. Results and discussion

The results of this research confirm that Artificial Intelligence (AI) is not merely a supplementary technology but a transformative economic force that reshapes industries, redefines labor dynamics, and challenges traditional governance structures. AI has become deeply embedded in both microeconomic and macroeconomic dimensions of modern economies, with substantial evidence of increased efficiency, reduced costs, and novel business models (Jordan, 2019).

In the financial sector, AI significantly enhances risk management, fraud detection, algorithmic trading, and personalized financial services. Machine learning models allow banks and fintech firms to process large data sets in real-time, enabling better credit scoring and dynamic pricing. Furthermore, AI applications in investment decision-making have led to the rise of robo-advisors,

predictive analytics, and automated portfolio management, thus reducing human error and operational costs (Copeland, 2025).

On the labor market, AI's impact is dual in nature: while it automates routine and repetitive jobs, it also creates demand for new, high-skilled positions. The data suggest that jobs requiring human attributes such as empathy, creativity, and interpersonal skills are more resilient to automation (Agrawal, Gans, & Goldfarb, 2018). However, sectors like logistics, manufacturing, and administration are experiencing significant structural shifts. These changes necessitate large-scale reskilling initiatives and strategic workforce planning, especially in regions with slower AI adoption, such as parts of Hungary and Romania (Agrawal, Gans, & Goldfarb, 2018).

Macroeconomically, AI contributes to GDP growth, productivity gains, and innovation-driven competitiveness (Jordan, 2019). Countries investing in AI infrastructure and education are better positioned to benefit from AI-induced economic acceleration. Nonetheless, disparities remain evident—developing countries face challenges in AI integration due to weaker infrastructure, limited digital literacy, and funding gaps. Case studies on Amazon and leading fintech startups demonstrate that AI can provide a strong competitive edge by enabling operational efficiency, customer personalization, and scalable innovation.

From a regulatory standpoint, there is a growing need for ethical oversight and governance frameworks. Issues such as data privacy, algorithmic transparency, and accountability must be addressed proactively. The European Union's Artificial Intelligence Act serves as a notable benchmark, offering a structured, risk-based approach to AI regulation (European Commission, 2021).

Overall, the findings emphasize that while AI presents tremendous opportunities for economic development, these benefits are not automatically distributed. Institutional readiness, policy alignment, and public trust are critical for ensuring inclusive outcomes.

11. Conclusion and future outlook

Artificial Intelligence is not merely a technological innovation but a transformative force fundamentally reshaping economic models, business operations, and societal structures. Its influence permeates all levels of economic activity—from automating micro-level decisions to redefining macroeconomic policy priorities and reshaping labor markets (Agrawal, Gans, & Goldfarb, 2018).

This study concludes that AI's economic impact is both profound and multifaceted. On one hand, it fosters innovation, drives productivity, and enables new business models and data-driven governance (Jordan, 2019). On the other hand, it brings significant risks, such as labor displacement, algorithmic bias, and widening socio-economic inequalities. This duality necessitates proactive, coordinated responses from policymakers, industry leaders, and educators alike (Copeland, 2025).

Looking ahead, AI's trajectory will be determined not only by technical developments but by the values, policies, and institutional decisions societies choose. Transparent regulation, inclusive digital education, and public engagement will be essential to navigating the ethical, legal, and economic challenges posed by AI (European Commission, 2021).

Future economic systems are likely to be shaped by AI-augmented labor, hybrid human-machine decision-making, and data as a strategic asset. AI also holds the potential to advance sustainable development goals, enhance public services, and help address complex global issues such as climate change and healthcare equity (Manasa & Devi, 2022; Amazon Web Services, 2025).

Effective AI governance will require robust cross-border cooperation—particularly in areas like data privacy, accountability, and fair competition. Strategic foresight and interdisciplinary collaboration will be crucial in ensuring that AI adoption contributes to inclusive and resilient economic growth (Agerpres, 2024).

In summary, the future of AI is inevitable. It will be shaped by how effectively technological capabilities are aligned with societal needs and human values. With the right governance, investment, and ethical commitment, AI can serve as a catalyst for positive transformation and long-term global economic sustainability.

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Contact information of the authors

Dr. Bíró Bíborka Eszter
Assistant Professor
Sapientia Hungarian University of Transylvania, Faculty of Economics, Miercurea Ciuc
Department of Business Studies
birobiborka@uni.sapientia.ro

Silvia Gábor
Master's Student in Applied Economics and Finance
Sapientia Hungarian University of Transylvania, Faculty of Economics, Miercurea Ciuc
gabormsilvia@uni.sapientia.ro

DEVELOPMENT OF FAMILY FARMS - IN AND AROUND TÂRGU SECUIESC

PORCZEL BARBARA-DR. PÉTER EMŐKE-KATALIN

ABSTRACT

Family farms have long been a dominant player in the agricultural structure of Szeklerland, but the technological development of the agricultural sector presents them with new challenges and opportunities. My research aims to explore how agricultural innovations in and around Târgu Secuiesc serve the survival and competitiveness of family farms. The study focuses on how technological advances can help local family farms to increase efficiency, manage natural resources sustainably and thus ensure their long-term economic stability.

The empirical study is based on quantitative research, consisting of a detailed questionnaire survey of local farmers. The research covers key topics such as the assessment of the functioning and development potential of family farms, openness to technological developments, willingness to invest, the role of cooperative cooperation, agricultural policy support and the impact of market challenges on the competitiveness of family farms.

