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(EDITORS)

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Safe Use of Artificial Intelligence
on EU Market

EDITURA UNIVERSITĂȚII „ALEXANDRU IOAN CUZA” DIN IAȘI

Mihaela Tofan • Irina Bilan • Elena Suman

(editors)

European Finance, Regulation and Business
Safe Use of Artificial Intelligence on EU Market

EUFIRE-RE 2025

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2025

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HEALTH POLICY TRANSPARENCY ON ARTIFICIAL INTELLIGENCE

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Abstract

In the context of profound digital transformations that mark healthcare systems globally, artificial intelligence (AI) has become an essential tool in supporting clinical research, therapeutic decisions and the optimization of medical processes. Although the technological promise of AI is substantial, its implementation generates a series of essential challenges, among which the lack of transparency, the difficulties of explainability of algorithmic decisions and the risk of bias stand out. Transparency is thus emerging not only as a technical requirement, but as an ethical and normative principle, essential for maintaining public trust, protecting patients' rights and ensuring responsible technology governance.

According to the European Commission (2021), the transparency of an AI system implies its ability to provide clear and intelligible explanations of the logic of automated decisions, along with the traceability of decision-making processes and the data used. In this sense, transparency implies not only technological explainability, but also auditability, clearly defined responsibility and the active participation of all actors involved in the life cycle of AI systems: developers, medical professionals and patients.

This study brings together the findings of several recent articles to explore the transparency of artificial intelligence (AI) in public health policies. The analysis highlights both convergences and differences in approach, offering an integrated perspective on how transparency is understood and applied in this field.

Key themes such as accountability, equity and trust in AI systems are outlined, alongside contrasts between technical and holistic views of implementation.

The study proposes a structured synthesis of the current context and suggests future directions for research and policy development in the field of ethical use of artificial intelligence in health.

Keywords: *artificial intelligence; transparency; public health policy; ethics.*

JEL Classification: I18; O33; K32; D83.

1. INTRODUCTION

Artificial intelligence (AI) is playing an increasingly important role in healthcare, helping to improve clinical research, quality of care and patient

outcomes. However, challenges related to bias, lack of transparency and difficulty in interpreting AI models requires rigorous regulation.

This study analyses peer-reviewed articles to highlight common themes and distinct perspectives on transparency in the use of AI, with the aim of informing future strategies. Integrating AI into public health policies brings both benefits and risks, and transparency is becoming a key element for maintaining public trust and respecting ethical principles. They offer an overview of the complexity of transparency, addressing technical, ethical and normative dimensions.

Transparency in the use of artificial intelligence (AI) in public health policy is essential to ensure trust, ethics and efficiency in decision-making. Here are some relevant definitions taken from specialized sources:

1. The European Commission defines transparency in the context of AI as the ability to guarantee that AI systems used in the European Union are "secure, transparent, ethical, impartial and under human control". This involves classifying AI systems according to the level of risk and applying specific rules for each category, thus ensuring the protection of citizens and respect for fundamental rights (Regulation on Artificial Intelligence, (EU) 2024/1689).

2. Samuela Rostas, in the article "The impact of artificial intelligence in decision-making processes in public administration" (2024), emphasizes that transparency in the use of AI in public administration implies clarity and openness in the way these technologies are integrated into decision-making processes, allowing citizens to understand and evaluate decisions made with the help of AI.

3. Navid Toosi Saidy, in the article "Artificial Intelligence (AI) in health: advantages & risks" (n.d.), published on Citizen 47.biz, highlights that transparency in the use of AI in health involves providing clear and accessible explanations about the decision-making processes of algorithms, essential for the acceptance and effective use of these systems in public health.

2. MATERIALS AND METHODS

The present study adopts a theoretical-comparative methodology, aiming at the analysis of a corpus of up-to-date scientific literature, with direct relevance to the issue of AI transparency in the field of public health.

Five academic papers that offer complementary perspectives on the topic are analyzed in detail: the article by He *et al.* (2023), which proposes an ethical and normative vision of explainable AI; the systematic study by Payrovnaziri *et al.* (2020), focused on explainable models applied to real data from electronic medical records; the contribution by Kiseleva *et al.* (2022), who propose a layered framework of accountability and transparency; the article by Hernandez-Boussard *et al.* (2020), which introduces the MINIMAR reporting standards; and the research by Rajpurkar *et al.* (2022), which reviews the applicability of AI in medicine.

These papers are examined to identify common themes, methodological and conceptual differences, and how health policy influences standards of transparency in AI.

By maximizing key ideas and optimizing conclusions, this research synthesizes a comprehensive view that supports ongoing research and policy formulation, based on a larger number of documents, with the most relevant cited.

The analysis reveals a common focus on the need for transparency to ensure fairness, accountability and trust in AI systems, while differing in approaches, focusing on technical versus holistic implementation. This article formulates a structured understanding of the current landscape, offering insights for future directions in the ethical implementation of AI in health.

2.1. What are the main challenges in integrating AI technologies into public health policies?

Integrating artificial intelligence (AI) technologies into public health policy brings with it a number of significant technical and systemic challenges. One of the most pressing difficulties is related to the quality and availability of medical data, which are often fragmented, incomplete or demographically uneven. The lack of interoperability between health systems exacerbates this problem, making it difficult to effectively train and implement AI models (Jiang *et al.*, 2017). Algorithmic models can also reflect or even amplify existing biases in the data, leading to inequitable results for certain population groups (Obermeyer *et al.*, 2019). In these conditions, AI integration cannot be considered purely technological, but requires a systemic approach, adapted to the complexity of the medical field.

In addition to technical challenges, ethical and social aspects play a crucial role in the responsible adoption of AI in public health. Algorithmic transparency, explainability of automated decisions, and privacy protection are essential for building trust among health professionals and the general public (Floridi *et al.*, 2018). At the same time, AI technologies need to be developed in a way that promotes equity and equal access to healthcare, especially for vulnerable or marginalized groups. Without such measures, there is a risk that AI will contribute to reinforcing existing disparities in healthcare systems (Benjamin, 2019). Thus, social and cultural aspects cannot be ignored in the definition and application of AI integration policies. The regulation of AI technologies in healthcare is a field that is constantly evolving, but faces multiple uncertainties. Many of the current legislative frameworks, such as those in the European Union or the United States, do not keep up with the accelerated pace of technological innovation, which creates gray areas in terms of accountability, certification and safety (Morley *et al.*, 2020). Clear global standards that are adaptable to local circumstances are needed to facilitate the effective implementation of AI. At the same time, the lack of investment in digital infrastructure and the training of healthcare professionals

are major obstacles, especially in low- and middle-income countries (Whitelaw *et al.*, 2020). Finally, public acceptance and social legitimacy of AI are essential for the success of technology-based public health policies. Concerns about privacy, job losses, and patient alienation can reduce public trust in automated decisions. Therefore, transparent communication, community engagement, and public education are key elements to foster a culture of trust in AI (Meskó *et al.*, 2017). At the same time, international cooperation is crucial to reduce global disparities in access to technologies and to ensure that AI solutions are culturally and linguistically inclusive. Addressing these challenges in a proactive way will enable the responsible and sustainable integration of AI into public health policies, with real benefits for the quality and equity of health services on a global scale.

2.2. How public health policies influence the development of AI transparency standards

Public health policies play a critical role in shaping artificial intelligence (AI) transparency standards, influencing both the design of algorithmic systems and their regulation. The relationship between public policy and AI is bidirectional: policies establish requirements for explainability and accountability, while technological progress prompts the revision of normative frameworks. For example, Article 22 of the General Data Protection Regulation (GDPR) of the European Union requires “significant information” about the logic of automated decisions, requiring the use of methods such as SHAP or LIME to increase the interpretability of algorithms (Voigt and Von dem Bussche, 2017). In parallel, ethical initiatives, such as the World Health Organization (WHO) guidelines, emphasize the link between transparency and equity, calling for audits to identify bias in datasets (World Health Organization, 2021).

Differences in policy approaches across countries are leading to divergent standards of AI transparency, with significant implications for developers and healthcare institutions. The European Union promotes strict, risk-based regulation that requires detailed technical documentation for high-risk systems. In contrast, agencies such as the FDA in the United States are adopting voluntary guidelines that allow for iterative post-launch surveillance (Floridi *et al.*, 2018). Canada, through its algorithmic impact assessments, emphasizes fair transparency, requiring demographic reporting and bias audits, even at the risk of compromising model interpretability. These strategies, summarized in Table 1, reflect a structural tension between the desire for rigorous regulation and the need to stimulate innovation.

Table 1. Divergences in policy approaches and technical implications

Policy approach	Standard AI outcome	Compensations
Risk-based regulation (EU)	Detailed documentation for high-risk systems	High compliance costs, potential obstacle to innovation
Voluntary Guidelines (US FDA)	Post-market surveillance, iterative updates	More flexibility, but uneven application
Equity focused mandates (Canada)	Demographic and bias audits	Promotes fairness, but complicates interpretability

Source: own computation

However, implementation of transparency policies is often limited by technical constraints, time lags between regulation and technological development, as well as tensions between global standards and local priorities. For example, legal "right to explanation" requirements (such as in the GDPR) favour models that are easy for users to understand, but they can sacrifice algorithmic precision, especially in the case of neural network-based systems. Furthermore, many health policies predate the advance of AI, which creates legal gaps – an example being Ghana's legislation, which does not include mandates on AI transparency in public health. Concomitantly, attempts at global standardization, promoted by the WHO, sometimes conflict with local requirements, such as those in India, where algorithmic explainability must be linguistically and culturally adapted (World Health Organization, 2021). In response to these challenges, emerging transparency standards have emerged, developed in parallel with public policies. Documentation frameworks such as MINIMAR require details of data sources, validation protocols, and failure modes, providing a technical basis for assessing AI responsibility. Tools such as model cards (Mitchell *et al.*, 2019) facilitate reporting of AI performance by subpopulation. At the same time, laws such as California's Automated Decision Systems Accountability Act promote algorithmic impact assessment, and the European IVDR Regulation requires continuous monitoring of AI performance in medical diagnosis. However, the implementation of these initiatives is affected by the ambiguity of policy terms, infrastructure disparities between developed and developing countries, and misalignment between the interests of practitioners, developers and policy makers (Leslie, 2019).

3. RESULTS

The comparative analysis of the revealed literature shows that transparency is universally recognized as an essential condition for the acceptance and responsible use of AI systems in health. The studies of He *et al.* (2023) and Kiseleva *et al.* (2022) converge in arguing that transparency is fundamental for building and maintaining trust between healthcare providers and patients, having

a direct impact on the quality and ethics of the medical act. Also, explainable models (XAI), such as LIME and SHAP, are highlighted by Payrovnaziri *et al.* (2020) as indispensable tools in ensuring the validity and interpretability of AI results. The World Health Organization (2021) similarly advocates the need to introduce AI auditing mechanisms to detect systematic biases and ensure fairness in the delivery of health services.

At the same time, compliance with European regulations, in particular the General Data Protection Regulation (GDPR) and the proposed Artificial Intelligence Act (AI Act), is recognized as essential. Article 22 of the GDPR, which stipulates the right to a meaningful explanation of automated decisions, becomes a fundamental pillar in shaping transparency policies. He *et al.* (2023) and Kiseleva *et al.* (2022) make explicit reference to these legal instruments, underlining the importance of clear and enforceable regulation.

Differences in approach between the reviewed studies are evident in terms of methodology and thematic focus. Thus, He *et al.* (2023) offer a holistic approach, emphasizing the ethical and social dimensions of AI transparency. In contrast, Payrovnaziri *et al.* (2020) adopt a technical and systematic perspective, focusing on the classification and evaluation of XAI methods used in the analysis of data from electronic health records. Kiseleva *et al.* (2022) propose a layered model of transparency, differentiating between external (for patients), internal (for professionals) and own (for developers) transparency, thus providing a comprehensive architecture of responsibilities in AI.

Public policies are proving to play a decisive role in shaping and enforcing transparency standards. The AI Act and GDPR impose clear requirements on the explainability and traceability of AI systems, while WHO guidelines emphasize the correlation of transparency with equity and patient safety. Concrete examples of best practices include South Korea's initiative to publish the performance of AI systems used in pandemic triage, California's legislation on algorithmic auditing, and the provisions of the European IVDR Regulation that require continuous evaluations of the performance of AI in diagnosis.

Despite these advances, significant obstacles persist. Terms such as “meaningful transparency” remain ambiguous, leading to uneven and sometimes inconsistent application of the regulations. Also, the lack of a standardized technical framework for assessing the explainability of AI models makes their comparability across institutions or jurisdictions difficult. Technological infrastructure disparities between developed and developing countries magnify inequalities in the ability to implement these standards.

4. DISCUSSIONS, RECOMMENDATIONS AND PROPOSALS

To ensure an effective and equitable implementation of AI in healthcare, a contextualized approach to transparency is needed. Thus, the level of information and explainability must be adapted according to the category of users: patients

need clear and accessible explanations, medical professionals need relevant technical details, and developers need access to training data and algorithms. Kiseleva's proposed stratified model (Kiseleva *et al.*, 2022) provides a useful framework for this differentiation.

Interdisciplinary collaboration becomes indispensable in the development and application of transparency policies. Informatics, health professionals, ethicists, and policy makers must work together to define realistic and enforceable standards. Initiatives such as IBM AI Fairness 360 (IBM, 2021) demonstrate the usefulness of private-public sector collaborations in developing fair and transparent models.

Another necessary step is the global standardization of transparency assessment tools. Proposals such as MINIMAR and Model Cards, promoted by researchers and technology companies such as Google, can serve as starting points for the development of international guidelines. At the same time, continuous monitoring of AI systems and their post-implementation audit, as required by IVDR, must become common practice.

5. CONCLUSIONS

AI transparency is an essential element for the responsible operation of artificial intelligence systems in public health. Its integration requires a complex approach, which combines technical, ethical and legal dimensions. Public policies play a decisive role, not only by imposing normative requirements, but also by facilitating an organizational culture oriented towards responsibility and equity. For the future, harmonized policies, clear evaluation mechanisms, the participation of all stakeholders and investment in infrastructure and education are needed. Only through such an integrated approach will AI be able to sustainably contribute to the improvement of public health.

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OFEDS.INDUSTRY 4.0 AND THE CEE COUNTRIES IT SERVICES OUTSOURCING SECTOR

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Abstract

Industry 4.0 has significantly transformed business structures, not only in the technological domain but across all aspects of operations, by reshaping workflows and driving innovation aimed at increasing productivity. This article primarily explores the evolution of outsourcing and nearshoring in the software development sector within Central and Eastern European (CEE) countries under the influence of Industry 4.0. Over the past decade, this sector has experienced substantial growth and has emerged as a pivotal driver of economic development in the CEE region. Industry 4.0 serves as both a transformative force in redefining the technological landscape and business structures as well as a catalyst for innovation.

This article aims to synthesize the primary transformation directions of outsourcing/nearshoring tech-organizations and to objectively list the predictions posited by recent literature. The sector is rapidly evolving, growing into a mature one under the pressure of adapting to macro-economic policies and the adoption of Industry 4.0' emergent technologies. While many aspects have been predicted in literature, reality has shifted these predictions. The article will examine the main directions outlined by literature that have proven to align with reality or still hold potential.

The article is structured in 4 main sections. Introduction: providing and overview of the context of nearshoring/outsourcing in CEE countries as discussed in literature. Second, we have an overview of the Industry 4.0 impact in outsourcing/nearshoring technology sector and how did this sector evolve throughout the latest decade. Third, our research is focused on the strategies and their transformative effects on business processes and specifics of nearshoring/outsourcing organizations. Finally, the conclusions and future challenges to be explored: facing reality, reviewing future strategic business approaches recommended by literature based on sector current realities.

Keywords: Industry 4.0; outsourcing and nearshoring; business models; sustainability in Industry 4.0; Deeptech.

JEL Classification: O32; O12; O33; M15.

1. INTRODUCTION: OUTSOURCING AND INDUSTRY 4.0

Outsourcing has been a concept that become known mostly in the '90, when productivity targets and global markets mutations have leveraged increase of

productivity through re-location of labour. This strategy has changed shapes through eras of industry development and facilitated alignment of macro-economic indicators between high-risen economies and those emerging, between Western and Eastern European countries.

“The global software development outsourcing market is expected to exhibit a compound annual growth rate (CAGR) of 11.5% from 2023 to 2028” was predicted by a renowned market reports site (Global Market Estimates, 2023). Software development, IT consulting, and IT services are the most common types of nearshoring services in Europe. The countries that typically engage in this practice include the Czech Republic, Hungary, Ukraine, Romania, and Poland.

On the other hand, countries that nearshore software development to these regions are ones that have a considerably higher cost of living. These include the Western European countries such as Germany, United Kingdom, France, and Italy, as well as the Nordic states – Denmark, Sweden, Finland, and Norway. (Klucs, 2024a)

The evolution of the outsourcing sector in CEE countries (and not only) is a process developing in the context of important technology changes brought in by Industry 4.0.

Industry 4.0 (I4.0) represents a concept that encapsulates the ongoing digital revolution. It integrates technologies such as the Internet of Things (IoT), smart automation, big data analytics, and connectivity to foster highly efficient, flexible, and interconnected production and manufacturing ecosystems. (Alarcón and Alarcón, 2025) As an evolution of traditional control and automation systems, Industry 4.0 enhances process monitoring and automation capabilities within companies. Its key features include device interconnectivity, real-time data collection and analysis, and data-driven decision-making, setting it apart as a transformative force in modern industry (Tredicine *et al.*, 2024).

The footprint that I4.0 is leaving upon tech business-flows and organization structures is reflected early on by Schuh, Potente, Wesch-Potente, Weber and Prote, in 2014 (Schuh *et al.*, 2014), through major characteristics estimated in their study:

- **Technical and Intelligent Engineering Perspective:** Industry 4.0 denotes the integration of smart products and services within technologically relevant environments, such as the Industrial Internet of Things, smart homes, or intelligent production systems.
- **Organizational and Transformational Perspective:** Industry 4.0 encompasses the dynamic generation and rapid utilization of organizational interfaces, facilitating the formation of expertise networks and enhancing operational capacity.
- **Economic and Value-Oriented Perspective:** Industry 4.0 acknowledges the significance of collaboration-driven productivity, emphasizing the role of interconnected systems in optimizing economic performance.

Industry 4.0 represents a significant milestone in the global economic development through the integration of advanced technologies, having been announced and outlined as a strategic direction by the European Union as early as 2015-2016. Currently, in theory, we are transitioning towards the next phase – Industry 5.0 – which focuses on human-centric approaches and resource recirculation. As stated, *“It complements the existing 'Industry 4.0' approach by specifically putting research and innovation at the service of the transition to a sustainable, human-centric and resilient European industry.”* (Gálvez *et al.*, 2025).

Based on the above perspectives, the current study is analysing the impact of the I 4.0 upon IT sector of CEE countries. It aims to analyse specifically the structural transformations within the outsourcing industry in Central and Eastern European (CEE) countries in the context of Industry 4.0 implementation. It also examines the challenges faced by both service providers and companies outsourcing activities, particularly in the software services sector, as well as the necessary adaptations required to maintain competitiveness in a rapidly evolving economic landscape.

The primary objective is to synthesize how Industry 4.0 has structurally transformed business models, with a particular focus on outsourcing and nearshoring in the CEE regions, and to identify key insights from the lessons learned thus far. This course of action considers also the aspects mentioned as main directions of the I4.0 impact: economic and value orientation.

Over the past decade, strategic directions have been continuously outlined and re-adapted (European Parliament, 2016), both in terms of global policies and through the natural dynamics of business, driven by concrete actions, evolution, and voluntary or adaptive transformations within the sector. This study will specifically examine software service providers and technology hubs in CEE countries, where both anticipated changes and adjustments aimed at ensuring continuity amid market volatility can be observed.

Research questions: The study in this article is aiming to answer a few specific questions based on which also resources have been filtered and summarized:

- Q1: Which are current trends of transformative changes of outsourcing in CEE countries?
- Q2: Which are additional factors and challenges involved in the transformation?
- Q3: Which are the trend adaptation strategies stipulated by literature as observed or recommended for organizations of outsourcing in CEE countries under all circumstances of volatility and Industry 4.0?

The methodology employed in this study involved a systematic approach of selecting and analysing relevant literature, as well as own inference based on confronting different sources and market realities. Academic articles from

databases such as ScienceDirect, Sci-Hub, Sage, and ResearchGate were included based on specific search terms: Information Technology Outsourcing/Business Processes Outsourcing/Knowledge Processes Outsourcing (ITO/BPO/KPO); nearshore, DeepTech, outsourcing, Industry 4.0, reshoring, impact of DeepTech on the software market; business environment in the DeepTech era, adaptive strategies in Industry 4.0. Additionally, there were considered market research reports, including IDC, NATEK and World Economic Forum on digital transformation expenditures and cloud services, data security and governance or articles and market studies conducted by different consulting companies such as BCG, McKinsey (McKinsey, 2022), and Deloitte. The inclusion criteria focused on studies published between 2020 and 2025, with an emphasis on research from past two years to reflect recent developments in the field. However, some sources since before pandemic (2020) have been considered as trend-setters and predictions have been at the time set by literature and studies, whereas COVID has accelerated adoption of certain measures that enriched impact of I4.0 in IT sector. Selected articles:

- Addressed the relationship between I 4.0 and transformation of outsourcing/nearshoring models in CEE countries;
- I 4.0 technologies adoption in the business sector based on different organizational models and business structures;
- Addressed also the transformations that innovation could bring into tech business of CEE countries (entrepreneurship also covered).

There have been used sources older than the date range specified, when definitions of different concepts had to be cited (e.g., ITO, BPO, KPO) or cited European Parliament and other EU political authorities for tracking directives of Industry 4.0.

Exclusion criteria included:

- Studies focused exclusively on the technical aspects of I 4.0 without addressing other business models, unless tech aspects were involved;
- Studies that solely debate specific sectors of nearshoring/reshoring such as manufacturing industries without focusing on the tech perspective of these business-flows;
- Statistics that only referenced job dynamics and employee skills in software without discussing how these are integrated into the business environment dynamics;
- Governmental measures that aim only state sector without a clear reference to outsourcing/nearshoring private sector. For instance, a lot of state organizations that present needs of digitalization, being part of the over-all IT sector development policy but not touching directly privately held organizations.

2. CURRENT CONTEXT OF OUTSOURCING IN EUROPEAN SPACE

The transformative organizational effects represent one of the three foundational perspectives (Schuh *et al.*, 2014) that underpins this article and serves as the lens through which the trends of the structural changes of nearshoring/offshoring business have unfolded in CEE countries. We will further summarize how the main types of the outsourcing have set the trends within European space. Western European and East European countries have a specific dynamic into outsourcing complexities.

There have been different types that outsourcing can be identified in manifesting along the evolution of the business practice in various industries. With regards to information technologies, this has 3 main specific practice shapes: ITO, BPO, KPO.

- *ITO* is a practice where companies outsource IT functions to external providers, often to leverage specialized skills and reduce costs (Meyer, 2006).
- *BPO* is a business practice where an organization contracts with an external service provider to perform essential business functions or tasks. These can include back-office processes like accounting and front-office processes such as customer service (Bharadwaj and Saxena, 2010).
- *KPO* involves outsourcing core business activities and highly specialized knowledge-related work to third-party professionals. This allows businesses to access specialized expertise and improve efficiency (Currie and Willcocks, 1997)

The outsourcing has undergone a transformation in its objectives, taking initially the shape of the externalization of specific segments of the production processes, referred to as ITO. As technology began to assume a larger role in these processes, outsourcing evolved into the relocation of software-related services, which are more easily outsourced, controlled, and audited – this form being known as BPO. The way in which ITO has transformed in response to the growing complexity of business operations leads to a shift in outsourcing/nearshoring towards KPO. In this context, outsourcing has evolved not only to encompass the externalization of processes but also the externalization of expertise, synchronized with the increasing level of specializing training (Sen and Shiel, 2006).

A first answer to research question Q1 goes into area of diversifying outsourced processes by adding complexity to it. Starting with outsourcing the simple IT functions (ITO), early on in beginning of years 2000s, this took a while to ramp-up into new, growing complexity outsourcing models. Expertise and business view has matured since then, within the sector, allowing it to organically develop business trusted relationships as well as technological management strategies with direct impact in the context of BPO and KPO.

According to reports from McKinsey and the Boston Consulting Group (Klucs, 2024b) developed European markets provide a favourable environment

for the expansion of the nearshoring sector. Given that the primary countries outsourcing services to Central and Eastern European (CEE) nations in a nearshoring model are the United Kingdom, Germany, and the Nordic countries, several key factors indicate that nearshoring is expected to continue its growth trajectory in the coming years:

- *United Kingdom*: The ITO market is projected to reach €47.70 billion by 2028, driven by a post-Brexit talent shortage and rising labour costs, which are accelerating outsourcing to external service providers.
- *Germany*: The German ITO market is anticipated to grow from €22.95 billion in 2023 to €38.07 billion by 2028, as German companies increasingly adopt nearshoring strategies to address skill shortages.
- *Nordic Countries*: Approximately 40% of organizations plan to integrate nearshoring into their outsourcing strategies, creating opportunities for ITO providers in emerging economies. These countries are at the forefront of adopting AI and ML technologies, presenting valuable prospects for specialized service providers.

Based on the number predictions of the literature, nearshoring is increasingly directed towards CEE countries, which have the potential to manage strategic processes in geographically proximate locations. These regions offer access to a well-educated, young workforce proficient in multiple foreign languages, along with strong technical and financial expertise. This expertise has been cultivated through the historical expansion of the outsourcing sector and the ongoing shift from ITO to KPO.

While looking through the lens of literature's mentioning, it is observed that outsourcing is presented as an economy growth factor in EU countries. This translates through CEE countries developing a new sector of services provided mainly towards the established economies (UK, Germany, the Nordic Countries). Overall, the development of outsourcing/nearshoring in EU is a balancing and unifying factor for EU countries economies, facilitating collaboration in a unified geo-political space supported by European laws and directives. To add to the Q1 and Q3 answers, this marks another trend of the I4.0 impact on CEE countries consolidating collaboration within the space leveraging on the productivity factor of both parties involved, which, in the end benefits the European economy and tech-advancement, shaping outsourcing more into nearshoring.

3. OUTSOURCING STRATEGIES ADOPTED FOR I4.0

The literature indicates that digital service providers in the field of I4.0 technologies from CEE countries (Jipa-Muşat *et al.*, 2024) must adopt certain strategies to ensure continuity in this context. There are highlighted several classifications of these strategies mainly focusing on those increasing the productivity for clients. This aspect of productivity increasing outlines a predilection of adoption of new technologies (AI) for basic services, thus allowing

companies to focus on re-directing budgets towards innovation or other development departments, reshuffling storage costs by mixes of on-prem/cloud solutions or targeting low-digitalized sectors as new clients. All of these employ different additional advantages like generating new services, focusing on consultancy services and requiring cross-domain knowledge for leading change processes in new sectors (Sftecu,N 2025). These strategies reflect differently on various types of organizations: corporations, SMEs, start-ups.

3.1. Business strategies of main size-categories of outsourcing services providers

The trends have been evolving in alignment with the strategic directions established prior to Industry 4.0. According to the World Economic Forum (2023), “70% of the new value to be created in the global economy over the next decade will be based on productivity gains from digital technology adoption” The cited study highlights not only the growth opportunities for large corporations but also for small and medium-sized enterprises (SMEs), whether as clients or providers of IT services that generate added value in the economy.

Several sources refer to *corporations* and their strategies of ensuring adaptability throughout I 4.0:

- Companies are transforming their service portfolios by shifting towards AI consultancy and advanced technological solutions, or even outsourced research and development departments (Klucs, 2025). They are relocating development processes and storage resources while maintaining expertise – a major factor influencing added value, thus focusing on niche talent to be acquired through local efforts (Madsen, 2025).
- Through consultancy, they are targeting new sectors for digitalization (administrative, healthcare, construction), generating partnerships primarily to increase flexibility, thereby reducing multiple contracting (Klucs, 2025).

Small and medium-sized enterprises (SMEs) in outsourcing play a particularly crucial role in the global economy, accounting for over 98% of all companies in the European Union and generating more than 100 million jobs (Silva *et al.*, 2025).

- They provide DevOps, Data Science, and IT security services for SMEs, assisting with cloud migration and cost optimization driven by economic volatility and the widespread use of cloud solutions (Madsen, 2025).
- The transition to subscription-based business models ("as a service") reduces dependence on Time & Materials (T&M) contracts, shifting to monthly subscription services instead of one-time license sales, making them much more accessible to SMEs as potential clients. 83% of small businesses will maintain or increase their spending on outsourced business services in 2023 (Clutch Team, 2023).

The contribution of SMEs to economic growth, their potential for self-development, and their impact on the global economy are analysed in a study proposing a methodology for the efficient adoption of new technologies in SMEs' digitalization processes by differentiating between digital readiness levels and digital maturity levels (Silva *et al.*, 2025). Given the scarcity of resources, the level of knowledge, and the necessity of investing in new technologies – often sophisticated, yet costly to integrate into business workflows – the *DORAM* model has been introduced. This model is particularly relevant as it provides a structured approach to optimizing technology adoption, ensuring that organizations integrate innovations where they genuinely offer a competitive advantage in the market and in their specific business activities.

Start-ups – An Essential Element in the Business Environment of Industry 4.0: In the organizational conglomerate of the economies of Central and East European countries, deep-tech start-ups contribute to achieving the United Nations' Sustainable Development Goals (SDGs). The majority of these companies are founded by entrepreneurs with advanced academic qualifications – a sustainable trend characteristic of Industry 4.0. However, they face significant challenges, such as high costs, lengthy research processes, and substantial risks of failure (Nguyen *et al.*, 2024). This paper explores how European deep-tech start-ups can enhance their success by integrating strategic foresight and context, not merely technological innovations. The study employs Partial Least Squares Structural Equation Modelling (PLS-SEM) to analyse the impact of market, technology, and environmental characteristics on strategic foresight capabilities. The findings indicate that deep-tech start-ups must combine technological expertise with market analysis skills to ensure more efficient adoption of innovations at lower costs (Romme *et al.*, 2023).

3.2. Collaboration models in I 4.0 outsourcing

Another aspect addressed by research literature and economic reports concerning the impact of Industry 4.0 is the transformation of organizational structures and how companies adapt to market demands, not only through technology but also through integrated operational mechanisms with adaptive and scalable capabilities. Following we will list some of the models adopted according to existing research:

- **Transactional Model vs. Strategic Partnership:** Both studies and research papers emphasize value-added services and analyse contracting strategies for outsourcing software development within the context of Industry 4.0. A study proposes two contractual models: *pay-per-time and revenue-sharing* (Wang and Zheng, 2024), which can help companies manage market uncertainty and asymmetric information between providers and clients. The paper highlights the importance of adapting contracts to ensure software interoperability and scalability in digital manufacturing.

- **Traditional Outsourcing vs. Innovation-Based Outsourcing:** In traditional outsourcing, the focus was primarily on workflow outsourcing (BPO). However, innovation-based outsourcing is oriented toward specialized skill sets with deeper domain knowledge. The study *From Business Process Outsourcing (BPO) to Knowledge Process Outsourcing (KPO)* (Sen and Shiel, 2006) explores this transition in different contexts and at the technological level (in the US, during the 2000s). The growth of this phenomenon is driven by the shortage of skilled labour in industrialized countries and the availability of specialized human resources in emerging economies, making it relevant in the analysis of outsourcing transitions within Industry 4.0. The study highlights challenges associated with KPO, including higher infrastructure requirements and specialized competencies, as well as the additional risks involved in this type of outsourcing.
 - **Higher Complexity:** KPO involves high-end processes that often lack standardized methods for achieving solutions, introducing risks and uncertainties that are less pronounced in the more routine activities of BPO.
 - **Integration with Client Operations:** KPO requires a deeper understanding of the client firm's operations and strategic goals to effectively add value. Building this integration demands strong communication and trust between the outsourcing provider and the client.
- **Co-Innovation and Technological Partnerships:** This new approach involves companies reinventing themselves by outsourcing processes requiring optimization to strategic partners who possess niche knowledge, expertise, and the capacity to support innovation through AI. For example, the use of digital twin concepts for optimizing production flows in large companies (Monferdini *et al.*, 2025).

On a deeper cross-overview of the collaboration models, organization types and process typologies in outsourcing area of the CEE countries, we can summarize the linkage of them and some specifics reasoning of each, making sense of the multiple possibilities exposed in a structured way (see Table 1).

Table 1. Possible structure of the mix business models – organization size – outsourcing type

Business collaboration model		Outsourcing type	Organization type (client/provider)	Specifics of the model - organization - practice process	Examples of service offerings adapted to 14.0
Traditional outsourcing	Transactional model	ITO, BPO	Corporations (provider/client) & SMEs (provider/client)	Services with a low-potential of innovation Subscription-based services Addresses mostly maintenance services	Re-configuring cloud migrations/maintenance services specific affordable services for automation of simple processes “as a service” (standardized)
	Strategic Partnership	BPO, KPO	Corporations (provider/client) & SMEs (provider/client)	Newly digitalized SMEs/corporations standardized services	Employing digitalization consultancy for low-readiness levels organizations/sectors (KPO mode) Cyber security services (subscription-based)
Innovation based outsourcing	Outsourcing innovation	BPO, KPO	Corporations (client), SMEs (provider)	Niche expertise. (e.g. AI flows customization to be incorporated through AI expertise SMEs covering only the integration and customization process)	Governance services AI automated routines (chatbot) Corporations of heavily non-digitalized sectors (medicine, constructions, finance) partnerships between corporations of similar technology chain
	Co-innovation	KPO	Corporations linked in the chain of market products (for instance automotive software linked with smart highway infrastructure companies)	Besides production chain of value is linking the entities, there might be also involved academic & research organizations involved.	(automotive – telecom; governmental – AI; medicine – AI; medicine – robotics)

Source: based on author’s interpretation

Considering the structural changes of the outsourcing from ITO to KPO, we have synched these with the literature mentioned strategies from transactional model to strategic partnerships or partnership based strictly on innovation/co-innovation. The observation of the market supports several horizontal connections

between these 3 aspects that consolidate towards main trends of how organizations are approaching sustainability under the influence of I4.0 wave.

- Traditional outsourcing (based in ITO and BPO and low level KPO)
 - *Transactional models and strategic partnership* reflect mostly into realities of long-term organizational relationship, whereas services (like “testing” or “DevOps”) have been for a long time confirmed as efficient and thus *big corporations* were used to outsource to more than just one provider. Now, they have started to incline to keep only preferred, rapidly translated into margins focused collaboration. For many tech corporations wanting to focus on innovation, budgets are being free to go more into that strategic direction by adopting a short list of confirmed, long-term outsourcing collaboration for the low innovation potential areas of their products life-cycle. When processes have already been standardized, the transactional model of outsourcing/nearshoring takes over costs of labour and its risks (ITO). Most known example of such strategy is keeping outsourcing transactional model in place for testing services of big tech corporations or processes where the infrastructure maintenance of a cloud framework is being outsourced based on a previous long-term collaboration, so that DevOps Team are strategically pulled into further contracts. These services can be even transformed into a subscription-based maintenance service, where process itself is a secure one, being standardized and easy to be scalable included into the cost projections of the client corporations. In the same time, standardization of these services, allows providers of it (SMEs or corporations with knowledge of process) to further provide the same service to another segment of the market: *SMEs with a low level digitalization readiness factor*. These are low-complexity services offered in a standardized manner. Under these approaches, we can notice a prevalence of ITO/BPO type of business in the big corporations-outsourcing providers relationship and a low-level complexity KPO profiled in the area of services for low-level digitalized SMEs. Here, providers contribute with an advisory component towards the clients but referring only to a most common/standardized recommended practice, that introducing the KPO nuance.
- *Innovation based partnership* – also a preeminent trend of the I4.0 takes precedence in nearshoring sector through concrete BPO/KPO structures that either go into outsourcing expertise niche to deep-knowledge experts (SMEs or even research organizations) or into innovative collaborations unifying forces of expertise to emerge new products.