My results show that smaller farmers tend to approach new technologies with caution, mainly due to high investment costs and lack of expertise. However, those who are already applying innovative solutions on their farm (e.g. precision farming tools, renewable energy use) report positive impacts on productivity and sustainability.

KEYWORDS: family farms, Szeklerland, questionnaire survey, technology, small farm area, production, consumption

1.INTRODUCTION

In Szeklerland, and in particular in the area around Târgu Secuiesc, there is a long agricultural tradition, where family farms are the dominant players in the local economic structure. However, these smaller farms are increasingly confronted with new technologies, such as drones and robotic machines (e.g. FarmDroid), which could fundamentally change the way farming is done. The research explores how well family farms in Szeklerland are prepared to embrace these innovations and what opportunities and challenges they see in the developments and collaborations that larger agricultural enterprises are adopting.

Agriculture, as the basis of humanity's food supply, is undergoing dynamic changes that are radically transforming production methods and farming strategies. Global challenges - population explosion, the increasingly severe consequences of climate change and the depletion of natural resources - are calling for new and innovative solutions to ensure more efficient and sustainable food production (FAO, 2023). In this critical context, technological advances, in particular in precision farming, digitalisation and automation, play a key role in increasing agricultural productivity, reducing production costs and minimising environmental pressures (Rosegrant & Cline, 2003). The future of agriculture is therefore inextricably linked to technological innovation, which enables more efficient resource management, more accurate production management and the adoption of more sustainable farming practices.

As the basic units of agricultural production, family farms are the foundation of rural life and local economies in many regions of the world. These farms are particularly vulnerable to the impacts of technological change, as the application of modern technologies can bring significant benefits, but smaller family farms often face serious barriers to financing, adapting, and applying technological improvements (Lowder, Scoet, & Raney, 2016). This dichotomy - the potential of technological development and the difficulty of implementation - is particularly prevalent in peripheral or

disadvantaged regions, where the diffusion of technological innovation is slower and farmers have more difficulty accessing the necessary information, training and support (OECD, 2020) .

In this context, it is of particular importance to explore the extent to which family farms are able to exploit the potential of technological development and what factors influence the diffusion and adoption of technological innovation. The present research investigates the impact of technological development on family farms in and around Târgu Secuiesc. The chosen area is of particular importance because the specific socio-economic and cultural context of the Szekler region has a significant impact on the diffusion and adaptation of technological innovation. Traditional farming methods and modern technologies are both present in the region, which offers a unique research opportunity to explore the complex relationship between technological development and local agriculture. During the research, I sought answers to the following central questions: How does technological development affect family farms in and around Târgu Secuiesc, with a focus on productivity, cost-effectiveness and sustainability?

2. LITERATURE REVIEW

2.1 THE THEORETICAL CONTEXT OF FAMILY FARMS

The concept of the "family economy" is very different and is defined in sociological terms. Economists, however, define it as 'economic units' or 'enterprises', while geographers define it as 'family farms located on the periphery of a territory'. Family farms, however, are seen as positive and generally valid (M.Fuller, Xu, Sutherland, & Escher, 2021) . Political science and historical research focuses on the factors that influence the long-term viability of family farms, particularly agricultural policy regulations and support systems (M.Fuller, Xu, Sutherland, & Escher, 2021) . The theoretical foundations of family farms were laid by Chayanov. Chayanov argued that the primary goal of agriculture is family maintenance and not profit maximization (Chayanov, 1991) . Harriet Friedman's later work was based on the theory of simple commodity production, which emphasises family labour-oriented production (Friedmann & McMichael, 1989) . The modernisation of the 'family farm' and agricultural production in general in the mid-20th century led to a more critical view of agriculture. Authors such as Wendell Berry and Rachel Carson have raised social and environmental justice issues related to the modernisation of agriculture, 'critical agrarianism', group of idealists in the 1960s and 1970s in both Europe and North America 'returned to the land' and pursued family-based farming that sought to counter the economic power and environmental impacts of agricultural intensification, against wider social impacts such as the Vietnam War (Carlisle, 2014) .Fuller, Xu, Sutherland, & Escher, 2021) describe a new counterculture of family farming based on short food supply chains and low-input (often organic) production. Parallel and conflicting discourses thus proclaim the value of family-based agriculture, and perceptions of family farming vary widely (Beus, C. E & Dunlap, R. E., 1994) . Indeed, family farms play a dominant role in the structure of EU agriculture in terms of their number, their contribution to agricultural employment and, to a lesser extent, the land they cultivate and the value of their production. For the remainder of this article, the term 'family farm' is used in the FAO definition of work to refer to all family farms where at least 50 % of the agricultural labour force is made up of family workers. In other words, a family farm is operated by a household where the labour force comes largely from that household. A more detailed distinction can be made between farms where the labour force was provided exclusively by the family (family labour only farms) and those where at least 50 % (but not 100 %) of the labour force was family labour (Eurostat, Agriculture statistics - family farming in the EU, 2023) .