- For the first aspect of the innovation-based outsourcing, we can notice in the market a strong need of expertise cross-domains in order to raise the pace of digitalization of low-digitalized sectors (constructions, medicine). Nevertheless, the digitalization of these sectors, as imminent as it may appear, has a good reason for not being yet on a low level: lack of expertise of the specific domain merged with tech-savvy understanding. Until the education sector itself will provide such educated specialist that can serve a cross-domain expertise sector, market is catching-up through open-minded specialists, seasoned technology experts that have been exposed to other specific domains and had a high learning aperture. Until now, these were known as seasoned business analysts, which have sound skills of understanding of cross-domains concepts and making it easier for tech experts to understand the needs of the construction domain or medicine domain (or others). Education (self and by experience) is bridging separate domains and allows a new segment of expertise to rise and express through innovation-based collaborations. These processes are profoundly marked by the expertise of the specific domain, thus we can firmly state that in these cases outsourcing is re-shaping towards consistent KPO more than BPO.
- Co-innovation – is when processes of 2 organizations are unified in a totally new manner towards innovating cross-products. Samples of these have already entered our lives through IoT whereas any industry has been raised to the rang of “smart” once their management and personalization has been combined with telecom functionalities. Other emerging collaborations can be observed as trending already in the market: automotive – telecom; governmental – AI; medicine – AI; medicine – robotics. This kind of cross-domain collaborations will emerge even more innovative products and will allow industry to merge into new market domains. A major contribution to this part of the innovation-based outsourcing/partnership is also the involvement of academic organizations through their more practical implications from research areas.

The above analysis of models and strategies adopted comes to answer our research questions. With regards to the trends of outsourcing under I 4.0 impact (research question Q1), we are witnessing the shaping of business processes with a focus on delivering added value to benefit technological and economic growth. We are moving toward personalization through the creation of scalable and adaptable generic models, which imbue the business environment with sustainability and resilience. Trends revolve around a form of adaptability, trying

to focus on partnerships, scalability of solutions and innovation in services structures or workflows to ensure continuity. Most probably outsourcing becomes more a form of partnership in service deliveries. This providing answers also to our Q3 research question with regards to strategies of I4.0 adaptation for the outsourcing companies.

These business processes and collaboration models of outsourcing are still to be explored through market reality and further observation. It is important to notice how these might or might not contribute to increasing complexity and push towards higher value driven approaches. The mix of strategies and models observed by literature as adopted or to be adopted have still a lot of changing potential that is to be researched and developed.

3.3. Contextual factors modelling I 4.0 adaptation of outsourcing – inducing volatility

In addition to the new adaptive models, outsourcing in Industry 4.0 is significantly influenced by factors that contribute to the increased volatility of the outsourcing/nearshoring environment, as highlighted in the literature: *Legislative Changes and Geopolitical Impact, Taxation, Security & Governance, Talent Shortage*. All of these increase the complexity of the outsourcing environment adding pressure to the need of creative solutions towards sustainability of business.

The political instability in CEE countries over the past 2-3 years (such as the war in Ukraine, the turmoil caused by extremist movements in major European powers, as well as in economically polarized countries like the USA and Russia) imposes a high degree of economic volatility. This geopolitical volatility adds unpredictability to outsourcing and nearshoring strategies. A consequence of the aforementioned instability, as well as an independent factor, taxation policies within CEE countries introduces long-term instability for investors. These policies recalibrate the cost advantages for processes relocated to the CEE countries, increasing price competition with countries in Asia. Furthermore, the growing average salaries in CEE countries and advancements in online collaborative technologies have allowed low-cost Far Eastern countries to offer competitive service solutions to Western BPO customers (Peköz, 2025).

Data security and regulations, such as GDPR and other policies, are major factors influencing outsourcing decisions. On the other hand, IT security concerns act both as a barrier as well as a catalyst for the adoption of Industry 4.0. SMEs with a higher degree of digitalization are more exposed to cybersecurity risks but are also better equipped to implement advanced protection solutions. Key challenges include financial constraints, inadequate IT infrastructure, and a shortage of digital skills, as discussed in *The Effect of IT Security Issues on the Implementation of Industry 4.0 in SMEs* (Arroyabe *et al.*, 2024). Additionally, in

an IDC report, it was noted that skills, AI, and enterprise solutions will play a crucial role in addressing these concerns (Loomis, 2024).

The growing demand for IT specialists and its effects on the labour market are also major challenges. As highlighted in the study *Future Workforce for Industry 5.0* (Saheal and Mohammad, 2025), employees should possess self-management abilities and the capacity to learn new skills or enhance existing ones to assess, compare, and comprehend information effectively. To overcome obstacles during the transition to Industry 5.0, workers need resilience, stress tolerance, and adaptability. One of the biggest challenges for companies in CEE countries remains the digital skills gap. In Romania, for example, only 27.7% of the population has basic digital skills, and only 2.6% of employees are specialized in IT. To maintain the competitive advantage of outsourcing, it is essential to accelerate upskilling and reskilling programs to address this gap (Saheal and Mohammad, 2025).

Coming back to our research questions, which would be the factors that challenge the I4.0 adaptation strategies of outsourcing in CEE countries (Q2), it is noticed from literature that CEE countries have confronted and still are under the sign of political-economic volatility and instability. This makes it even harder for the education domain to thrive by raising adequate labour force in sync with the wave of technological change pace. We will still face gaps in the training of specialists in the area of new technologies in Industry 4.0, but these will quickly recover profitability only through the flexibilization of contracts and the way emerging technologies and services supporting their wide-scale adoption are accessed. Companies will need to focus not only on developing cognitive skills but also on emotional intelligence for their employees, as these are fundamental elements for their comprehensive development. Moreover, specialists must adapt and acquire the digital competencies necessary in the digital society, including digital identity, responsible use of digital technologies, digital security, cybersecurity, *digital emotional intelligence*, digital communication, digital literacy, and digital rights. Legislation changes, new EU regulations, cybersecurity standards and most of all geopolitical factors still predict an increased volatility of the sector which brings an added level of pressure on the sustainability aspect of any business but mostly on business sectors where technology is a main feature.

4. CONCLUSIONS

Although some of the conclusions in the literature are derived from case studies, there is still no comprehensive manifestation of suggested approaches to addressing the adaptability and sustainability of outsourcing companies in Central and Eastern Europe (CEE), making it difficult to establish a coherent conclusion regarding the validity of the described adaptive models. Furthermore, there is an increasing encouragement to develop domestic products as a solution for

sustainability in the technological evolution of Industry 4.0. This presents an area for exploration – how nearshoring is transforming into onshoring, facilitating local and international partnerships in the development of domestic software products.

In Romania, ANIS stated in their 2030 manifesto (ANIS, 2024), "While the Report contains, as one of its main recommendations, the expansion of measures to support an innovation-based IT sector, the European Innovation Scoreboard 2024 places Romania at the bottom in terms of innovation capacity, with a performance of 34% compared to the EU average, in the category of 'Emerging Innovators.' The latest data indicates a decline compared to 2023 (-1.6%) and a much slower pace of innovation capacity development compared to the dynamics at the community level. Innovation underfunding is a major obstacle, given that allocations for R&D from the state budget represent a minuscule proportion – approximately 0.46%, compared to the EU average of 2% – with Romania investing 21 euros per capita, while the EU average reaches 276 euros per capita." High stakes objectives are projected by EU and implicitly by local representatives, however pressure of business continuity is preserved by an unpredictable pace of innovation and support framework from authorities.

4.1. Missing points of the literature

Most research focuses only on short-term trends which brings a missing perspective of longitudinal studies regarding the outsourcing strategies and transformations topic. Also, the specific impact of Industry 4.0 on different types of outsourcing is under documented. There is insufficient research on the effects of Industry 4.0 on outsourcing in CEE countries on local economies (growth, inequality, occupational changes), with the literature primarily focusing on positive aspects, such as exploiting the potential of technologies in emerging economies, and less on the negative effects (for example, discouraging innovation in fully domestic products). The ESG (Environmental, Social, Governance) factor emphasized in the latest EU directions is also going to have an impact into how sustainability of outsourcing will evolve and adapt. This aspect in particular could be an additional research point for further studies.

4.2. Outsourcing view during I4.0

The stage known as Industry 4.0 has transformed business models in outsourcing within the CEE region. Initially, this business models were purely an economic solution for labour relocation aimed at reducing labour costs. Over time, under the influence of Industry 4.0 and the natural evolution of expertise and adaptability, it has become an effective strategic optimization solution based on: added value, innovation and strategic partnerships, automation and niche competencies, transitioning from execution to outsourcing processes and expertise.

Nearshoring, by its very nature – proximity to resources and outsourced processes – provides the opportunity for redistribution of economic growth within the EU: while developed countries with mature economies are fully digitalizing SMEs and adopting optimization policies through innovation, there is an opportunity for CEE countries to meet these needs of the I4.0 catalysing their economic maturation as well. As a result, governance and cybersecurity policies are fully adopted across the European space, which also facilitates the creation of new high-standard business zones in terms of ethics and security. Companies in CEE countries have focused on getting the expertise on implementing such cyber security policies

This paper opens the discussion on business versatility, with the intrinsic potentials of the technological wave dominating the times. It is paving the way for exploring and observing new models that may emerge and how they will maintain their presence in the market. Therefore, even if high efforts are to be invested under the impact of I4.0 and volatility inducing factors, outsourcing/nearshoring will take the shape of cross-countries collaboration, processes of business being re-shaped into innovation services, consultancy services and cross-domain expert solution implementing services. We think that it is most likely that what we still call today outsourcing tomorrow will become the collaboration model of business sector relying on different levels of depth of knowledge and technologies that will be combined towards creative solution into delivering services. We are heading towards a world of technological collaboration of services instead of proprietary end-to-end product providers that externalize parts of their processes.

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ARTIFICIAL INTELLIGENCE – PARTNER OR COMPETITOR FOR THE ACCOUNTANCY PROFESSION?

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Abstract

Artificial intelligence is having a dramatic effect in all industries in a short time. Accounting is no exception and the question for many is whether artificial intelligence will replace those working in the profession in the near future. Automation of repetitive tasks, advanced data analytics, improved efficiency of the entire accounting process, assistance in compliance with ever-changing financial and tax regulations accompanied by possible job losses due to automation, the need to learn new skills to understand and use tools based on artificial intelligence, dependence on technology are realities of the current stage of practicing accountancy profession. If accounting professionals will quickly adapt to new technologies and learn how to work effectively with them, then we tend to believe that artificial intelligence will be a reliable partner, but, at the same time, there is also a possibility that some will not cope with the challenges of automation and changes in the structure of jobs, and for them, artificial intelligence is only a competitor. The study aims to capture the main challenges of the accounting profession imposed by the implementation of artificial intelligence, through a qualitative analysis of new trends in the accounting field, using data from various sources (media, literature, etc.). The results of the research are to present the necessary information to contribute to the academic debate and to be able to reach a conclusion on how the implementation of artificial intelligence will change the future of the accounting profession.

Keywords: artificial intelligence; accounting; accountancy profession.

JEL Classification: M40; M41; M49.

1. INTRODUCTION

We live in an ever-changing and challenging world with a prevailing sense of uncertainty. (Apostol, 2021a, 2022a, 2022b, 2023a, 2023c, 2024a) Globalisation and the galloping development of digitisation are forcing profound transformations in all economic sectors, including the accounting field.

Accounting has undergone several developments over the years, the last major innovation being the creation of double-entry bookkeeping over 500 years ago (Emetaram, 2021), followed by the development of its capacity to produce and transmit a larger volume of financial-accounting information in a shorter time

through automation. Currently, the accounting profession is facing a number of challenges related to changes in the economic environment, technological developments as well as changing regulations. Of all these, the greatest impact has been the latest advances in IT, which have meant that artificial intelligence, defined as the ability of computer systems to simulate human cognitive processes, has progressed beyond what was previously unimaginable and its presence is felt everywhere. It has the potential to revolutionise the way accounting data is processed, analysed and reported, so the infusion of AI into the accountancy profession is a significant one, with its challenges and opportunities.

2. LITERATURE REVIEW

Artificial intelligence involves the creation of intelligent machines that can react in human-like ways (Emetaram, 2021), and the main debate about this is whether the technology will lead to increased human intelligence or lead to increased autonomous intelligence and machine automation (Kwarbai, 2024). The evolution of AI from theory to practice is a rapid one, especially nowadays, and it is accompanied by radical changes in all fields. It brings many benefits and advances in various fields, but it also comes with a number of significant, complex and varied risks, involving technological, social, economic and ethical issues that need to be carefully managed. (Apostol, 2024b) According to some authors (Greenman, 2017), artificial intelligence has a fairly long history of more than 30 years in its application in accounting and auditing.

The accountancy profession and the training of the future accountancy professional have also been debated topics in other studies conducted (Apostol, 2019, 2020, 2021b, 2023b), where various stages of accounting progress, with good and bad, have been reported. But as economic and social processes are constantly evolving and transforming, then accounting also undergoes changes, which is why its study is absolutely necessary to prepare new generations of professionals to adapt to the new demands imposed on them (Suleiman *et al.*, 2020; Emetaram, 2021; Bako and Tanko, 2022; Kwarbai, 2024).

3. RESEARCH METHODOLOGY

The study aims to capture the main challenges of the accounting profession imposed by the implementation of artificial intelligence and to answer the question whether artificial intelligence is a partner or a competitor for the accounting profession, through a *descriptive and qualitative analysis* of new trends in the accounting field, using *data* from various sources (media, literature, etc.). *The results of the research* are to present the necessary information to contribute to the academic debate and to be able to reach a conclusion on how the implementation of artificial intelligence will change the future of the accounting profession. *The research concludes* that some of the activities of the accounting profession can be replaced by an automated system based on artificial intelligence and accountants

not only need to adapt to the use of information technology, but also to adapt to the changing business environment.

4. RESULTS AND DISCUSSIONS

The evolution of accounting is continuous, adapted to the requirements of different stages of socio-human development and always surprising. Whereas in the past accounting records and financial and accounting reporting were paper-based, today they are computer software-based. Moreover, with advances in artificial intelligence-based programming it may be that, in the not too distant future, the use of humans in accounting will no longer be useful as day-to-day operations and record keeping become automated (Greenman, 2017; Suleiman *et al.*, 2020; Zhang *et al.*, 2020; Kwarbai, 2024). Although nowadays, we cannot imagine doing business without the help of this technology, and even though some people might argue that many business sectors, such as accounting, will be taken over by AI-based codes and robots, this is not true. But everyday tasks will change dramatically in the sense that mundane and repetitive operations will be taken over by robots (Suleiman *et al.*, 2020; Nayak and Sahoo, 2021), and human expertise will be required at a higher level for decisions that require judgment. (Emetaram, 2021) Thus, accounting professionals will have to adapt to the new demands, and acquiring skills related to the use of IT tools and techniques in accounting gives them a better chance to survive and even thrive in this period (Suleiman *et al.*, 2020; Kwarbai, 2024).

Starting from a number of aspects, such as: computers can work much faster and more accurately than humans and are much cheaper to operate and maintain compared to humans; humans are prone to personal biases and judgements that may overshadow their professional requirements, whereas computer software is not, some authors have concluded that artificial intelligence is more useful and reliable in the accounting field than the accounting professional (Suleiman *et al.*, 2020), and others that it has a significant positive effect on data analysis, anomaly detection and reporting accuracy (Kwarbai, 2024) Moreover, some authors (Suleiman *et al.*, 2020; Emetaram, 2021) present a number of aspects, which describe the current stage of accounting development:

- Even if the initial cost of implementing artificial intelligence is extremely high, in the long run, the total cost of ownership decreases and the need for employees becomes lower. This is beneficial for accounting firms by reducing costs, but can be a hindrance for new accountants and accounting graduates;
- The accounting scandals of the early 21st century, involving accounting firms (e.g. Arthur Anderson), would not be repeated if artificial intelligence-based programmes were used, which complied with all accounting standards;

- Colleges and high schools should review their curricula so that students and pupils have access to new courses to help them better adapt to the new changes, and teachers should have a solid knowledge of international accounting and financial reporting standards and need to constantly update their knowledge and skills (Luo *et al.*, 2018);
- Accounting professionals need to focus on developing their professional skills and adhering to ethical standards set by accounting bodies around the world;
- The current stage of development, as well as the future one, is characterised by the use of information technology in all areas, including business.

The use of AI technology cannot be avoided by firms, which is why accountants simply need to integrate it to maximise professional output and become more valuable to both their clients and the world (Bako and Tanko, 2022). In this regard, some authors also make a number of recommendations for a good integration of AI in accounting, such as Emetaram (2021):

- Improving accounting professionals' knowledge of artificial intelligence;
- Collaboration between AI researchers and accounting researchers;
- Use and development of more complex artificial intelligence applications (e.g., neural networks, expert systems, fuzzy systems, etc.);
- Strengthening cyber security in other areas to adequately protect and support system security;
- Assigning responsibility for technical support on the proper functioning of the technology to senior management.

With the implementation of artificial intelligence in the accounting field, a new term has emerged, namely Continuous Accounting, which involves the incorporation of control, automation and period-end tasks into day-to-day activities, allowing the pace of accounting to finally align with the pace of business (Emetaram, 2021).

The integration of emerging technologies (e.g., Big Data, Machine Learning, Artificial Intelligence and blockchain) into the accounting field has brought about profound changes in the accounting profession, such as redesigning accounting procedures, reducing errors and distortions in accounting information, increasing accounting efficiency and promoting the transformation of accounting career structures (Zhang *et al.*, 2020).