1. Figure Family farming in the EU, 2020

Source: own editing (Eurostat ,2023)

2.2 DEFINITION OF FAMILY FARMS IN ROMANIA

Romania faces many problems in rural areas, the most important of which is the depopulation of rural areas. Young people are migrating to urban centres or to Western European countries in search of a better life. One solution to this phenomenon is the promotion of family farms, where all members of the family participate (Dumitru, Ursu, Tudor, & Micu, 2021) . The concept of "family farm" varies considerably from country to country and is often explored through sociological approaches. However, economists see it as an "economic unit" or "enterprise", while geographers see it as "family farms confined to the periphery of a given territory". However, family farming is seen as positive and universal (M.Fuller, Xu, Sutherland, & Escher, 2021) . Family-based farming units are present in most farming systems, with different forms and functions, influenced by the structure of agriculture and political systems. The concept of 'family' has more sociological implications, but family farming can also be seen as an economic unit with the aim of making a profit. Overall, the "family economy" is seen as a positive aspect all over the world (Engelhart, Vogel, & Larcher, 2018) .For this type of work to be attractive to young people, the main factor that must be met is the salary, which must be comparable to that in urban areas, but with additional income to compensate for the shortcomings of rural areas (infrastructure, health services, etc.). According to the work "Family Farm-Solution for Sustainable Development of Rural Area", the annual profit fixed at farm level should be determined on the basis of the number of family members, the average wage on the farm (in Romania), to which should be added the household consumption, which is the basic food for the family. Based on this formula, it has been possible to determine the optimal economic size of a family farm, so that the economic size of a two-member family farm should be around 45,000 SO, and depending on the number of household members, it could be around 180 000 SO (Dumitru & Petre, 2021) .

2.3 THE SITUATION AND CHALLENGES OF SMALL FARMS

In the early 1950s, the discontent of the peasantry declined, partly due to the relaxation of compulsory supply quotas and an increase in the proportion of contract purchases. In 1954, food exports were greatly reduced and the rationing system (except for bread and sugar) was abolished, which eased the financial burden on the population. However, nationalisation progressed more slowly in agriculture than in industry, mainly because of smallholdings, and it was only after the disintegration of

traditional village social and economic structures that cooperatives were established (Hunya, 1990) (Elek, Illyés , György, & Péter, 2016)

In the period 1957-1962, collectivisation gained new momentum. By 1960, more than 80% of the country's agricultural land was in the hands of collective farms. Collective farms were often transformed without the consent of local communities, leading to resistance and unrest in some places. Part of the collectivisation campaign was aimed at eliminating the middle classes, who sought to take advantage of the new educational and employment opportunities. The growing urban employment opportunities led many to leave farming and started a decades-long internal migration (Elek, Illyés , György, & Péter, 2016) .

Livestock farming was pushed into the background during this period, and the sector was disadvantaged by poorly equipped large farms. From 1965, the increase in purchase prices improved farmers' incomes and helped the development of backyard farms. Backyard farms allowed families to feed themselves and to access fodder, but the number of people employed in agriculture continued to fall. The incomes of industrial workers were almost double those of agricultural workers, which further accelerated the migration to the cities. Increasingly, families opted for a two-family lifestyle, working in nearby factories during the main working hours and doing farm work in their spare time. Women, the lower skilled and the elderly became the main performers of agricultural labour. The income of cooperative members came from the backyard and collective farm, and after 1965 wages were mostly paid in kind, which helped families to become self-sufficient. Collective farms were dismantled and private ownership returned. The area of backyard farms was increased from 0.15 hectares to 0.5 hectares, the obligation to supply was abolished and market prices were liberalised. These measures led to a boom in production and brought cooperative members closer to their land. After the changes, around 10% of agricultural land remained in private hands, reflecting the redistribution of peasant society in Romania and the transformation of the economic structure (Elek, Illyés , György, & Péter, 2016) .



2. Figure: Distribution of EU CEOs by age and type of economy, 2020 (%)

Source: own editing (Eurostat ,2023)

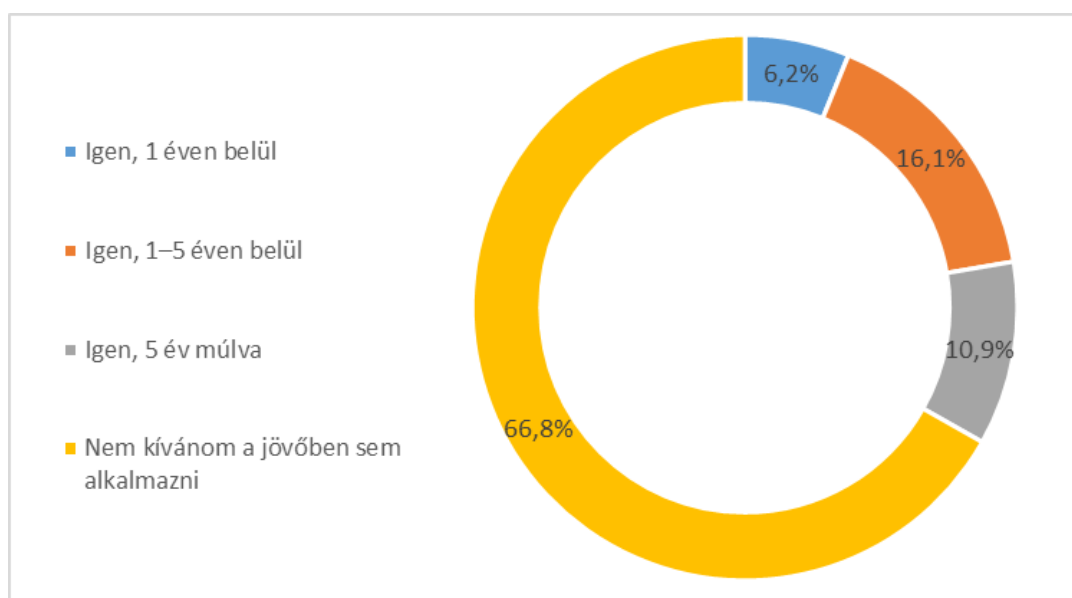
Romania's accession to the European Union has in principle facilitated the modernisation of agricultural activities, thanks to an increase in the amount of land that can be returned to former owners through the abolition of state farms and to land sales processes. This created the basis for a shift towards more efficient agriculture (Ianoş & Secăreanu, 2020) . Unfortunately, the whole process of transformation was accompanied by the destruction of irrigation infrastructure, livestock structure and agricultural research facilities. Taking the specific example of irrigation systems, about 75% of them have been destroyed, and the remaining part is far from being fully functional (Barbu, 2019) . As for the number of tractors, there is a clear and constant increase during the period of regime change. A similar trend was observed for mechanical seed drills. The cooperative idea was spread by the Saxon settlers, who were familiar with the German Raiffeisen and Schulze-Delitzsch cooperatives. The first people's bank was founded by Roman Visarion in 1868, although it still

deviated from the German model (Marinova, 2021) . An important milestone was the establishment of the Aurora bank in 1873, which served as the basis for later rural banks (Marinova, 2021) . Based on the Transylvanian experience, the Dumitru Bank was established in 1891 to help farmers obtain credit (Marinova, 2021) . Later, in 1889, it joined the International Cooperative Federation (Bercu, 2014) . The number of cooperatives grew rapidly in 2 years from 1900, mainly due to the activities of ministers C. Istrati and Spiru Haret. The early cooperatives were more widespread in mountainous areas. In addition to agricultural cooperatives, the bank that provided loans to larger farmers with state support was important (Marinova, 2021) . The communist system radically transformed local cooperatives. The cooperatives became instruments of state planning, and agricultural cooperatives dominated. The principles of voluntarism and democratic governance were violated, which led to negative feelings about cooperatives in many people (Bercu, 2014) . The word 'cooperative' took on a negative connotation and no progress was made in rebuilding democratically based cooperatives (Bercu, 2014) .

2.4 THE LINKS BETWEEN TECHNOLOGY AND SUSTAINABLE FARMING

Precision farming and digital agriculture paradigms are essential to harness the synergy between technology and sustainability. These innovative approaches integrate the latest technological advances such as global positioning systems (GPS), sensor networks, unmanned aerial vehicles (drones), autonomous robots, Internet of Things (IoT), big data analytics and artificial intelligence algorithms into agricultural production systems to optimize production and manage natural resources more efficiently (Fertu,, Dobrota, & Stanciu, 2019) .

One of the main barriers to accessing new technologies is the high cost of acquisition, ongoing upgrading and related services. This problem is particularly pronounced for capital-intensive investments such as machinery, equipment and software. This trend is supported by domestic research, which shows that businesses often postpone the development of their IT systems due to the high cost of implementation and operation, and the inefficiency of small-scale operations (Édson, Lucio Andre, Ieda , & Restrepo Ramirez, 2020) (Berta, 2018) . Infrastructural constraints, especially in rural areas, is one critical barrier to the adoption of digital technologies is the lack of adequate internet connectivity, which is a significant problem, especially in rural areas. Also, connectivity difficulties in other countries, especially in poorer parts, and the use of internet world and systems also pose challenges for the uptake of digital agriculture (Édson, Lucio Andre, Ieda , & Restrepo Ramirez, 2020) . Understanding which technologies are most appropriate for farmers can be a challenge. Moreover, lack of professional technical training can also limit the effective use of software and equipment (Édson, Lucio Andre, Ieda , & Restrepo Ramirez, 2020) . Looking at the situation in Hungary and Romania, it is clear that low human resource skills can also be a problem in the adoption of new technologies (Berta, 2018)



3. Figure: Plans for an integrated management system in organisations

Source: own edit (Berta, 2018) based on research data from

For farmers, understanding which technologies are best suited to their needs can be a challenge. Moreover, a lack of professional technical training can also limit the effective use of software and equipment (Édson, Lucio Andre, Ieda , & Restrepo Ramirez, 2020) . Looking at the situation in Hungary and Romania, it is clear that low human resource skills can also be a problem in adopting new technologies (Berta, 2018) . Small farms often face even greater challenges in accessing new technologies due to limited financial resources. Research shows that for smaller farms (below 20 ha), the main difficulties are the cost of purchasing machinery, equipment or applications, and the cost of hiring specialized service providers (Édson, Lucio Andre, Ieda , & Restrepo Ramirez, 2020) (Berta, 2018) .

3. METHODOLOGY

The research examines the impact of technological development on family farms in and around Târgu Secuiesc, with a focus on productivity, economic outcomes and sustainability. The primary aim of the research is to collect and analyse quantitative data, which will allow statistically supported conclusions to be drawn about the people under study. Qualitative elements were also introduced during the research process to contextualise and deepen the understanding of the quantitative results. The research is mainly based on a quantitative, cross-sectional questionnaire survey. The questionnaire was designed to explore the situation of family farms, their technological development, economic situation and attitudes towards cooperative membership. The questionnaire included structured, closed questions, allowing for easy categorization and statistical analysis of responses. In writing the questionnaire, I also took into account recommendations from the literature and the results of previous research on the topic. To ensure the clarity and relevance of the questions, the questionnaire was pre-tested with a small group (N=10) and modified based on feedback.