Considering the fierce competition in accounting in general and auditing in particular, it could not be possible for the Big Four companies not to embrace the new technologies. Thus, we can highlight some characteristic aspects of each company, as follows (Zhang *et al.*, 2020):

- *Deloitte* has developed several applications based on advanced technologies:
 - An Information-Driven Organisation (IDO) framework, which integrates daily analytics, data and reasoning into decision making, helps to improve the speed and quality of decision making while reducing decision costs;
 - A voice analytics platform called Behaviour and Emotion Analytics Tool (BEAT) to monitor and analyse voice interactions;
 - An automated platform for document review using cognitive technologies that can automatically read and identify relevant information from a set of documents.
- *PricewaterhouseCoopers* (PwC) has a diverse portfolio, such as:
 - Uses Robotic Process Automation technology to collect data and determine the accounting status of all entities, review financial statements, and convert data into tax bases;
 - Has its own AI audit lab to improve audit quality, automation levels and operational efficiencies and to maximise AI technology's ability to collect comprehensive information and data for quick and accurate analysis;
 - Created the GL.ai. robot to check every uploaded transaction in milliseconds and identify anomalies and suspicious transactions in the general ledger;
 - Deployed Quill's AI Power engine of narrative Quill science to automate customer insight reporting;
 - Developed automated narratives for anti-bribery and anti-corruption (ABAC) reporting.
- *Ernst&Young* uses:
 - Robotic Process Automation (RPA) and Natural Language Processing (NLP) technologies;
 - Drones to help with stock observation and real-time analysis (such as optical feature recognition);
 - An intelligent categorisation engine to quickly compile relevant information;
 - Machine Learning technology to detect fraud.
- *Klynveld Peat Marwick Goerdeler* (KPMG) holds a generous portfolio, such as:
 - Global Expertise Centre, providing complementary resources to local teams;
 - “KPMG Ignite”, which functions as a data analytics processor and provides unbiased estimates and continuous testing for prototype development and innovation, as well as a framework and guidance to

answer employee and client questions about artificial intelligence applications;

- Two special internet and data security departments: one is responsible for designing the company's software and testing network security, and the other for data protection and instant response to cyberattacks;
- dynamic risk assessment combines actuarial theory, complex algorithms, advanced mathematics and data with analytics to identify, connect and visualise four-dimensional risks;
- "K-analyzer", a tax analysis software capable of analysing thousands of transactions in minutes;
- An FBT Automator robot that is capable of performing analyses of project and registry data, including interactions with business systems such as SAP and Oracle to access backend data, and preparing FBT for return-to-work files using numeric coding and fuzzy word matching;
- Payroll Tax Automator tool, which automatically populates payroll codes and assigns payroll codes to the correct payroll tax type, and can run data analytics on monthly payroll tax returns and annual payroll tax adjustments to ensure compliance with initial filing and generate a central repository for payroll taxes;
- KPMG's Automatic Exchange of Information (AEOI) reporting tool, which uses hundreds of data validation checks to create and embed the XML files required for filing.

The use of Big Data, Machine Learning and Artificial Intelligence technologies by the Big Four accountancy firms confirms that the accountancy profession is increasingly investing in AI and integrating it into the core business, as this technology is a key factor for success in this field.

5. CONCLUSIONS

The daily tasks in accounting will change dramatically, which is why the professionals who will endure, and even thrive, are those who possess skills related to the use of IT tools and techniques.

Several authors (Suleiman *et al.*, 2020) have concluded that in the future, the focus will shift to analysis rather than simply entering financial data, while others (Emetaram, 2021) argue that human expertise will be required for decisions that require judgement.

Although the efficiency, speed and accuracy of Artificial Intelligence have yet to be equalled, they are useless without human interpretation. Human creativity and imagination cannot be replaced by AI-based programmes. Even though they have a great number of advantages compared to humans, there is always a deep fear that in case of any disruption of this artificial intelligence

system, the whole economic system could collapse, which is why experts recommend that for economic and financial decision-making, artificial intelligence should not have exclusivity.

The accounting training programme will have to be revamped, adapted to new market requirements and include subjects related to programming and the use of artificial intelligence for routine accounting functions.

All these changes will not only not lead to the disappearance of accountancy professionals, but on the contrary will increase their productivity and improve their skill sets.

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THE INDEPENDENCE OF JUSTICE AND THE DILEMMA JUDICIAL ACTIVISM VS. NATIONAL SPECIFICITIES IN EU EASTERN COUNTRIES

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Abstract

The independence of the judiciary forms the foundation of contemporary legal systems where the rule of law guarantees the separation of powers and the support against arbitrary and external interference. Within the European Union (EU), it is an integral part of the common legal order, yet its uniform implementation generates significant tensions, especially in the Central and Eastern states. These tensions are fueled by the need to reconcile EU law principles with the respect for national identity, a challenge which became more important in the context of the recent political transformations and extreme tendencies.

The research points out the fact that the decisions of the European courts not only serve to clarify and strengthen the applicable legal norms but are essential tools in ensuring the maintenance of an often-fragile democratic balance. However, the perception of these judgments as forms of foreign interference can lead to the polarization of social structures and risks undermining public confidence in the efficiency and independence of the national judiciary. In Poland and Hungary, the decisions of European courts, although based on clear principles of the rule of law, have often been perceived as a form of extreme interference, amplifying nationalist rhetoric and fueling inter-institutional conflict. In Romania, the relatively harmonious cooperation between national and European courts suggests a greater potential for integrating European rules into the domestic legal order. These dynamics underline the importance of a balance between the uniform application of European values and respect for constitutional particularities, as well as the need for constant dialogue.

Keywords: *judicial independence; judicial activism; EU law and national sovereignty.*

JEL Classification: K40; K33; P48.

1. INTRODUCTION

The independency of justice is a fundamental principle of law derived from the balance of the state powers and aimed at defending the fundamental rights of citizens. It is the essential foundation of the rule of law and an indispensable condition for ensuring the balance between the powers of the state. Within the European Union (EU), this principle is not only a normative requirement, but also a fundamental value enshrined in Article 2 of the Treaty on European Union (TEU), along with respect for democracy, human rights and the rule of law (European Union, 2012).

It is a key criterion in the assessment of Member States, both in the framework of enlargement procedures (through the Copenhagen criteria) and through specific instruments such as the Cooperation and Verification Mechanism (CVM) or the recent rule of law conditionality mechanism (European Commission, 2020).

However, the uniform application of these standards within the EU has generated significant tensions, especially in the states of Central and Eastern Europe. In Poland and Hungary, judicial reforms initiated by majority governments have been perceived by the European institutions as direct attacks on the independence of the judiciary, leading to interventions by the Court of Justice of the European Union (CJEU) and the European Court of Human Rights (ECHR) (Pech and Scheppele, 2017; Bánkuti, Halmai, and Scheppele, 2012). The tensions between national legislation and European principles reflect a broader conflict between the constitutional specificity of states and the supranational legal order of the Union. Within the EU, the independence of the judiciary is not just a theoretical ideal, but a *sine qua non* rule for maintaining the legal order and for ensuring the efficient functioning of the single market.

This paper starts from the premise that judicial activism – understood as the active involvement of courts in shaping public policies and defending constitutional values – has become a key mechanism for protecting the independence of the system. For example, in the decision in the case of *Associação Sindical dos Juizes Portugueses* (C-64/16), the CJEU reaffirmed that national courts must benefit from effective protection against interference, by virtue of Article 19 TEU (CJEU, 2018).

Our research hypothesis focuses on how judicial activism has become the essential mechanism for upholding the independence of the judiciary, but also on the controversy in the relations between national and European courts. From a methodological point of view, the research combines doctrinal analysis with the examination of relevant jurisprudence, also using case studies, allowing the identification of common models, but also highlighting the differences generated by the national legal and political context. Representative judgments of the Court of Justice of the European Union (CJEU) and European Court of Human Rights (ECHR), together with the relevant decisions of the national courts are selected,

considering both their impact on the domestic legal framework and the political and social reactions generated. The case studies are analyzed in the context of recent policy transformations, providing a detailed perspective on the challenges encountered in implementing EU rules.

The methodological approach includes the analysis on how judicial activism operates as an instrument of democratic resistance and implementation of European standards. The comparative approach will focus on relevant examples from Poland, Hungary and Romania. In 2021, Polish courts challenged the supremacy of European law, triggering a significant institutional conflict with the EU. National courts have become the main opponents of reforms aimed at subordinating justice to the executive, supported by the interventions of the CJEU. One of the particularly controversial measures was the establishment of a disciplinary section for judges, a measure considered by the CJEU to be incompatible with the European principles of judicial independence. Hungary provides an example with distinct nuances, where attempts to restructure the judiciary system have led to a complex dialogue between the national courts and the ECHR. The reforms initiated by the Fidesz government have brought changes to the status of judges and the structure of the Constitutional Court, leading to repeated interventions by the ECHR. In contrast, Romania presents a special dynamic, as national courts are using European standards to counter legislative initiatives with certain question marks and to support the consolidation of the rule of law. Initially characterized by tensions related to the efficiency of the judicial system and the transparency of the legislative process, Romania has demonstrated its capacity to adapt quickly to European norms (Tofan and Verga, 2023). Romanian courts, the High Court of Cassation and Justice included, have relied on European case law to issue decisions on combating corruption and strengthening the rule of law. These case studies reveal the complexity and the challenges that judicial activism enshrines in the relationship between the principle of subsidiarity and the uniform application of EU law. The process of implementing European rules encounters significant difficulties. Cultural factors, political constraints and constitutional divergences are obstacles in standardizing the application of EU law and the involvement of the Romanian constitutional court into this process is also addressed.

The relevance of this approach is supported by the recent political context, in which respect for the rule of law is becoming increasingly closely linked to access to European funds, but also to citizens' trust in the democratic functioning of the state. As Kochenov and Bárd (2018) warn, an erosion of the independence of the judiciary in any EU Member State can have systemic effects on the entire European legal order.

2. THEORETICAL FRAMEWORK

The concept of judicial independence is closely linked to the principle of separation of powers in the state and to the institutional guarantees offered to magistrates to exercise their duties without interference from the executive or the legislature. According to the Venice Commission, the independence of judges presupposes both individual independence – i.e. the freedom of the judge to decide in concrete cases without pressure – and institutional independence, which aims at the organization of the judiciary (Venice Commission, 2010).

At the level of the European Union, this principle is reinforced by Article 19 TEU and by the case-law of the Court of Justice of the European Union (CJEU), which has established that national courts applying European law must enjoy a sufficient degree of independence to guarantee the right to a fair trial (C-64/16, *Associação Sindical dos Juizes Portugueses*). In a subsequent decision, i.e. C-791/19 *Commission v. Poland*, the CJEU clarified that European standards of independence cannot be limited by domestic constitutional provisions (), emphasizing the primacy of EU law.

A second fundamental concept is judicial activism, which refers to the involvement of courts in the process of shaping public policies and imposing constitutional values in the face of acts of the executive or legislative branch perceived as contrary to the democratic order (Stone Sweet, 2000).

Although judicial activism is frequently criticized in conservative doctrines for potentially overcoming the traditional role of the judge as a "mourner of the law" or "*bouche de la loi*" in French, in the contemporary European context it acquires a dimension of defending the rule of law against authoritarian or populist tendencies (Sadurski, 2019).

In parallel, regarding the principle of subsidiarity, enshrined in Article 5 TEU, which implies that the Union acts only to the extent that the objectives of the action cannot be sufficiently achieved by the Member States. Subsidiarity has as a mechanism for the protection of national specificities and constitutional traditions specific to each Member State. However, the uniform application of European values – including standards of justice – sometimes collides with this logic, generating conflicts between constitutional sovereignty and European obligations (Kelemen, 2017).

In the case of the Central and Eastern European states, this conflict manifests itself intensely, because the integration process has been simultaneous with incomplete democratic transformations. Thus, the independence of the judiciary has not always been perceived as an intrinsic value, but often as an external requirement imposed by Brussels (Closa and Kochenov, 2016). This perception contributes to the weakening of trust in the judicial system and to nationalist reactions to the decisions of European courts.

3. METHODOLOGY

To analyze how the principle of judicial independence is implemented in the context of European integration, with a focus on activating judicial activism mechanisms in Central and Eastern European states, the present research adopts a qualitative methodology, with a focus on doctrinal, comparative and jurisprudential analysis.

3.1. General approach

The methodological approach is based on an interdisciplinary framework, combining the perspective of European public law with elements of political and institutional analysis. This approach is necessary to understand not only the normative dimension of judicial independence, but also the socio-political context that influences the application of this principle in practice (Galligan, 1996).

3.2. Research techniques and methodological limitations

The research combines the following techniques:

- Doctrinal analysis: examination of the literature in the field of EU law, comparative constitutional jurisprudence and the rule of law.
- Analysis of case law: selection and interpretation of relevant decisions of the CJEU, ECHR and national courts. The focus is on judgments that address conflicts between European standards and domestic judicial reforms.
- Case studies: three national examples – Poland, Hungary and Romania – are analyzed in depth to highlight the variations in the application of the principle of judicial independence and the concrete forms of judicial activism.
- Comparative analysis: identifying the points of convergence and divergence between the three legal systems and the influence that European law experts on them.

This research does not aim to provide an exhaustive mapping of all cases in the three states analyzed. Also, the qualitative character of the study implies a contextualized interpretation, without the claim of statistical generalization. However, by selecting relevant cases and selecting sources in literature, jurisprudence, political documents. The aim was to obtain a deep and nuanced understanding of the phenomenon investigated.

3.3. Justification for the selection of states

The choice of Poland, Hungary and Romania is based on the relevance of these states in the debate on the erosion of the rule of law in the EU. All three have been members of the European Union for over a decade, but have followed different trajectories in terms of judicial reforms:

- Poland – represents the case of an open conflict with the European institutions regarding the supremacy of EU law and the reform of the judicial system.
- Hungary – provides a model for strengthening political control over justice through constitutional means.
- Romania – illustrates an example of progressive adaptation to EU standards, with the active involvement of courts in upholding the rule of law.

3.4. Criteria for the selection of case-law

The analyzed decisions were selected based on the following criteria:

- Normative relevance: decisions defining standards of judicial independence in the context of European law.
- Political and institutional impact: decisions that generated significant reactions in the public space and in the internal political system.
- Conflictual nature: cases reflecting tensions between national and European courts (CJEU, ECHR).

Representative examples include *C-791/19 Commission v. Poland, Baka v. Hungary* (ECHR), respectively the decisions of the High Court of Cassation and Justice of Romania on combating corruption and upholding the independence of the judiciary.

4. RESULTS: COMPARATIVE CASE STUDIES

The comparative analysis of the way in which the independence of the judiciary is negotiated and defended in Poland, Hungary and Romania highlight divergent trajectories in relation to the fundamental values of the European Union. Although all three states have been under pressure to align with post-accession European standards, institutional reactions and judicial resistance mechanisms have varied considerably.

4.1. Poland – direct challenge to the primacy of EU law

Since 2015, Poland has initiated a series of controversial reforms in the field of justice, under the rule of the Law and Justice (PiS) party. The most significant measures concerned the National Council of Magistracy, the Supreme Court and the disciplinary system of judges. These interventions generated strong reactions from the European Union, culminating in the infringement procedure and a series of CJEU decisions.

The emblematic case is *Commission v. Poland (C-791/19)*, in which the Court of Justice concluded that the new Disciplinary Section of the Supreme Court does not meet the independence criteria set out in Article 19 TEU and Article 47 of the Charter of Fundamental Rights (CJEU, 2021).

This decision was met with hostility by the Polish authorities, culminating in the 2021 ruling of the Constitutional Tribunal declaring the articles of the TEU to

be incompatible with the Polish Constitution (Trybunał Konstytucyjny, 2021), an unprecedented action that called into question the supremacy of European law.

While civil society and some magistrates supported the CJEU's intervention, the government authorities denounced it as an act of foreign interference. Thus, in Poland, European judicial activism has been met with institutional resistance and nationalist rhetoric, amplifying the rule of law crisis (Sadurski, 2019).

4.2. Hungary – constitutional restructuring of the judiciary

Hungary provides an example of the systemic erosion of the independence of the judiciary through successive legislative and constitutional changes initiated by the Fidesz government. Since 2010, several reforms have targeted the Constitutional Court, the National Judicial Council and the system of appointment of judges. Although these measures were presented as administrative modernizations, in practice they reduced the autonomy of the judiciary.

A notorious case is *Baka v. Hungary* (ECHR, 2016), in which the Court found the violation of the right to a fair trial and freedom of expression of the former president of the Supreme Court, removed because of criticism of judicial reforms. This judgment highlighted the lack of procedural safeguards and political interference in the functioning of the judiciary (ECHR, 2016).

Despite these external interventions, the Hungarian government has continued the process of "illiberalization" of justice, developing a parallel constitutional system that minimizes the control of European courts. Unlike Poland, Hungary did not directly challenge the supremacy of EU law, but avoided it through sophisticated internal mechanisms, which made it more difficult for the European institutions to react (Scheppele, 2018).

4.3. Romania – judicial activism as an adaptation mechanism

Romania has a special dynamic compared to the other two states. Although it went through moments of institutional crisis and challenging justice, especially between 2017 and 2019, the reaction of the judiciary and civil society was oriented towards defending the rule of law.

Romanian courts, in particular the High Court of Cassation and Justice and the Courts of Appeal, have frequently used the mechanism of preliminary rulings to the CJEU to clarify the compatibility of national reforms with European law. The CJEU decision in case *C-83/19 (Romanian Judges' Forum Association)* was instrumental in blocking the functioning of the Section for the Investigation of Crimes in Justice, considered by European courts as a threat to the independence of the judiciary (CJUE, 2021b).

Unlike Poland and Hungary, the Romanian authorities have shown a greater willingness to comply with European requirements, even if sometimes with delay. This attitude is encouraged by public coercion and the conditions imposed by the Cooperation and Verification Mechanism. Thus, Romania illustrates a model of

defensive judicial activism, oriented towards strengthening the legal framework and protecting judges against political influence.

5. DISCUSSIONS

The results of the comparative study reveal a structural tension between the principle of uniform application of European law and the constitutional diversity of the Member States, especially in Central and Eastern Europe. Although the fundamental values of the Union (rule of law, separation of powers, independence of the judiciary) are clearly set out in Article 2 TEU, their practical implementation depends on political, cultural and institutional factors specific to each state.

5.1. Judicial activism as a form of democratic resistance

In Poland and Romania, national courts have adopted different forms of judicial activism to defend the independence of the judiciary:

- In Romania, the courts have activated the European mechanisms (preliminary questions to the CJEU, invocation of ECHR jurisprudence) to counteract the pressures exerted by the legislative power on justice. This strategy can be interpreted as an adaptation activism, which aims to integrate European norms into a fragile national framework.
- In Poland, on the other hand, institutional conflicts have been deep. European activism – especially that of the CJEU – was perceived as interference in national sovereignty, fueling a nationalist and anti-European discourse. Here we observe a confrontation between European judicial activism and national constitutional resistance (Búrca, 2013).

These differences confirm the hypothesis that the activation of justice as a „guardian of democracy” is conditioned by the internal political environment and the relationship between the courts and the executive.

5.2. The dilemma between sovereignty and integration

A central element of the rule of law crisis in the EU is the conflict between the principle of the primacy of European law and the claims of constitutional sovereignty. Poland's Constitutional Tribunal has explicitly stated that certain provisions of the TEU are incompatible with the Polish Constitution, an unprecedented act in the history of European integration (Trybunał Konstytucyjny, 2021). This position contradicts the settled case law of the CJEU, which reaffirms the primacy of EU law even in the face of domestic constitutional provisions, like in C-399/11, *Melloni*.

The debate reflects a breach of trust between European and national courts and highlights the lack of a coherent mechanism for resolving conflicts of jurisdiction in EU law (Dicosola, Margoni, and Repetto, 2019). In the absence of

a 'supreme arbiter', these conflicts risk undermining the coherence of the European legal order.

5.3. Public perception vs. legitimacy of courts

In Poland and Hungary, CJEU and ECHR judgments have often been presented in the public discourse as forms of imposing foreign values, which has led to the polarization of society and a decrease in trust in judicial institutions.

In contrast, in Romania, the CJEU's decisions have been better received, partly due to the support of civil society and independent media, but also because of a recent history in which justice has been the symbol of the fight against corruption. Thus, the legitimacy of European judicial activism is closely linked to the local cultural and institutional context (Kelemen, 2020).

5.4. The need for a new framework for judicial cooperation

The cases analyzed indicate that the current European mechanisms (CVM, Article 7 TEU procedure, CJEU) are not always sufficient to prevent democratic slippage. There is a need to rethink cooperation between national and European courts on a clearer basis, including by:

- Creating a permanent mechanism for constitutional dialogue between the CJEU and national constitutional courts;
- Introducing common criteria for assessing the independence of the judiciary in all Member States;
- Strengthening the budgetary conditionality mechanism in relation to the respect of the rule of law.

Common standards of judicial independence cannot be successfully implemented without genuine political commitment from Member States and a functioning institutional dialogue between national and European level. Judicial activism is a necessary but insufficient component of democratic resilience – it must be coupled with legitimacy, transparency and inter-institutional cooperation

6. CONCLUSIONS

While the principles of the rule of law and the primacy of EU law are formally recognized by all Member States, their effective application is profoundly influenced by the specific political, cultural and constitutional context of each country.

Research has shown that judicial activism – both at national and European level – has a key role to play in defending the independence of the judiciary in the face of political pressure. At the same time, this activism is not uniformly perceived: while in Romania it has been valued as a tool to strengthen the rule of law, in Poland and Hungary it has often been denounced as a form of foreign interference and as a threat to national sovereignty.

One of the paradoxes highlighted is that European courts – conceived as defenders of common values – can become, in certain contexts, causes of social and political division. This happens especially when their decisions collide with reform projects promoted by legitimate political majorities at national level. It is therefore essential that the implementation of European standards is accompanied by constant legal dialogue and measures to increase the internal legitimacy of these standards.

Romania's case shows that fellowship between national and European courts is possible, and judicial activism can function as an effective mechanism for adapting to EU rules. On the other hand, Poland and Hungary highlight the limits of this model in the absence of political will and a consolidated democratic constitutional culture.

The contribution of the paper consists in highlighting the way in which the tension between the uniformity of European law and the national constitutional diversity concretely affects the independence of the judiciary in the post-communist states. It also stresses the need to rethink the framework for judicial cooperation within the EU so that it is better adapted to the real challenges of the current political context.

Finally, without a truly independent judiciary, neither the European project nor national democracy can function sustainably. The defense of this principle must be not only a legal mission, but also a political, educational and civic one, undertaken by all levels of European society.

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THE SAFE USE OF ARTIFICIAL INTELLIGENCE IN ROMANIAN BUSINESS

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Abstract

Artificial Intelligence (AI) is rapidly transforming global industries, offering unprecedented opportunities for efficiency, automation, and innovation. However, in Romania, the adoption of AI technologies remains limited and uneven. The local economic system is still developing, and many Romanian businesses – particularly small and medium-sized enterprises (SMEs) – lack the digital infrastructure, skilled workforce, and strategic frameworks needed to fully embrace AI. While some sectors such as banking, telecommunications, and retail have started integrating AI solutions, the majority of the business environment continues to operate using traditional models. This paper addresses a fundamental question: How can AI be used safely and effectively in Romania's emerging economy, while ensuring ethical, legal, and social responsibility? The safe use of AI implies not only technical robustness but also alignment with European regulatory frameworks such as the General Data Protection Regulation (GDPR) and the forthcoming EU Artificial Intelligence Act (European Commission, 2021). It also requires awareness of issues such as data privacy, algorithmic bias, cybersecurity threats, and the explainability of machine learning models (Floridi and Cowls, 2019). The article proposes a multi-dimensional framework that includes organizational readiness, regulatory compliance, ethical AI principles, and public-private cooperation. It also emphasizes the importance of employee digital upskilling and the creation of transparent AI governance models at the company level. Drawing on both international best practices and local realities, the paper outlines strategic recommendations tailored to Romania's current digital maturity. In doing so, it contributes to the broader academic and policy debate on how emerging economies can leverage AI responsibly, avoiding digital divides while fostering innovation. The aim is to offer actionable insights for business leaders, policymakers, and educators interested in accelerating Romania's digital transformation in a way that is secure, inclusive, and sustainable.

Keywords: Artificial Intelligence; Romanian business; digital transformation; AI governance; ethical AI.

JEL Classification: L86; M15; O33.

1. INTRODUCTION

Artificial Intelligence (AI) has emerged as a cornerstone of global economic and technological progress. As AI systems increasingly permeate sectors such as healthcare, manufacturing, finance, and logistics, they bring with them promises of efficiency, productivity, and transformative innovation (Brynjolfsson and McAfee, 2017; Russell and Norvig, 2021). In the European context, AI is recognized as a critical driver of competitiveness and sustainable development, with initiatives like the European Commission's Coordinated Plan on AI (2021) aiming to strengthen AI capabilities across member states.

In Romania, however, the path toward AI integration is more complex. Despite being home to a robust IT workforce and a growing ecosystem of tech start-ups, Romania ranks consistently low on the Digital Economy and Society Index (DESI), particularly in categories related to digital public services, the use of internet services, and human capital (European Commission, 2023). These deficits reflect deep-rooted structural, infrastructural, and educational challenges that constrain the country's ability to adopt AI at scale.

The Romanian business environment – especially among small and medium-sized enterprises (SMEs), which comprise over 99% of the business sector (INSSE, 2022) – faces several obstacles in harnessing AI, including inadequate infrastructure, limited AI expertise, insufficient digital skills, and a lack of alignment with evolving regulatory frameworks. Although larger firms in banking, telecommunications, and retail have started leveraging AI tools for tasks such as fraud detection, customer service automation, and supply chain optimization (PwC Romania, 2021), these examples remain the exception rather than the norm.

The concept of “safe AI use” encompasses more than just minimizing technological risks. It also includes ensuring compliance with ethical standards, legal obligations – such as the General Data Protection Regulation (GDPR) – and the forthcoming EU Artificial Intelligence Act (European Commission, 2021), while also promoting public trust and transparency (Floridi *et al.*, 2018; Mittelstadt, 2019).

Thus, this study seeks to explore how Romania can achieve safe, inclusive, and effective AI adoption. The central research questions include:

- What are the structural and organizational barriers to safe AI adoption in Romanian businesses?
- How can Romania align its AI strategies with EU ethical and legal frameworks?
- What role should education and public policy play in fostering AI-readiness?
- How can AI be used to reduce rather than widen the digital and economic divide in Romanian society?

By addressing these questions, this article contributes to the growing body of scholarship on responsible AI implementation in emerging economies and offers policy and business recommendations tailored to Romania's unique socio-economic context.

2. METHODOLOGY

To investigate the safe use of AI in Romanian business, this study adopts a qualitative, exploratory research design, grounded in a multidisciplinary review of literature, policy documents, and case studies. The methodology involves the following components:

1. Literature Review. The theoretical foundation of this study is based on existing literature concerning AI ethics, digital transformation, and innovation in emerging economies. Sources include peer-reviewed journals, policy reports from the European Commission, and technical guidelines from standards bodies such as the OECD and UNESCO. The literature review enables the identification of key variables such as “digital readiness,” “ethical AI,” and “regulatory compliance” (Jobin *et al.*, 2019; OECD, 2020).

2. Policy and Regulatory Analysis. A critical analysis of European and national legislation – such as the GDPR, the EU AI Act proposal, and Romania's National Digital Strategy – is conducted to understand the legal context in which AI technologies must operate. This ensures that the article aligns its recommendations with existing and forthcoming regulatory structures (European Parliament and Council, 2016; Romanian Government, 2022).

3. Case Study Sampling. The study draws on illustrative case studies from Romanian enterprises (both SMEs and large firms) that have begun implementing AI technologies. These cases are selected based on accessibility and relevance and aim to highlight both successful practices and encountered challenges. Sources include industry white papers, interviews, and secondary data from consulting firms like Deloitte, KPMG, and PwC.

4. Stakeholder Perspective. The views of business leaders, educators, policymakers, and IT professionals are integrated through a secondary analysis of interviews and surveys published in Romanian digital transformation studies (Digital Nation, 2022; ANIS, 2023). This enriches the analysis with context-specific insights on perceived risks, organizational culture, and readiness levels.

5. Framework Development. Based on the above data, the study proposes a multi-dimensional framework for the safe use of AI, integrating organizational, regulatory, ethical, and educational components. This framework is evaluated in light of international best practices and adapted to Romania's socio-economic realities.

By triangulating across these data sources and analytical methods, the study ensures a comprehensive understanding of Romania's AI landscape and the mechanisms through which AI can be safely and effectively adopted.

3. CONTEXT AND CHALLENGES IN THE ROMANIAN BUSINESS LANDSCAPE

Romania's trajectory toward digital transformation and AI integration reflects a paradoxical landscape – one characterized by both high potential and significant systemic obstacles. On one hand, Romania boasts one of the highest percentages of ICT graduates in the EU and a thriving tech services sector, concentrated in urban hubs like Cluj-Napoca, Bucharest, and Timișoara (Eurostat, 2022). On the other hand, the broader business ecosystem, especially SMEs, remains digitally underdeveloped, with a low rate of technology adoption, limited innovation capabilities, and persistent regional disparities (European Commission, 2023).

One of the foundational challenges facing Romanian businesses is the uneven distribution of digital infrastructure. While urban areas enjoy relatively robust internet penetration and access to cloud services, rural regions still struggle with connectivity and basic digital services (European Commission, 2023). According to the Romanian Digital Transformation Strategy (Romanian Government, 2022), fewer than 40% of SMEs have adopted cloud computing, big data, or AI solutions. The lack of enterprise resource planning (ERP) systems and integrated platforms limits the ability of companies to process large datasets, a prerequisite for effective AI use (World Bank, 2020).

This infrastructure gap significantly constrains the development of intelligent automation or data-driven business strategies. Without the technological backbone required to support AI systems – such as cloud computing, secure data storage, and reliable networks – AI remains inaccessible to a large portion of the Romanian business community.

Despite a strong output of STEM graduates, Romania faces a critical mismatch between academic training and labour market needs, especially in AI-specific domains like data science, machine learning engineering, and AI ethics (Bălan, 2021; Petre *et al.*, 2022). The National Authority for Qualifications (ANC) notes that while programming and basic IT skills are widespread among young professionals, competencies in AI architecture, algorithm design, and data governance are scarce.

Furthermore, digital illiteracy remains high among the general population. According to Eurostat (2023), only 28% of Romanians possess above-basic digital skills – well below the EU average. This deficiency extends to management levels: business leaders often lack a strategic understanding of digital technologies, impeding informed decision-making regarding AI investments (PwC Romania, 2021).

The integration of AI must be situated within a framework that ensures compliance with European regulatory standards. The GDPR mandates data privacy and informed consent, while the proposed Artificial Intelligence Act introduces tiered risk classifications for AI systems and enforces stringent

obligations for high-risk applications (European Commission, 2021; Veale and Borgesius, 2021).

However, Romanian businesses – especially SMEs – are frequently unprepared for these legal expectations. A survey by ANIS (2023) revealed that over 60% of companies implementing AI had not conducted a Data Protection Impact Assessment (DPIA), a key requirement for GDPR compliance. Similarly, few firms have internal structures to evaluate algorithmic fairness, explainability, or the social impact of their AI models (Floridi and Cowls, 2019).

Beyond material constraints, the safe use of AI is often hindered by cultural factors and organizational inertia. Many Romanian firms operate within rigid hierarchies and risk-averse mindsets, discouraging experimentation and innovation. Resistance to change, particularly in family-run or traditionally managed businesses, can stall digital initiatives before they begin (Mihăilescu, 2020).

Moreover, AI projects typically require cross-functional collaboration between IT, operations, legal, and human resources teams – an organizational structure that many Romanian firms lack. In environments where siloed departments and outdated workflows dominate, the holistic integration of AI technologies becomes difficult, if not impossible.

Unlike other EU member states that have articulated comprehensive national AI strategies – such as Finland, France, and Germany – Romania’s approach has been fragmented and reactive. While the Romanian National Recovery and Resilience Plan (NRRP) includes funding for digital education and business support, there is still no unified national AI roadmap that defines long-term goals, ethical guidelines, investment incentives, or sector-specific priorities (Romanian Government, 2022).

As a result, Romanian businesses face uncertainty regarding government support for AI, leading to inconsistent adoption across sectors. The absence of AI sandboxes, innovation hubs, and dedicated funding channels further limits Romania’s ability to scale pilot projects into commercially viable solutions.

4. SCHOOL: THE KEY FACTOR IN DIGITAL EDUCATION AND AI

The safe and effective adoption of Artificial Intelligence (AI) in Romania hinges not only on the readiness of businesses and regulatory frameworks but also on the preparedness of future generations to engage with these technologies. The educational system plays a pivotal role in shaping the digital skills, ethical considerations, and AI literacy of the workforce, especially at the primary and secondary school levels. The transition towards an AI-driven economy requires the cultivation of a digitally proficient and ethically informed population from a young age (OECD, 2020).

Romania’s educational system faces significant challenges when it comes to supporting the country’s digital transformation. These challenges range from

outdated curricula to insufficient teacher training, limited access to modern digital infrastructure, and a lack of alignment between educational outputs and industry requirements (Bălan, 2021). Nonetheless, schools remain the foundation upon which Romania's AI future will be built. Ensuring that students are equipped with the skills needed to thrive in an AI-driven world must therefore become a national priority.

One of the most glaring barriers to digital education in Romania is the significant regional disparity in access to educational technology. Rural schools are especially underserved, lacking essential tools such as computers, internet connectivity, and smartboards, which hinders students' exposure to even basic digital tools, let alone advanced AI technologies (European Commission, 2023). The Digital Economy and Society Index (DESI) report from the European Commission (2023) points out that while urban areas may have access to high-speed internet and modern learning resources, rural areas are at risk of being left behind in the digital education race.

Moreover, the existing digital curriculum in Romanian schools is outdated and fails to equip students with the competencies required for a rapidly evolving technological landscape. While the inclusion of coding and computer science has been increasingly emphasized, these subjects remain peripheral in many school curricula, often limited to a few hours per week or to specific specialized schools (Petre *et al.*, 2022). As a result, while some students may gain basic digital literacy, they are not exposed to the critical thinking, problem-solving, and ethical reasoning skills necessary for understanding the broader societal impact of AI.

The role of teachers in promoting digital literacy and AI understanding cannot be overstated. However, many Romanian educators still lack the necessary knowledge and skills to teach modern digital subjects, including AI (Benta *et al.*, 2021). Teacher professional development programs focused on AI, machine learning, and data ethics are sorely lacking, and there is a need for training that goes beyond the basics of technology use. Teachers must be empowered not only to use digital tools in the classroom but also to teach students how AI works, the ethical dilemmas it presents, and how it impacts various industries and society at large.

The European Commission (2023) emphasizes the importance of comprehensive teacher training programs that integrate digital literacy and AI as part of the core curriculum. In Romania, initiatives like the "Smart Lab" program have sought to equip educators with digital teaching tools, but such initiatives need to be scaled and supported through sustainable funding and government backing. Additionally, creating a network of AI educators and fostering collaboration among schools, universities, and tech companies could significantly improve the capacity of educators to teach these complex subjects.

Curriculum reform is essential for preparing Romania's students for a future dominated by AI technologies. Schools must offer not only technical skills but

also integrate interdisciplinary approaches that connect AI to real-world applications in fields like healthcare, business, agriculture, and social sciences. For instance, coding, algorithmic thinking, and data science should be introduced early in the curriculum, with progression toward more specialized AI topics at the secondary and tertiary levels.

Research suggests that AI education should not be confined to the sciences alone; instead, it should be incorporated into subjects like philosophy, social studies, and ethics to promote a more holistic understanding of AI's societal impact (Floridi and Cows, 2019). Introducing AI ethics, algorithmic bias, and data privacy at the school level is crucial for fostering responsible AI use among future professionals and citizens.

The introduction of AI literacy into the curriculum should be supported by government policies that ensure equitable access to technology across all schools, especially in disadvantaged rural and urban areas (Romanian Government, 2022). The National Recovery and Resilience Plan (NRRP), which includes provisions for digital education, presents a unique opportunity to modernize Romania's educational infrastructure and integrate digital competencies into the curriculum across all grade levels. However, the success of this initiative depends on consistent implementation and monitoring, as well as collaboration between the Ministry of Education, technology providers, and local authorities.

An effective approach to AI education involves collaboration between educational institutions, the private sector, and government bodies. Public-private partnerships (PPP) can bridge the gap between educational outcomes and industry needs, ensuring that students are prepared for careers in AI and other digital sectors.

Private companies in Romania, especially in the tech sector, can play an important role in providing resources such as internships, mentorship programs, guest lectures, and AI learning materials. Companies like Endava, UiPath, and Bitdefender are already engaged in educational initiatives, offering training and support to help students understand AI's real-world applications (Cârstea, 2022). These partnerships can also foster innovation hubs where students and teachers collaborate with industry experts on AI projects, thereby gaining hands-on experience that directly translates into workplace competencies.

Furthermore, universities and research institutions must be involved in curriculum development, ensuring that the courses offered are not only scientifically rigorous but also aligned with the ethical and social implications of AI technologies. Such collaborations between academia and industry will create an ecosystem where the skills taught in schools are aligned with future job market demands.

While preparing students for careers in AI is important, fostering AI literacy at all levels of society is equally crucial. AI is not just for technologists – its impact extends to everyday life, from automated healthcare tools to personalized

shopping experiences. Ensuring that Romanian citizens understand how AI works and how it impacts their lives is key to maintaining an informed, empowered public that can engage with and shape AI technologies responsibly (OECD, 2020).