Data were collected in two ways. Firstly, the questionnaire was available online (Google Forms), so farmers could answer the questions at their own time. Secondly, to take advantage of personal contacts and local knowledge, the questionnaire was also administered in person to farmers in the area. This method was particularly important among farmers who were less familiar with online platforms or for whom personal contact provided greater confidence. I manually entered the data from the face-to-face responses into my database, ensuring accuracy and consistency.

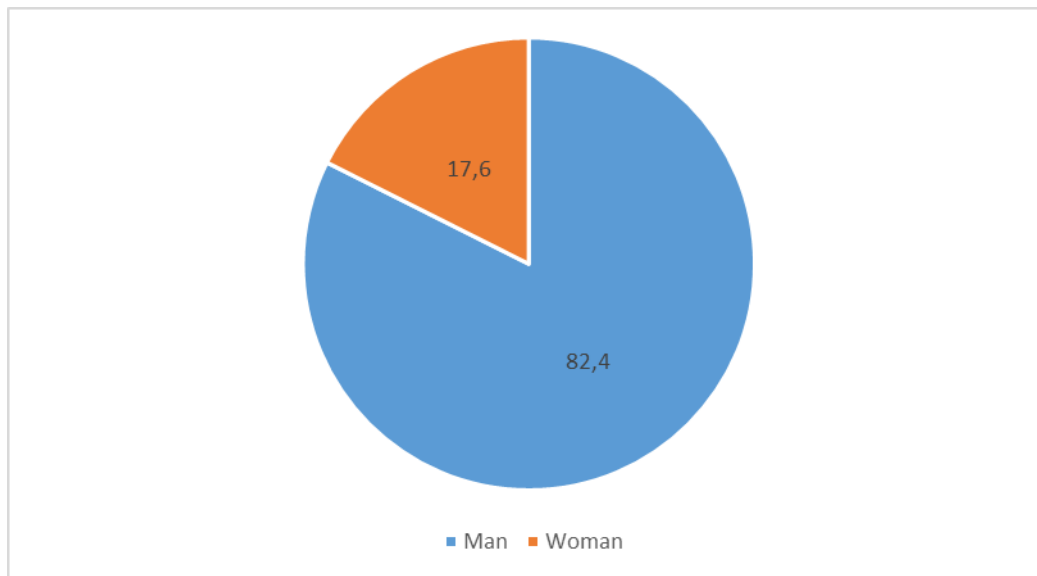
The sampling was purposive rather than representative. This is because the research is not intended to survey the entire farming community, but to explore attitudes to technological development and

economic impacts among local family farms. The sample included farms that are an integral part of agriculture in and around Târgu Secuiesc, of different sizes and sectoral profiles.

I analysed the data using SPSS statistical software. In the statistical analysis, descriptive statistics (mean, standard deviation, minimum, maximum) were used to describe the demographic characteristics of the sample and the main parameters of the farms. Cross-tabulation analyses and chi-square tests were performed to explore the relationships between technology use and the different factors. Pearson correlation analysis was used to measure the strength and direction of the linear relationship between variables. The significance level was set at 0.05 in all cases.

4. PRESENTATION AND DISCUSSION OF RESEARCH RESULT

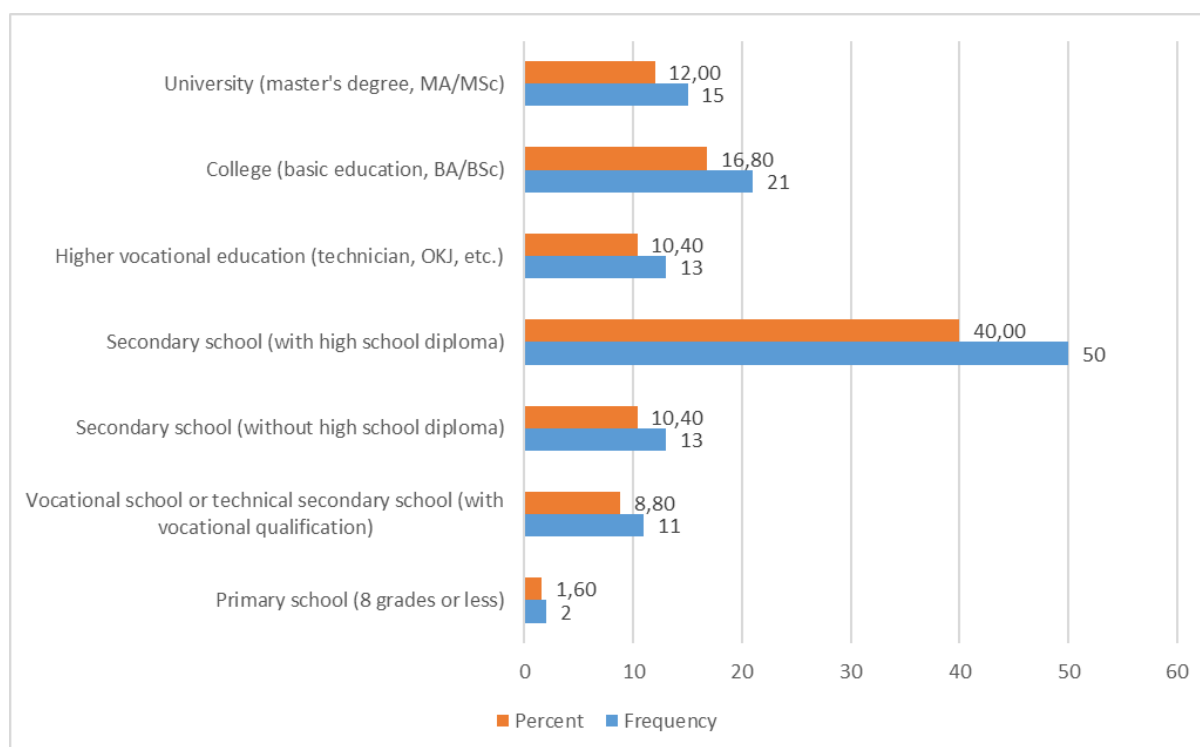
In the following, I present the results of the research on the technology development and attitudes towards technology use of family farms in and around Târgu Secuiesc and its surroundings. First, I present the demographic characteristics and main economic parameters of the sample.