Public awareness campaigns, community engagement programs, and lifelong learning opportunities can help adults and older generations acquire the necessary digital competencies to interact with AI systems safely and effectively. These efforts must be coordinated with educational initiatives to ensure that digital literacy is not restricted to youth but is embraced by the wider population, thus fostering an AI-savvy society.

5. TOMORROW'S AI NEEDS: BASIC DIGITAL SKILLS FROM THE PRIMARY SCHOOL PUPIL

The future of Artificial Intelligence (AI) relies not only on the integration of advanced technologies in various industries but also on the ability of the future workforce to interact with these technologies effectively. As AI becomes an increasingly ubiquitous part of daily life, it is essential that the foundations for a digitally literate society be laid at an early age. In Romania, this means equipping primary school pupils with the basic digital skills necessary to thrive in an AI-driven world. This approach is not just about teaching students how to use computers; it is about fostering the critical thinking, problem-solving, and ethical understanding that will be essential as they grow into the AI-savvy professionals of tomorrow (OECD, 2020).

The skills required for engaging with AI are no longer limited to those involved in computer science or engineering fields. They are becoming universal competencies that all students will need to master, irrespective of their future career paths. AI technologies are embedded in nearly every aspect of modern life – from social media algorithms to personalized healthcare recommendations, smart devices, and even transportation systems (OECD, 2020). As such, the importance of providing foundational digital skills to children in primary school cannot be overstated.

At its core, basic digital literacy includes understanding how technology works, how to use digital tools safely, and developing early computational thinking. However, the future workforce will also need to be equipped with deeper knowledge about how AI systems operate, how data is processed, and how algorithms make decisions. These competencies, while advanced, can be introduced gradually starting from the earliest stages of education. The European Commission (2023) acknowledges the need for early AI education, advocating for the introduction of digital and computational thinking skills from primary education onwards.

Romania has made some progress in advancing digital education at the primary school level, but there are still significant gaps that need to be addressed. According to the European Commission's Digital Economy and Society Index

(DESI) 2023, only a small proportion of Romanian primary schools offer structured and systematic digital competence training. Access to digital tools and devices remains inconsistent, especially in rural areas, where schools often lack adequate infrastructure (European Commission, 2023). As a result, many Romanian students still graduate from primary school without having developed the foundational digital skills needed to succeed in an AI-driven world.

Moreover, there is a significant disparity between urban and rural schools when it comes to access to technology. While larger cities such as Bucharest and Cluj-Napoca have well-equipped schools with high-speed internet and modern computer labs, rural areas are still struggling with outdated equipment and slow internet connections. This digital divide exacerbates inequalities in education and prevents many children from accessing even basic digital training. The Romanian government has recognized these challenges, but ensuring equal access to digital education across all regions of the country remains a work in progress (Romanian Government, 2022).

Primary schools are in a unique position to help children develop early digital competencies, laying the foundation for more advanced AI education later in their academic journey. Introducing digital skills at the primary school level helps ensure that all children, regardless of their socioeconomic background or geographic location, have equal opportunities to engage with technology and gain digital fluency. It also serves to demystify technology and foster curiosity, creativity, and problem-solving skills that will be essential as AI becomes a more integral part of their lives (OECD, 2020).

At the heart of AI education in primary schools should be computational thinking, which involves understanding how to break down complex problems into smaller, more manageable parts, identify patterns, and create step-by-step solutions. This skill is fundamental not only for understanding how AI systems function but also for approaching problems logically and systematically – skills that are transferable across many disciplines.

In addition to computational thinking, students should also be introduced to the basics of data literacy. For instance, they can learn how data is collected, processed, and used to make decisions. They can be introduced to concepts such as data visualization, interpretation, and basic statistics. Exposure to these topics at a young age can help build a deeper understanding of how AI systems make predictions and decisions based on data, which is crucial in a world where data-driven technologies are pervasive.

Implementing a robust AI curriculum in primary schools presents several challenges. First, there is the issue of teacher training. Many primary school teachers in Romania lack the necessary skills and confidence to teach digital subjects, particularly AI-related content. While there have been some initiatives to address this, such as the “Smart Lab” program, which provides training and digital resources for educators (Benta *et al.*, 2021), teacher preparedness remains

a significant bottleneck. Professional development programs must be expanded and include content related to AI, machine learning, and data ethics to ensure that teachers are equipped to foster digital literacy among their students.

Second, there is the challenge of infrastructure. Ensuring that all schools – particularly those in rural areas – have access to the necessary digital tools and reliable internet is critical for enabling widespread AI education. While initiatives like the National Recovery and Resilience Plan (NRRP) aim to improve digital infrastructure, the success of these efforts will depend on effective implementation and equitable distribution of resources (Romanian Government, 2022). Ensuring that all primary schools have access to the necessary tools for teaching digital and AI-related skills is an essential step in closing the digital divide.

The curriculum for primary schools should be designed in such a way that it gradually introduces children to the key concepts of AI and digital literacy, while also fostering a broader understanding of how technology impacts society. The integration of AI literacy into the national curriculum is essential for preparing Romanian students for the future. This would involve including content on the ethical implications of AI, such as bias, fairness, and transparency, as well as teaching students about the potential risks and benefits of these technologies.

Curriculum development should be guided by interdisciplinary principles, combining elements from mathematics, science, technology, and social studies. For example, lessons could teach students about the fundamentals of coding, but also encourage them to think critically about how algorithms might affect decision-making processes in areas such as healthcare, finance, and governance. By combining technical knowledge with ethical reasoning, primary school education can help create a generation of students who not only understand how AI works but also how to use it responsibly.

While schools play a central role in AI education, parents and the broader community also have a significant role to play. Parents can support their children's digital education by providing access to digital tools at home, encouraging safe internet use, and fostering curiosity about how technology works. Community-based initiatives, such as after-school programs, workshops, and online resources, can also help reinforce the skills taught in school and provide additional opportunities for children to engage with AI in a hands-on way.

Additionally, governments and technology providers should work together to ensure that educational resources – such as interactive AI learning platforms, coding tutorials, and digital games – are widely available to both students and teachers. Public-private partnerships can also play a vital role in making AI education more accessible and engaging, particularly in under-resourced areas.

6. AI GOVERNANCE AND ETHICAL CONSIDERATIONS IN ROMANIAN BUSINESSES

As Artificial Intelligence (AI) continues to evolve, so too does the need for a robust governance framework that ensures the responsible, ethical, and transparent deployment of these technologies in Romania's business landscape. In line with the global shift toward AI regulation, Romanian businesses must recognize the importance of AI governance, encompassing legal, ethical, and social considerations, while also addressing technical aspects. This section explores the necessary steps for establishing effective AI governance in Romania's business environment.

One of the key aspects of AI governance is ensuring compliance with local, regional, and international regulations. The General Data Protection Regulation (GDPR), adopted by the European Union, has become a cornerstone for data privacy in AI systems. It imposes strict guidelines for how companies handle personal data, especially when it is processed by AI algorithms. For Romanian businesses, particularly small and medium-sized enterprises (SMEs) who are often less aware of compliance requirements, aligning AI initiatives with GDPR is a critical first step toward ethical AI deployment (European Parliament and Council, 2016).

Furthermore, the EU Artificial Intelligence Act (2021) is set to become the world's first comprehensive AI regulatory framework. This regulation aims to classify AI systems based on their risk level, with stricter regulations for high-risk applications. Romanian businesses must familiarize themselves with the provisions of this Act to ensure that their AI solutions meet the required standards of transparency, safety, and accountability (European Commission, 2021).

For businesses that adopt AI for high-risk applications, such as autonomous vehicles or AI-driven healthcare solutions, compliance with both GDPR and the AI Act is not merely a matter of legal necessity – it is essential for ensuring the trustworthiness of their systems and the safety of end-users. As AI continues to impact more sectors, the pressure on Romanian businesses to align with regulatory requirements will only grow.

AI systems must be developed and deployed in ways that promote fairness, inclusivity, and accountability. One of the greatest challenges facing AI in Romania – and globally – is the issue of algorithmic bias. AI algorithms are trained on data, and if that data contains inherent biases, the resulting AI models can perpetuate or even amplify these biases. This is particularly concerning in high-stakes areas such as hiring, credit scoring, and law enforcement (Binns, 2018).

Romanian businesses must adopt practices that ensure their AI systems are fair and transparent. This includes conducting regular audits of AI algorithms to identify and mitigate any biases present in training datasets. Moreover, it is crucial for businesses to provide clear and accessible explanations of how AI models

make decisions, particularly when these decisions affect individuals' lives. In this regard, AI explainability is a core ethical principle, and companies that can make their AI processes transparent will not only comply with regulations but also build public trust in their systems.

Developing ethical AI also requires that Romanian businesses take proactive steps to safeguard data privacy, ensure accountability, and foster responsible AI usage. Ethical AI guidelines should be integrated into business practices and decision-making processes, ensuring that companies not only avoid harm but also strive to create AI solutions that benefit society as a whole.

A central feature of effective AI governance is the establishment of robust governance structures within businesses. AI governance committees should be set up to oversee AI projects, ensuring that they adhere to legal, ethical, and regulatory standards. These committees should include a diverse range of stakeholders, including legal, technical, and ethical experts, as well as representatives from the business leadership team.

In Romania, fostering public-private partnerships is essential for building transparent and trustworthy AI systems. These partnerships can take the form of collaborations between businesses, governmental bodies, academic institutions, and civil society organizations. By engaging a wide range of stakeholders in AI development, Romanian companies can ensure that their AI solutions are not only effective but also socially responsible and ethically sound (Floridi and Cowls, 2019).

Moreover, businesses should be transparent about their AI practices, actively engaging with customers, regulators, and the public to communicate how their AI systems work, how data is handled, and what measures are taken to prevent harm. Public engagement helps build trust and ensures that AI adoption occurs in a manner that reflects societal values and expectations.

Small and medium-sized enterprises (SMEs) in Romania represent a significant portion of the national economy but often face challenges in adopting AI due to limited resources and expertise. To promote responsible AI use, Romanian SMEs must be provided with educational resources, training programs, and access to AI tools that help them implement AI systems responsibly. This is particularly important for sectors where AI adoption is still in its infancy, such as agriculture, manufacturing, and local retail.

Government programs, private-sector collaborations, and EU-funded initiatives can help SMEs overcome barriers to AI adoption. AI literacy programs targeting business owners, managers, and employees can help build foundational knowledge of AI technologies, enabling SMEs to make informed decisions and adopt AI responsibly. Additionally, establishing clear AI guidelines for SMEs will help ensure that they prioritize ethical considerations and comply with legal requirements, even as they innovate and adopt new technologies.

As AI systems become more integrated into Romanian businesses, the potential risks associated with their use – such as cybersecurity threats, data breaches, and system failures – must be carefully managed. Businesses need to adopt comprehensive cybersecurity measures to protect both their AI systems and the sensitive data they handle. AI solutions can be vulnerable to attacks, including adversarial attacks where small modifications to input data can lead to erroneous outputs (Grosse *et al.*, 2017). Romanian businesses must therefore invest in securing their AI infrastructure and ensuring that their systems are resilient against both external and internal threats.

Additionally, AI systems must be robust and capable of handling unexpected scenarios without causing harm. This requires ongoing testing, validation, and monitoring of AI models, particularly in high-risk environments. For Romanian businesses, investing in AI resilience is crucial for mitigating the long-term risks associated with the deployment of intelligent systems.

7. DIGITAL SKILLS AND WORKFORCE UPSKILLING FOR AI ADOPTION IN ROMANIA

The successful integration of Artificial Intelligence (AI) into Romanian businesses hinges not only on technological infrastructure and governance frameworks but also on the ability of the workforce to engage with and harness these technologies effectively. A critical barrier to AI adoption in Romania is the skills gap – the disparity between the current workforce capabilities and the skills needed to support AI development and implementation. This section discusses the necessity of workforce upskilling and how Romanian businesses can foster a culture of continuous learning to enable AI adoption at scale.

Romania has made significant strides in increasing digital connectivity and the number of skilled IT professionals, yet there remains a pronounced digital skills gap. According to the European Commission's Digital Economy and Society Index (DESI), Romania consistently ranks among the lower tiers in terms of digital skills, with many employees still lacking the necessary competencies to navigate advanced technologies such as AI (European Commission, 2023).

In Romania, the most significant skills gap is found in technical roles related to AI development, such as data scientists, machine learning engineers, and AI architects. This shortage is exacerbated by a mismatch between the skills imparted by the education system and the evolving demands of the tech industry. Moreover, there is also a gap in managerial and operational roles, where decision-makers need to understand the strategic implications of AI, data governance, and ethical concerns.

To bridge this gap, Romania's businesses must prioritize workforce development and partner with educational institutions to ensure that employees possess the skills necessary for both AI implementation and governance. Continuous professional development initiatives, including reskilling programs

for existing employees and upskilling initiatives for young professionals, will be pivotal for ensuring that the Romanian workforce is future-ready.

Building a digitally competent workforce in Romania requires collaboration between the public and private sectors, as well as educational institutions. The National Recovery and Resilience Plan (NRRP), a governmental initiative aimed at modernizing Romania's economy, includes provisions for boosting digital skills at all levels (Romanian Government, 2022). However, to create a sustainable AI workforce, this plan must go beyond basic skills training and focus on advanced AI competencies that meet the needs of both small businesses and large corporations.

Private companies, particularly tech giants and AI start-ups, can also play a critical role by partnering with universities and vocational training centers to offer AI-focused internships, research programs, and practical training opportunities. These collaborations ensure that students gain exposure to real-world AI applications and have a deeper understanding of how AI systems are deployed in business settings. Similarly, companies should foster a culture of continuous learning within their organizations by supporting employees' participation in AI certification programs and other relevant training courses.

While advanced AI skills are essential for a select group of technical professionals, there is an equally important need to promote digital literacy across all sectors of the workforce. Every employee, regardless of their role, should be equipped with foundational digital skills that enable them to interact with AI systems, understand the ethical implications of these technologies, and navigate the opportunities and risks they bring.

Romanian businesses must invest in digital literacy programs that focus on the core competencies needed to work in an increasingly digital economy. This includes understanding data privacy, recognizing algorithmic biases, and using AI-powered tools to improve productivity and decision-making. Human resources departments must also be proactive in training staff to use AI applications ethically and effectively, ensuring that all employees – whether in marketing, customer service, or operations – are empowered to leverage AI in a responsible manner.

One of the challenges facing Romania in its journey toward AI adoption is the digital divide between urban and rural areas. While cities like Bucharest, Cluj-Napoca, and Iași boast strong IT ecosystems, rural areas still face significant challenges in terms of digital infrastructure and access to quality education (European Commission, 2023). This geographic inequality further limits the ability of many individuals to acquire the digital skills necessary to thrive in a technologically advanced society.

The Romanian government, along with private sector actors, must focus on ensuring that digital upskilling efforts are inclusive and reach all regions of the country. This includes expanding internet access, improving the availability of digital devices in rural schools, and offering localized training programs that cater

to the needs of rural populations. Furthermore, mobile learning platforms and remote education initiatives can help bridge the geographical divide, ensuring that digital skills are accessible to everyone, regardless of their location.

AI itself can play a pivotal role in improving digital skills development. AI-powered educational platforms can personalize learning experiences, identify gaps in knowledge, and provide targeted feedback to students. For example, AI-driven tools can tailor educational content to suit individual learning speeds and preferences, improving engagement and outcomes. In Romania, educational institutions should explore the potential of AI to create smart classrooms, where AI assists both teachers and students in optimizing the learning process.

Moreover, AI can also be used to assess and improve the effectiveness of training programs. By analysing data on learning behaviours and performance, AI can provide insights into which training methods are most effective, helping businesses refine their upskilling initiatives over time.

8. AI APPLICATIONS IN KEY SECTORS OF THE ROMANIAN ECONOMY

AI is not a one-size-fits-all technology – it can be applied across a variety of sectors, each with its own set of challenges and opportunities. In this section, we explore the potential of AI in some of Romania's key economic sectors, including agriculture, manufacturing, healthcare, and retail.

Romania's agricultural sector is still heavily reliant on traditional farming methods. However, AI has the potential to revolutionize this sector by improving efficiency, reducing waste, and enhancing sustainability. Precision farming, driven by AI, involves using sensors, drones, and satellite imagery to monitor crop health, optimize irrigation, and predict harvests. Romanian farmers can leverage AI-powered tools to make data-driven decisions that increase yields while minimizing environmental impact.

For small and medium-sized farms in Romania, AI-powered platforms can offer affordable access to cutting-edge technologies, making it easier to adopt smart farming practices. Additionally, AI can help optimize supply chain management, reducing food waste and improving the distribution of products from farms to consumers. Manufacturing is a cornerstone of Romania's economy, with key industries such as automotive, textiles, and electronics driving exports. AI has the potential to enhance operational efficiency, improve product quality, and streamline production processes. Predictive maintenance, powered by AI, can reduce downtime by identifying equipment malfunctions before they occur. Moreover, AI can optimize supply chains, predict demand more accurately, and reduce energy consumption in manufacturing processes. By implementing AI-driven automation, Romanian manufacturers can increase competitiveness and reduce costs, helping them to maintain a strong position in the European and global markets.

In the healthcare sector, AI can enhance diagnostic accuracy, personalize treatment plans, and improve patient care. AI-powered medical imaging tools, for example, can analyse radiographs, MRIs, and CT scans to identify early signs of diseases like cancer. Moreover, AI can help healthcare providers predict patient outcomes, optimize resource allocation, and streamline administrative tasks, allowing medical professionals to focus on patient care. Romania's healthcare system faces challenges related to underfunding and a shortage of medical professionals. AI adoption can help alleviate some of these challenges by improving operational efficiency and enabling healthcare providers to deliver better care despite resource limitations.

Romania's retail sector has seen rapid digital transformation in recent years, with many businesses adopting e-commerce and AI-driven customer service tools. AI can enhance customer experiences by providing personalized recommendations, automating customer support through chatbots, and optimizing inventory management. As Romanian businesses continue to embrace AI in retail, the key to success lies in using AI to improve customer engagement, streamline operations, and offer personalized shopping experiences that enhance consumer loyalty.

9. CONCLUSIONS

Romania stands at the crossroads of a digital revolution, with AI adoption offering significant opportunities for businesses to enhance productivity, efficiency, and innovation. However, for AI to be integrated successfully, it is essential to prioritize the development of a digitally skilled workforce, establish effective governance frameworks, and ensure that ethical principles guide the adoption of these technologies. By fostering a culture of innovation and responsibility, Romanian businesses can unlock the full potential of AI and position themselves as leaders in the European digital economy.

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THE USE OF MULE WALLETS AND FAKE CRYPTO EXCHANGES BY CRIMINALS

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Abstract

The rapid proliferation of mule wallets and fake cryptocurrency exchanges has emerged as a significant threat to investors and the broader digital asset ecosystem. This study investigates the warning signs associated with fraudulent platforms and mule account networks by employing a mixed-methods approach that integrates blockchain data analytics, user survey responses, and forensic transaction tracing. Quantitative analysis of over 10,000 wallet transactions spanning major blockchain networks reveals distinct behavioral patterns, such as abnormal fund flows, rapid account creation, and disproportionate withdrawal rates, which serve as reliable indicators of illicit activities. Complementary qualitative insights from a survey of 250 cryptocurrency traders underscore the psychological and informational factors that render investors vulnerable to such schemes, including overconfidence bias, lack of due diligence, and susceptibility to social engineering tactics. The findings demonstrate that a combined metric of on-chain anomalies and user-reported experiences can achieve above 90% accuracy in predicting fraudulent platforms. Consequently, we propose a set of investor protection strategies, encompassing pre-trade risk assessments, enhanced know-your-customer (KYC) protocols, and real-time monitoring tools, to mitigate exposure to mule wallet networks and counterfeit exchanges. Policy implications for regulators and recommendations for best practices in crypto forensics are discussed, highlighting the need for collaborative frameworks between law enforcement, blockchain analytics firms, and financial institutions to safeguard the integrity of digital markets.

Keywords: *mule wallets; fake cryptocurrency exchanges; money laundering; mixing services; crypto regulation.*

JEL Classification: E42; G28; K42; O33; D82.

1. INTRODUCTION

The rise of cryptocurrencies has revolutionized financial transactions, offering users enhanced security, lower transaction fees, and increased accessibility. However, these advantages have also paved the way for illicit financial activities, including money laundering, fraud, and illicit financing. Criminals leverage the lack of regulation and the difficulty in tracking crypto transactions to conduct unlawful activities. Two primary tools used in such

activities are mule wallets, which facilitate untraceable fund transfers, and fake cryptocurrency exchanges, which serve as platforms for scams and financial fraud (Nakamoto, 2008).

The growing global economic significance of cryptocurrencies demands careful consideration of their risks, especially regarding crime. Cryptocurrencies have created unprecedented financial accessibility, but the lack of comprehensive global regulation has enabled extensive exploitation by criminals. International financial institutions and governments face the challenge of balancing the advantages of crypto-assets with the necessity of safeguarding the global financial system from illicit use (IMF, 2022).

In the future, closer international collaboration and harmonization of regulatory frameworks are essential. Regulators should prioritize creating standardized global procedures to quickly adapt and respond to new criminal methods. Blockchain companies must innovate continuously, developing more sophisticated forensic tools to stay ahead of criminals' evolving tactics (IMF, 2022).

2. UNDERSTANDING MULE WALLETS

Mule wallets function as intermediaries in illicit financial transactions, obscuring the origins and destinations of funds. Criminals recruit individuals, either knowingly or unknowingly – to create and operate these wallets, moving illicit funds through multiple accounts to launder money effectively.

Recruitment of money mules often involves sophisticated social engineering techniques that exploit financial hardship, lack of digital literacy, or emotional vulnerability. Mules may unknowingly engage in criminal activities through remote job offers or seemingly legitimate transactions. Combatting mule wallet operations requires educational initiatives targeting vulnerable populations, alongside strengthened financial transaction monitoring.

2.1. Methods of operation

- **Layering Transactions:** Funds are transferred through multiple wallets to break the chain of custody.
- **Use of Decentralized Platforms:** Transactions are often conducted through decentralized finance (DeFi) platforms to avoid scrutiny.
- **Employment of Mixing Services:** Mixing services (tumblers) blend illicit funds with legitimate ones, making it difficult to trace their origins.

2.2. Case studies

- **BitClub Network Scam (2019):** Operators used mule wallets to launder proceeds from a fraudulent mining scheme.
- **Twitter Bitcoin Scam (2020):** Cybercriminals used mule wallets to distribute funds collected from phishing attacks.

3. FAKE CRYPTOCURRENCY EXCHANGES

Fake cryptocurrency exchanges operate as fraudulent platforms designed to steal funds from unsuspecting investors. These exchanges typically lure victims with promises of high returns, minimal transaction fees, and exclusive trading opportunities.

Fake cryptocurrency exchanges are evolving rapidly, using increasingly advanced technological methods, such as fake mobile applications, spoofed emails, and cloned social media accounts. Additionally, cybercriminals leverage emotional triggers, including fear of missing out (FOMO), to manipulate potential victims. Greater awareness campaigns and tighter enforcement against unauthorized financial platforms are critical to mitigating these threats.

3.1. Key characteristics

- **Unrealistic Promises:** Offers that seem too good to be true, such as guaranteed profits.
- **Lack of Transparency:** No regulatory compliance or verifiable team members.
- **Withdrawal Restrictions:** Users are unable to withdraw their funds after deposits.

3.2. Notable cases

- **PlusToken Scam (2019):** A Ponzi scheme disguised as a legitimate exchange defrauded investors of over \$2 billion (U.S. Department of Justice, 2021).
- **Thodex Exchange Fraud (2021):** A Turkish exchange defrauded thousands of users before its CEO fled the country.

4. REGULATORY RESPONSES AND COUNTERMEASURES

Governments and regulatory bodies have implemented various measures to combat these illicit activities:

4.1. Legislative efforts (Basel Committee on Banking Supervision, 2021) (Congressional Research Service, 2022)

- **Financial Action Task Force (FATF) Guidelines:** Implementation of the "Travel Rule" for crypto exchanges.
- **EU's Markets in Crypto-Assets (MiCA) Regulation:** Stricter compliance requirements for virtual asset service providers.

4.2. Technological solutions

- **Blockchain Analytics Tools:** Companies like Chainalysis and CipherTrace track illicit transactions (Chainalysis, 2023; CipherTrace, 2022).

- Artificial Intelligence (AI) and Machine Learning: Detecting fraudulent wallet activities through predictive analysis.

In addition to existing regulatory frameworks such as FATF's Travel Rule and MiCA, other jurisdictions like the United States, Japan, and Singapore have adopted tailored regulatory approaches. Collaborative international regulatory frameworks, enhanced sharing of intelligence between national law enforcement agencies, and coordinated action through institutions like Interpol and Europol can significantly bolster global response capabilities (FATF, 2019; Europol, 2021; FATF, 2022; Interpol, 2022; European Commission, 2023).

5. BLOCKCHAIN FORENSICS

Blockchain forensics constitutes an emerging field within digital forensics, focusing on the investigation of activities conducted on blockchain networks. This field involves the systematic examination of blockchain data to uncover evidence of illegal activities, such as fraud, money laundering, and cybercrimes, which are increasingly facilitated through cryptocurrencies and decentralized platforms. The unique characteristics of blockchain technology, particularly the decentralized and pseudo-anonymous nature of transactions, present complex challenges for investigators, necessitating the use of specialized tools and techniques to correlate on-chain data with off-chain information. Nevertheless, forensic investigators leverage the core features of blockchain – transparency, immutability, and decentralization – to aid in investigations. Blockchain-based forensic frameworks are being developed to enhance the integrity, traceability, and transparency of the investigative process. As the use of blockchain technology expands across various sectors, the need for specialized forensic methods that allow for tracing, analyzing, and securing digital evidence grows, thereby ensuring its reliability (Atlam *et al.*, 2024).

6. NUMERICAL DATA ON REPORTED CRYPTO SCAMS

According to a report published by the FBI's Internet Crime Complaint Center (IC3), there has been a significant increase in the scope of fraud related to cryptocurrencies (Table 1) (Federal Bureau of Investigation, 2022; Federal Bureau of Investigation, 2023; Federal Bureau of Investigation, 2024).

- Total losses: In 2023, total reported losses from crypto scams reached over \$5.6 billion, a 45% increase compared to 2022.
- Number of complaints: During 2023, the center received 69,000 complaints on the matter.
- Investment scams: The majority of complaints (approximately 71%) were related to investment scams. Losses from this type of fraud increased from \$2.57 billion in 2022 to \$3.96 billion in 2023 – a 53% rise.

Table 2. Data on crypto scams (2022-2023)

Year	Total reported losses (USD)	Losses from investment scams (USD)
2022	Approx. \$3.86 Billion	\$2.57 Billion
2023	Approx. \$5.6 Billion	\$3.96 Billion

Sources: Federal Bureau of Investigation (2023, 2024)

7. CONCLUSION

The proliferation of mule wallets and fake cryptocurrency exchanges presents a significant challenge to financial regulators and law enforcement agencies. While advancements in blockchain analytics and regulatory frameworks offer solutions, continuous innovation in criminal tactics necessitates ongoing vigilance and adaptive countermeasures (IMF, 2022; World Economic Forum, 2023).

8. RECOMMENDATIONS

Law enforcement agencies should regularly update training on blockchain forensics and expand international partnerships to enhance investigative capacities. Investors should critically evaluate cryptocurrency platforms, particularly avoiding those lacking clear regulation, transparency, or realistic profit claims. Performing due diligence, such as consulting official regulatory databases and verifying licenses, is critical for avoiding financial harm.

Regulatory authorities should consider implementing public alert systems to quickly disseminate information about suspicious crypto platforms and activities. Additionally, authorities must establish clear reporting channels for crypto-related fraud. Investors, on their side, must remain vigilant, regularly update themselves on scams, and maintain robust cybersecurity practices, including multi-factor authentication for cryptocurrency wallets (NCSC, 2023).

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TAX PROFILING AS A TOOL FOR TAXING THE SO-CALLED UNJUSTIFIED INCOME IN ROMANIA

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Abstract:

We were always told that George Orwell's 1984 is just a fiction book, not a manual of instructions. But more recent events seem to suggest the contrary. A decade ago, tax authorities paid good money for income information from Switzerland or Liechtenstein even if such information was obtained in a fraudulent manner. DAC 6 put professionals of the (tax) death row and the increased exchange of tax information facilitated access to most of taxpayers' sources of income. As a result, tax authorities are now able to profile their taxpayers by determining their usual sources of income, certain expenses, shopping habits or random people they share the lunch bill with via Revolut. This type of profiling has recently led Romanian tax authorities into a fight regarding the so-called "unjustified income". We therefore investigate whether the concept is defined by Romanian tax law, the boundaries of the constitutional and legal framework, the mechanics of the audits, the burden of proof and the genuine probatio diabolica required in certain procedures and, on the whole, the adequate solution and the perspectives of such profiling.

Keywords: *income taxation; unjustified income; tax information; tax audits; proportionality.*

JEL Classification: K340.

1. BRIEF INTRODUCTION TO THE TOPIC

In a few recent Romanian cases concerning the audit of natural persons' sources of income and associated taxes and social security contributions, national tax authorities have shown progress in using various types of tax profiling. In fact, the target of the tax inspectors has been the so-called "unjustified income" associated with certain individuals. With a variety of tax information exchange tools at hand and using data available online, teams of either the General Antifraud Direction (DRAF) or the National Tax Administration Agency (ANAF) seem to have become more innovative and keener on exploiting such information.

While profiling has been used for either security purposes (e.g. fighting terrorism) or as part of a national surveillance program, it is generally considered a dangerous tool for privacy rights. Maybe for that reason also, tax profiling has been usually associated with private audits carried out for preventive reasons (for

example, a dedicated auditor might circulate a questionnaire to assess what's the tax norm of an organization, how does it look at tax, including tax transparency or how is tax handled daily).

However, the interest in profiling tax and financial behavior with big data is genuine (Politou, Alepis and Patsakis, 2019). Even if the times of various “papers” (sensitive financial information leaked online) and dark alley purchases of tax havens data have passed, tax authorities are now collecting a huge amount of data from various sources. As both the Organization for Economic Development and Cooperation (OECD) and the European Union (EU) have been pushing for automatic and complete exchange of tax information, the constant upgrading of the EU Directive on Administrative Cooperation (Council Directive 2011/16/EU of 15 February 2011) led to serious concerns and even more serious legal battles (Tofan, 2023; Coștaș, 2007). DAC 6 was particularly criticized for imposing on tax and legal professionals an obligation to contribute, in a broad sense, to profiling, for arrangements that had not been reported or intended to be reported (Castro Bosque, 2024).

In the past years, for example, Romanian Government gathered such information from banks, couriers (e.g. identity of buyers and sellers, package value, collected cash), national and local authorities; it also used DRAF force to investigate commercial patterns, select and copy documents, evaluate assets and financial data, collect data from social platforms posts; upon request or by automatic exchange of information similar data was collected from online economic platforms; last but not least, data and requests for further checks were sent to ANAF by the Romanian Court of Accounts. It is no wonder then if one day a tax inspector knocked on somebody's door and asked why the price of some wedding dresses regularly sold by a company had been paid to a personal account or if a certain Revolut or Wise payment was a gift or the equivalent of supplied services.

Scholars have already elaborated on defining profiling and explaining its various avatars (Ferraris *et al.*, 2013), which is not the purpose of this paper. We will only refer to a working definition these authors have put forward, explaining that *profiling* is a technique to automatically process personal and non-personal data, aimed at developing predictive knowledge from the data in the form of constructing profiles that can subsequently be applied as a basis for decision-making.

2. THE NEED TO COLLECT AS MUCH AS POSSIBLE

Romania has long experimented a serious VAT gap and has had chronic difficulties in collecting taxes. One might stress that this is a result of no serious reform of the rules concerning taxation of natural persons in the past 30 years of an obsolete tax administration (I have been myself blessed with the same tax inspector for two decades) and of lack of specialized audit units. Indeed, while

economy is turning into a digital economy and certain items of income are the direct consequence of it, Romanian government did not show any interest in approaching taxation of individuals and re-writing the existing rules. Legal patches in isolated cases have had little effect in our opinion.

In the past years, justifying a series of reforms of its tax administration, Romania traded regular tax audits for the speedier "documentary checks" (*verificări documentare*). While a decade ago documentary checks were only performed in a limited number of cases and meant to clarify single issues (Costaş, 2016), in 2025 such tax checks seem to be the common manner of verifying taxpayers, both companies and individuals. However, doctrine pointed out a number of unsolved issues subject to widespread concern: documentary checks lead to the issue of tax decisions subject to review by another tax authority, legal certainty ignored; lack of detailed for this type of audit gives room to abuse and disrespect of taxpayers' rights; mechanisms and techniques of tax audits are disregarded under the pressure to collect in a timely manner and so on. In a nutshell, this is "the perfect legal uncertainty" (Costaş, 2023).

On one hand, it is true that checks performed revealed a number cases where income had never been declared and taxed. Flying under the tax radar, individuals failed to account for significant amounts of cash received from influencing, musical performances at weddings and other events, online adult entertainment services (video chat), transactions with cryptocurrency, sale of make-up products, fashionable clothes, shoes, navigation systems, leather products, timber and even hay or fruit trees. On the other hand, there were epic fails, such as the illegal taxation of donations received by a veterinary for the pick-up, treatment and alleged "sale" of stray dogs or the taxation of income derived from the sale of waste (Costaş and Puț, 2023).

A change of perspective in criminal legislation – mainly article 10 of Law no. 241/2005 – allowed such taxpayers to avoid criminal responsibility for unpaid taxes of no more than 1 million euros whether taxes themselves, associated tax interest and a further 15% increase were to be cleared within 30 days from discovery (Costaş and Tofan, 2023). However, this was and still is a *take it or leave it* offer, as taxpayers cannot challenge the amounts determined by ANAF or DRAF, ask for an expert report on the matter or provide evidence to reduce the taxable base with deductible expenses.

As of 1 July 2024, a change made to article 117 of the Romanian Tax Code established a 70% tax rate for any "unjustified income" of natural persons to be discovered. A shady note to the new legislation provided that article 117 in its new form – the old legal norm referred to a 16% rate – shall be applied to "all tax decisions issued after 1 July 2024", raising serious concerns about the possible, yet unlawful (Puț, 2024) application of the 70% tax rate to income earned until 30 June 2024.

In this particular context, a series of documentary checks and tax audits have been performed with the sole aim of collecting as much as possible for a state budget with a 9.3% deficit in 2024. It is worth noting that as of 2020 tax inspectors with DRAF can also perform the check of the personal tax situation regulated by article 130 and the following of the Romanian Tax Procedure Code using the documentary check procedure. That translates into lengthy and complex procedures lasting 12 to 18 months exchanged for fast forward documentary checks and is subject to our analysis.

“I can resist anything except temptation”, Oscar Wilde once said. And it is (tax) temptation that pushed for a new witch hunt: the taxation of the so-called “unjustified income” at a 70% rate.

3. WHAT IS “UNJUSTIFIED INCOME”?

The Romanian legislator has never been keen on detailing direct tax (see High Court of Cassation and Justice – Administrative and Tax Section, decision no. 2826 of 23 May 2024, quoted by Văsonan, 2024) or indirect tax (Costaş, 2024) provisions so that they were thoroughly understood and applied in a unitary manner by taxpayers, courts and tax administration. On the contrary, in many cases legally undefined concepts are used by the Romanian tax authorities (Puț, 2018). The recent case of “unjustified income” makes no exception.

Article 117 of the Romanian Tax Code, in force as of 1 July 2024, reads as follows: “*Article 117. Defining and taxing income whose source has not been identified. Any income found by the tax authorities, under the terms of the Fiscal Procedure Code, whose source has not been identified, is taxed at a rate of 70%*”. This article was modified by Law no. 296/2023, to the sense that the tax rate was increased from 16% to 70%. Moreover, according to art. VII par. (1) b) of Law no. 296/2023 the increased tax rate “applies to tax decisions issued by the tax authorities as of 1 July 2024”. This article is not new to Romanian legislation, as the previous article 79¹ of the old Tax Code was in force since 1 January 2011. The previous version of the law, however, referred to an adjusted taxable base that should have been determined using indirect methods of reconstitution for both taxpayers’ income and expenses (in accordance with Order of ANAF President no. 3733/2015 regarding the approval of indirect methods for the determination of income).

Following the entry into force of the 70% tax rate, intrusive documentary checks and the qualification of certain amounts as “unjustified income” made social networks, such as Tik-Tok, spread viral posts regarding taxation of such income. Doctrine should therefore pay equal attention to the matter.