4. Figure: Gender distribution of farmers (%)

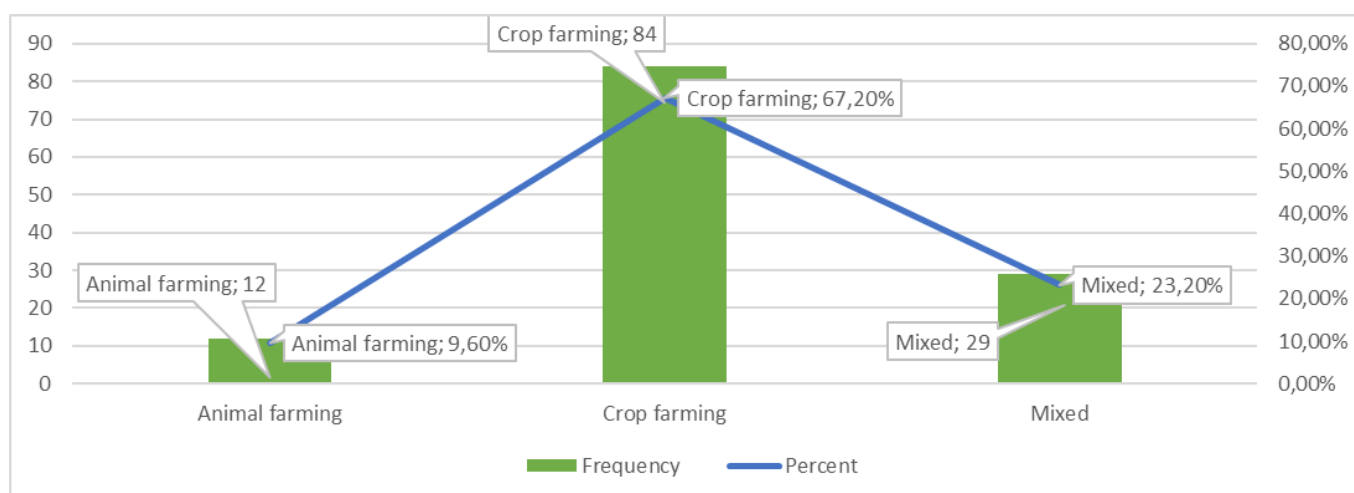
Source: own data collection, 2025, N=125

The gender breakdown of the sample of farmers is shown in Figure 4. The data show that the majority of farmers are male (82.4%), while the proportion of women is 17.6%. This gender distribution is quite common for agriculture, where men tend to be more involved. However, it is important to note that the presence of women in agriculture shows a larger increasing trend.



5. Figure : Distribution of respondents' educational attainment

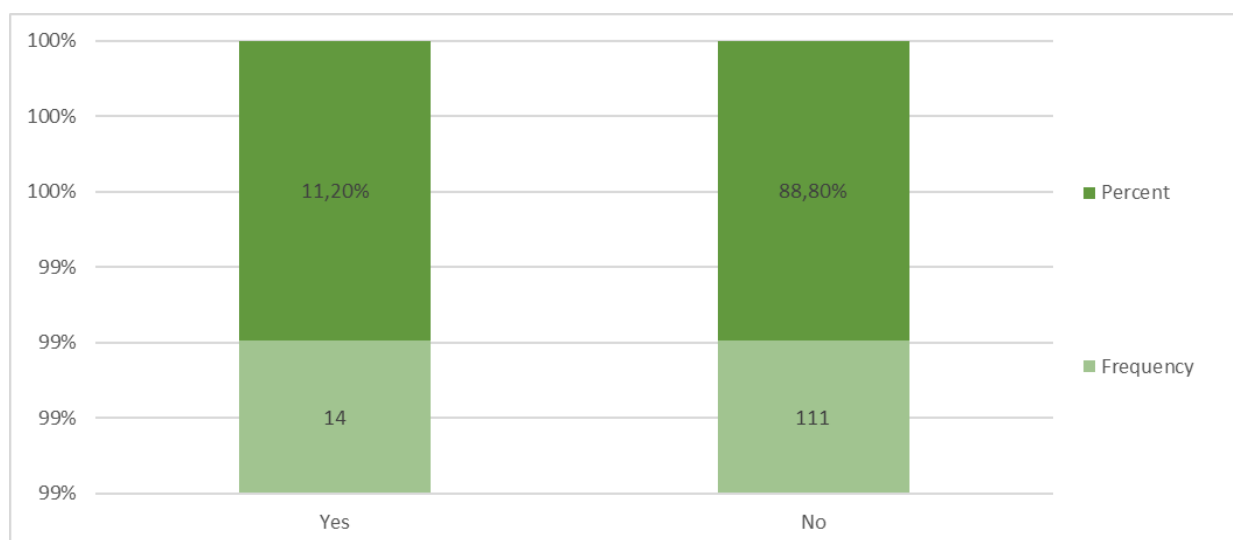
Source: own data collection, 2025, N=125



6. Figure: Distribution of farmers by farm type

Source: own data collection, 2025, N=125

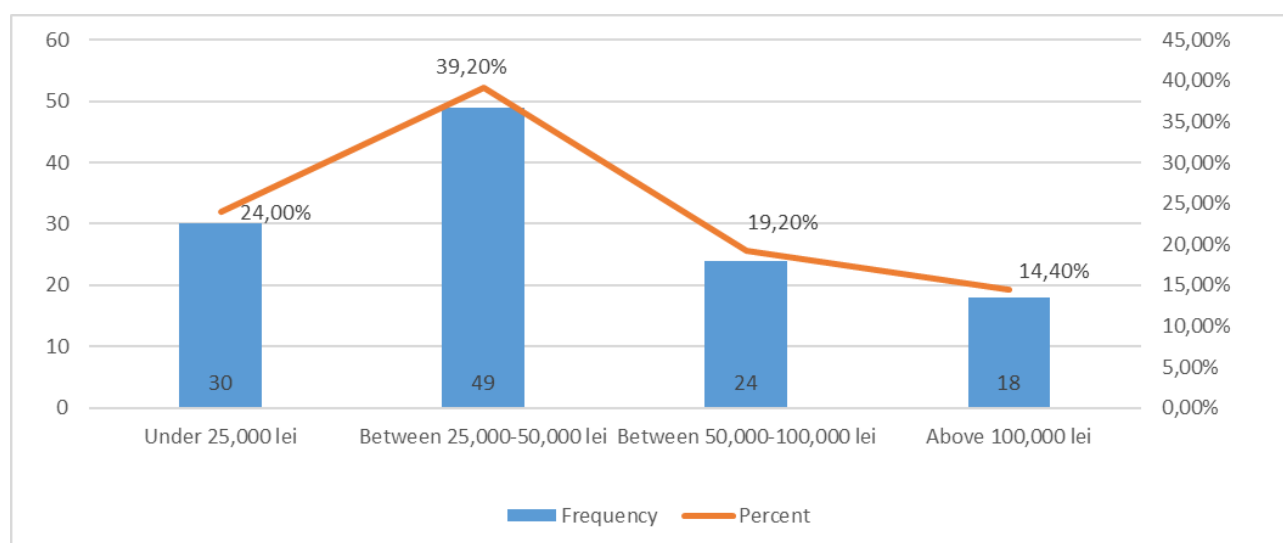
Figure 13 shows the distribution of farmers' educational attainment. Figure 5 shows the distribution of farmers' educational attainment. The majority of the sample (40%) has a secondary education (high school), while the proportion of those with a higher education (college, university) is 28.8%. From a technological adaptation perspective, this proportion is favourable because higher education is generally associated with technological knowledge and learning skills. However, the high proportion of farmers with secondary education highlights the importance of targeted technical education and training to help farmers to use modern technologies effectively. Figure 6 shows the sectoral distribution of farms, with crop production dominating the sample (67.2%), followed by mixed farming (23.2%) and the lowest proportion of livestock farms (9.6%). This sectoral structure may influence technological needs and development priorities. In crop production, for example, precision farming technologies, drones and soil sensors may be relevant, while in livestock production, automated milking machines and herd monitoring systems may be relevant.



7. Figure: Distribution of technology use

Source: own data collection, 2025, N=125

Figure 7 summarises patterns in technology use among farmers. The results are disappointing: only 11.2% of the farmers surveyed use some form of modern technology. This low rate highlights the technology gap between family farms and modern farming practices in the region. Identifying barriers to technological adaptation is key to the development of local agriculture.



8. Figure: Distribution of annual net turnover of farmers completing the survey

Source: own data collection, 2025, N=121

The profitability of the farm was analysed on the basis of the annual net turnover (Figure 8). The distribution shows that the majority of farms (39.2%) had a turnover between 25 000 and 50 000 lei, while the percentage of farms with a turnover of more than 100 000 lei was only 14.4%. Low profitability is associated with low technology use, small farm size and other structural problems. Technological improvements, productivity improvements and more efficient farming methods are essential to improve farm profitability.

1. Table: Descriptive statistics for the sample

	Mean	Std. Deviation	Minimum	Maximum	N
Respondent's age	35,26	9,84	19	66	125
How many hectares of land do you farm?	20,77	27,07	1	150	97
Size of leased land in hectares	11,96	12,58	0	60	52
Size of leased land in hectares	1,35	2,68	0	10	21
How many years has the farm been in operation?	9,58	7,479	1	30	125
How many seasonal workers do you employ on average per season?	5	6,822	0	40	49
How many permanent employees do you currently have on the farm?	1,11	1,323	0	5	35

Source: own data collection, 2025

According to Table 1, the average age of respondents is 35.26 years (standard deviation 9.84), indicating that the population of farmers completing the survey is relatively young. The average farm size was 20.77 ha (standard deviation: 27.07), which is typical of family farms. The average size of rented land was 11.96 ha (standard deviation: 12.58), indicating that many farms use additional land. The average farm operating cycle was 9.58 years (standard deviation: 7.479), indicating that farmers are an experienced group. The average number of seasonal employees is 5 (standard deviation: 6.822) and the average number of permanent employees is 1.11 (standard deviation: 1.323), indicating the level of labour demand. All these factors combine to influence the use of technology and the economic benefits to the economy.

Overall, the data presented show the challenges faced by family farms in and around Târgu Secuiesc. The gender distribution, average age, farm size, educational attainment, industry distribution, use of technology and annual net sales are all factors that affect the competitiveness and sustainability of farms. I then further examine the relevance of technology use, with a particular focus on the factors that impede development and the impact of technology use on economic performance.

After an overview of the demographic characteristics of the sample and the main parameters of the farms, I will now examine the relationship between technology use and farm size in more detail. First, I analyse the relationship between the use of precision farming tools and farm size.

2. Table Perception of the role of technological development in agriculture in Szeklerland (N=125)

Question	N	Minimum	Maximum	Mean	Std. Deviation
Overall, how do you assess the role of technological development in agriculture?	125	2	5	4,02	0,808
Is modern technology necessary in family farms in Székely?	125	1	5	3,88	0,972
How important is technological development for the long-term sustainability of the economy?	125	2	5	4,02	0,707

Source: own data collection, 2025

The table shows that, overall, respondents are positive about the role of technological progress in agriculture. The average of 4.02 for the very first question ("Overall, how do you rate the role of technological development in agriculture?") shows that the majority of respondents lean towards "Good" and "Very Good" on the scale. The relatively low variance (0.808) indicates that opinions are fairly consistent on this question.

The second question ("Is modern technology necessary on family farms in Szeklerland?") also received a positive answer, but the average (3.88) was slightly lower than the first question. This may

suggest that respondents acknowledge the importance of modern technology in family farms in Szeklerland, but perhaps less clearly than for agriculture as a whole. The higher standard deviation (0.972) indicates that there is a greater difference of opinion between respondents on this question. Some may think that modern technology is essential, while others may think it is less important for family farms, and that traditional methods may be sufficient.

The third question ("How important is technological progress for the long-term sustainability of the economy?") again shows a high average (4.02), which is the same as the average for the first question. This confirms the assumption that respondents attach great importance to technological development for the long-term future of agriculture. Again, the low standard deviation (0.707) indicates a relative unanimity of opinion. The survey results show that respondents are generally positive about technological progress in agriculture and stress its importance for long-term sustainability. Although there is a slight difference in the question on family farms in Szeklerland, the need for technology is also recognised here, but opinions are less consistent on this issue.

5.CONCLUSIONS

The present research investigated the impact of technological development on family farms in and around Târgu Secuiesc, with a focus on productivity, economic outcomes and sustainability. The aim of the research was to explore the level of technological development of local farmers, the types of technologies used, the factors influencing their interest in technological improvements and the impact of technology use on economic performance. The research also examined local farmers' attitudes towards cooperative membership and their views on the future role of modern technology.

The results of the survey revealed that the majority of family farms in the region (88.8%) do not use modern technologies, indicating a significant technological gap in local agriculture. In terms of profitability, the turnover of the majority of farms (39.2%) was between 25 000 and 50 000 lei, reflecting low profitability and associated with low technology use.

Overall, respondents are positive about the role of technological progress in agriculture and attach great importance to its role in the long-term sustainability of the economy. Although there is a slight difference in the question on family farms in Szeklerland, the need for technology is also recognised here, but opinions are less consistent on this issue.

Overall, the results of the research show that the challenges faced by family farms in and around Târgu Secuiesc are complex and multifaceted. The combination of technological backwardness, low profitability and structural problems make it difficult for farms to be competitive and sustainable. Encouraging technological improvements, supporting cooperative partnerships and providing targeted training are essential for the development of local agriculture and the viability of rural areas. Additional research objectives:

The results of the research suggest that future research should focus on the following areas:

Conducting qualitative in-depth interviews with farmers who are already using the technology: these interviews can provide a deeper insight into the advantages, disadvantages and concrete impacts of technology use on farms.

Examining the effectiveness of training to improve technological awareness and digital competences: research should assess the extent to which training contributes to farmers' technological literacy and effective use of technologies.

Exploring the potential of cooperative partnerships to facilitate technological development: research should focus on how cooperatives can help their members to access technology, invest and acquire skills.

To interview farmers in the area of Târgu Secuiesc to assess which technologies are most relevant for agriculture in Szeklerland and how they could be adapted to the needs of farmers, including the possibility of using geothermal energy in agricultural production.

These additional research objectives could help to promote technological development in family farms in and around Târgu Secuiesc and contribute to the sustainable development of local agriculture.

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7.AUTHORS' ADDRESSES

Authors' addresses:

Porczel Barbara

University of Sapientia, Faculty of Economics, Socio-Human Sciences and Engineering

Piața Libertății 1, Miercurea Ciuc

Email: porczellgbarbara@uni.sapientia.ro

Dr. Péter Emőke-Katalin

University of Sapientia, Faculty of Economics, Socio-Human Sciences and Engineering

Piața Libertății 1, Miercurea Ciuc

Email: peterkatalin@uni.sapientia.ro