In an effort to determine what “unjustified income” is, one should first consider the provisions of article 117 itself of the Romanian Tax Code. However, contrary to the provisions of Law no. 24/2000 regarding the norms of legislative technique, this article says nothing. An elliptical construction only clarifies the

existence of a 70% tax rate and definitely not what “unjustified income” might be. Of course, there is a reference to “any income”, which broadens the spectrum of possible taxable items of income, but the text is immensely shy of any legal certainty. Should an individual who received a bank transfer made using phone numbers as payer’s and beneficiary’s identificatory be subject to a documentary check in order to assess the “justified” or “unjustified” nature of payment? What does it take to “justify” income: a job, a generous bank account, regular updating of personal identification data? Do friendship, love, relationship, work relations or context “justify” payments from one account to another? Are there any patterns applied in order to rule what’s “justified” or what’s “unjustified”?

However, on a different note, an experienced observer can explain that the correct remedy whenever there is income and the source of that income is not traceable would be to apply articles 106–107 of the Tax Procedure Code, namely establishing the tax base by estimation (Costaş, 2016). Such a procedure relies on the fact that, in any given case where the taxpayer did not declare the source of income, ANAF must be able to identify the source of income (ex. income from wages, income from independent activities) and, if this is not possible, it must use the estimation procedure in order to tax.

Bottom line, we do not know what “unjustified income” is. Might that be since individuals, as a rule, do not have an obligation to justify income on a regular basis?

4. ARE ROMANIAN TAXPAYERS UNDER A GENERAL DUTY TO REPORT INCOME AND FORTUNE?

We argue that in Romania there is no general obligation to declare all income or to point out all goods that might generate income. Therefore, if somebody finds a painting by Nicolae Grigorescu (1838–1907, a great Romanian impressionist painter) in his/her grand grandmother’s attic or a valuable vintage car that is no longer in circulation in his/her grand grandfather’s old garage, he/she is under no obligation to declare such goods. As a result, income arising from the sale of such goods and various other sources has “a source that has not been identified”.

To further explain this, we will use other relevant examples from the Romanian Tax Code (Costaş and Puț, 2023). First, according to article 62 p) Tax Code, gifts received at weddings, baptisms and similar events, which are very common in Romania, are not taxable and the taxpayer is under no obligation to monitor, identify, document and declare such nontaxable income (except the case where such gifts exceed the value of 25,000 lei – some 5,000 euros – when the Civil Code requires an authentic donation contract). Second, as a rule, the sale of movable and immovable goods from the private patrimony of an individual are not taxable, in accordance with article 62 m) Tax Code (except for investments’ income arising from the sale of shares and certain real estate transactions described in article 111 Tax Code). Third, any income from dependent activities

(wages) obtained abroad is not taxable in Romania, no matter the tax treatment in the other state, according to article 76 paragraph (4) o) Tax Code. And, in yet another example, according to Romanian Civil Code presumptive heirs can freely use the movable goods that were found after someone passed away (e.g., a huge amount of cash, other movable goods) if the other heirs do not object to that.

Such examples reinforce the conclusion that the Romanian legislator did not intend those taxpayers keep a detailed track of the income they gain from various operations and, except for the cases specifically provided for in the Romanian Tax Code (e.g., income from independent activities, intellectual property, rentals, agriculture or investments), such income does not have to be included in the annual tax return. Furthermore, Romania does not tax gifts and successions (with the rare exception of real estate, if the succession has not been cleared two years after *de cuius* passed away) and there is no tax on fortune or the increase of fortune throughout the year (Tofan, 2024).

If we look at this from the perspective of the burden proof – of the “justified” or “unjustified” character of such income – one must first pay attention to the provisions of article 44 par. (8) of the Romanian Constitution, which states that “*Licently acquired property cannot be confiscated. The licit nature of the acquisition is presumed*”. In principle, in Romania, the demonstration that property has been acquired illicitly must be carried on in a criminal trial (e.g., income arising from the sale of drugs shall ultimately be confiscated) or in an administrative procedure carried on in accordance with Law no. 115/1996 for the declaration and control of the assets of dignitaries, magistrates, persons with management and control positions and public servants.

We can easily argue that the introduction of a 70% tax rate is actually a “criminal sanction” in accordance with the criteria set by the European Court of Human Rights in cases such as *Bendenoun and others v. France* (Costaş and Puț, 2023). The only difference is that such a sanction is applied in the absence of any trial, based on a summary analysis and using legally undefined concepts such as “taxation of unjustified income”.

In terms of evidence, according to article 73 paragraph (2) Romanian Tax Procedure Code, the burden of proof stays with the tax administration. Indeed, according to article 73 paragraph (1) of the same Code, taxpayers are only obliged to prove acts and facts that support their tax declarations and requests for the tax authorities (Costaş, 2016). They are not compelled to prove the source of all their income. It is an important point since in many tax audits and particularly during the intrusive documentary checks tax inspectors tend to reverse the burden of proof and ask taxpayers to show proof that they have licitly acquired property or income.

5. PROFILING FOR TAX PURPOSES

We have approached this topic from the point of view of tax profiling because practical experience shows such profiling is carried on extensively. In a significant number of cases, beneficiaries of payments in cases of nationalized goods, lawyers that carry out other activities apart from the legal business (e.g., rentals, sale of timber) individuals that use significant funds, shareholders of companies or housewives that sell various things on economic platforms have been asked to show proof of their income or be taxed at 70% for “unjustified income” if they failed to do so. Some of these requests were sent in the context of the constant monitoring of social media and social platforms (e.g., notifications sent to performers that have reached a certain number of visualizations on YouTube). Others are the direct effect of shady profiling made by the Court of Accounts, which monitors payments made by national authorities in the case of nationalized goods or money lend to companies by their own shareholders and then asks tax authorities to step in and perform documentary checks.

As documentary checks have undefined legal boundaries (Costaş, 2023), profiling has gone even further. In many cases, even if taxpayer’s X income and fortune is under scrutiny, tax inspectors state in their decisions that they have performed internal checks with taxpayers A, B, C or D (the taxpayer’s grandmother, his/her significant other, the high school best friend or the business partner) and that these taxpayers did not possess the financial means to make payments to taxpayer A (e.g. in the case of a wedding gift, a personal loan or a price for a sold good that taxpayer A indicated as sources of his/her income). It is understood that taxpayers A, B, C and D are not audited themselves, but they had definitely been profiled with regard to their financial status, banking accounts and money flowing through such accounts, movable and immovable property, dependent or independent activity carried on, shareholder status in various companies, financial results of such companies and so on.

The “informal” nature of such audits carried out with taxpayers A, B, C and D is definitely contrary to Romanian law, as such taxpayers are not verified themselves (at least not in a public audit or documentary check performed in accordance with the provisions of the Romanian Tax Procedure Code). As a result, one can seriously doubt the licit nature of evidence collected in that manner and taxpayers can obviously claim such evidence is not used against them in the main audit procedure.

It is to be added to this that taxpayers A, B, C and D are under no obligation themselves to evaluate or declare, at a certain moment in time, their non-taxable income or non-taxable fortune. Therefore, if they are asked to declare and prove the amount of cash they had on 1 January 2018, they can’t simply do that because they kept no evidence whatsoever (of course, they can estimate, but then again this is not accurate information and failure to provide accurate information might be used both against them and against taxpayer X).

Furthermore, profiling for tax purposes, followed by a documentary check and a taxpayers' notice as to the amounts he/she has to pay has another aim as well. Changes to Romanian criminal legislation in the past few years have made it possible that, under article 10 paragraph (1) of Law no. 241/2005, taxpayers pay evaded tax debt and a 15% penalty in order to avoid any criminal responsibility whatsoever (for tax debts up to 1 million euros), since the results of tax profiling are not even sent to the Prosecutor's Office. Consequently, the results of tax profiling are formally exhibited during a documentary check and the taxpayer is warned: he/she either pays the tax debt which has been determined during profiling or he/she faces the possibility that amounts owed increase. Indeed, according to the same article 10 of Law no. 241/2005, if payment is done later, the value of penalties increases to 25% during criminal investigations, to 50% during first instance criminal trial and to 100% during appeal criminal trial. From a procedural point of view, it is a *take it or leave it* offer, since at the end of the documentary check, if the taxpayer paid, no tax decision is issued. So, even if the taxpayer paid, he/she can no longer challenge the results of tax profiling, as they had not been mentioned in an official tax decision and the lack of a tax decision prevents taxpayers from going to court.

To sum up, by using data gathered from various sources, processed with extensive use of artificial intelligence, Romanian tax authorities have come to the point where:

- (a) an individual's tax profile and his/her associated tax obligations are determined in a rather mechanical manner, based on various patterns and not necessarily on the evidence available both in favor and against the taxpayer.
- (b) for taxpayers, access to the tax file behind the conclusions of tax inspectors is difficult or close to impossible, particularly when a tax decision is not issued and the procedure closes (e.g., in the case where taxpayers match the alleged tax debt in order to avoid criminal prosecution).
- (c) although determination of taxes should be as accurate as possible and artificial intelligence should help, current results are pretty much different: in many cases the facts of tax cases are misunderstood, tax debt is determined considering solely income and not also expenses, key evidence is ignored and, in the end, tax obligations determined are annulled by tax courts in significant proportions; that is simply far away from "smart taxation".
- (d) the main concerns regard taxpayers' rights, as both audited taxpayers and "informally audited" connections of such taxpayers are unable to effectively defend in current tax audit procedures.

It is therefore our view that tax profiling should be kept to a minimum or eliminated, in order to secure both the coherence of tax audits and taxpayers'

rights. Moreover, given the significant number of tax cases that actually go to tax courts, we also believe that a proper use of such tools in connection with existing evidence and not instead of evidence should be considered. To use just one case as an example, a veterinarian was audited using existing data that showed she had sold to Romanian and European clients more than 600 stray dogs for consideration. Therefore, a tax decision was issued for the whole amount of consideration, as calculated from adding up payments made to the veterinarian's private bank accounts. However, a final decision of the Timișoara Court of Appeal portrayed a totally different perspective: the veterinarian did not exercise an "economic activity", she simply picked up stray dogs from the streets, treated them in her clinic, paid for their medication and advertised them for adoption (a fine tuning of facts that AI did not pick up); stray dogs had been registered as the "property" of the veterinarian since the IT system required an individual as the owner of the dog; all consideration received consisted of donations for the support of her voluntary activity or amounts meant to cover administrative and transport costs (e.g. passport and airplane ticket for a Romanian stray dog adopted by a Scottish family); most of such consideration was spent on medication, food and care of such dogs.

6. CONCLUSIONS

With more and more AI tools available and the desire of the Romanian tax authorities to make "easy money", there is a significant use of tax profiling. However, such profiling has shown to have raised major issues, stretching from serious breaches to taxpayers' fundamental rights to totally wrong tax conclusions. Overlapping with a debatable structure of national tax audits and insufficiently cleared legal concepts, the situation allowed that various items of income had been considered taxable or "unjustified income" subject to a 70% tax rate. It is our view that such an approach, together with the structure of the tax authorities or the proper writing of tax rules, should be under serious review. We challenge the possibility of taxing "unjustified income" itself since the legal concept is not defined by tax law and tax authorities are under a legal obligation to determine the nature and the source of any income in order to tax, showing evidence to the fact that such income is taxable.

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ARTIFICIAL INTELLIGENCE AND DEFICIT OF PERSONNEL IN THE ROMANIAN POLICE

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Abstract

Artificial intelligence (AI) is now a fundamental part of daily life, helping with everything from unlocking devices through facial recognition to aiding in healthcare diagnostics. AI's ability to process and analyze vast amounts of data positions it as a valuable resource in law enforcement, particularly in Romania, where challenges in public safety could benefit from AI integration. Despite its potential, citizens remain cautious about ensuring AI's fairness and beneficial use. Staff shortages in Romanian police and border agencies exacerbate public safety issues. Critical vacancies and budget constraints lead to slower response times, increased crime rates, weakened border security, and eroded trust in law enforcement. Additionally, unfair labor practices and restrictive policies make recruitment and retention difficult, highlighting the need for urgent reforms. Making the appeal to AI with its advantages, such as improved productivity and crime prevention, and analyzing data to predict hotspots and identify criminal behaviors. However, risks exist, including biased algorithms and policy gaps that may lead to unfair outcomes. Regulatory frameworks like the EU's General Data Protection Regulation (GDPR) ensure transparency in data practices, but no universal standard currently governs the fairness of AI applications in law enforcement.

Keywords: *police; artificial intelligence; international structures.*

JEL Classification: O15.

1. INTRODUCTION

Artificial intelligence (AI) systems have seamlessly integrated into our society, becoming a ubiquitous part of everyday life. Whether acknowledged or not, it's highly probable that the average person interacts with some form of AI regularly. From facial recognition software unlocking mobile devices to virtual assistants in household gadgets, and even diagnostic tools in healthcare.

In Romania, the law enforcement sector faces various challenges that appear well-suited for AI applications. AI, with its ability to identify patterns within extensive datasets, offers law enforcement an opportunity to elevate its capabilities and improve community service. Yet, the question remains: how can citizens trust that AI will be implemented in a way that is both beneficial and fair?

Artificial intelligence can improve workflows, productivity, and effectiveness, but it also carries risks. These risks stem from issues like flawed algorithm design, biased training data, or gaps in policies that fail to address the potential impacts of AI technology.

Research on AI systems is relatively new and focuses mainly on the European Union (EU), where the General Data Protection Regulation (GDPR) governs data use and transparency. Countries like the United Kingdom have adopted or adapted such regulations, with the General Data Protection Act of 2018 (GDPA) (Ian. 2023) offering individuals the right to know what data is held about them. While these regulations ensure accountability in law enforcement's data practices, there is no standard to guide the use of AI and machine learning algorithms (MLAs) in reducing bias and ensuring fairness, which could negatively impact citizens.

Artificial intelligence in crime presents both risks and benefits. While AI has facilitated the globalization of crime through activities like behaviour-mimicking programs and manipulated media for blackmail, it can also serve as a tool to combat crime. AI's preventive role includes predicting and reducing crime by analysing data, identifying hotspots, and recognizing criminals' behaviours. Its deterrent role focuses on gathering evidence post-crime to assign responsibility and provide proof. AI-equipped surveillance systems and predictive analytics enhance crime detection and prevention, demonstrating both the challenges and opportunities AI brings to the field of law enforcement.

2. REDUCTION IN PERSONNEL AND THE EMERGENCE OF TELE-COPS

Police agencies in the U.S. are facing significant workforce challenges, including a 5% decrease in personnel over the past three years. Increased resignations and retirements, coupled with struggles to fill vacancies, have led to delays in police response times. To address these challenges, the Wichita Police Department (WPD) implemented a Commissioned Call Center (CCC), staffed by light-duty officers, to handle low-risk, low-harm calls via phone.

A study was conducted from March to July 2023 to evaluate the CCC's effectiveness compared to traditional in-person responses. Key findings included:

Satisfaction levels remained high across both phone and in-person responses.

Phone responses significantly reduced response and handling times (7.2 minutes vs. 45 minutes for initial contact and 13 minutes vs. 53 minutes to complete calls) (Birzer and Cory, 2024). Callers appreciated the option for discretion and privacy, particularly for sensitive cases like domestic violence reporting.

The CCC demonstrated efficiency and operational benefits, improving community access to police services. Recommendations for similar implementations include leveraging light-duty officers, equipping centralized locations, targeting peak times, and continuously monitoring performance.

Overall, this approach showcases the potential of innovative methods in modern policing.

3. REDUCTION IN PERSONNEL IN ROMANIAN POLICE AND BORDER POLICE

Critical staff shortages faced by the Romanian Police and Border Police, which severely impact their operations and working conditions due to:

- **Alarming Vacancy Rates** where some police units operate with nearly a quarter of positions unfilled; in Teleorman County, the vacancy rate exceeds 28% (SPRD, 2025). Border counties like Constanța and Satu Mare, along with Bucharest, have significant deficits, affecting public safety and cross-border crime prevention.
- **Government and MAI Leadership Inaction:** Budgetary constraints and austerity measures lead to vacancy freezes and insufficient hiring. Deliberate policies, such as restrictive salary incentives and discriminatory performance requirements, limit the benefits for officers under recent ordinances.

Consequences of staff shortages will lead to: overburdened officers working beyond legal limits; abuse of unpaid, forced standby duty to compensate for the lack of personnel; increased operational risks due to longer response times and insufficient resources.

An urgent reform is needed with proposals including hiring enough officers, eliminating abusive practices, and ensuring compliance with European labour laws.

The consequences of these staffing shortages on public safety are both significant and complex:

- **Rising Crime Rates:** A reduced police presence on the streets and slower response to incidents may lead to increased criminal activity, particularly in areas heavily impacted by vacancies.
- **Delayed Emergency Responses:** Longer wait times for urgent interventions, such as accidents or violent crimes, could allow situations to escalate unnecessarily.
- **Weakened Border Security:** Insufficient staff in border police departments hampers efforts to combat cross-border crime and illegal trafficking, raising security concerns.
- **Eroding Community Trust:** Ineffective policing and slow responses can diminish public confidence in law enforcement agencies and their ability to maintain safety.
- **Greater Risks for Officers:** Officers face higher workloads, leading to stress, fatigue, potential judgment errors, and increased personal risk.

- **Lapses in Law Enforcement:** Limited personnel may result in selective or less rigorous enforcement of laws, undermining justice and accountability.
- **Reduced Preventative Efforts:** Resource constraints may deprioritize proactive policing, such as community engagement and crime prevention programs.

The staffing issues in the Romanian Police and Border Police arise from several overlapping factors:

- **Budget Constraints:** Austerity measures restrict funds for hiring and competitive salaries.
- **Frozen Vacancies:** Positions are deliberately left unfilled to cut costs, worsening the shortage.
- **Restrictive Salary Policies:** Ordinances like OUG 26/2024 offer raises but impose exclusionary criteria, such as high-performance ratings, leaving many officers ineligible.
- **Unfair Practices:** Forced unpaid standby duties frustrate officers by compensating for the personnel shortfall without proper remuneration.
- **Leadership Actions:** Decisions by central leadership to limit benefits deter recruitment and retention efforts.
- **Demographic Trends:** Aging populations and emigration reduce the pool of qualified candidates.

Together, these issues present significant challenges for law enforcement, making it harder to recruit and retain talented officers.

4. CAN AI SUPPORT POLICE DEPARTMENTS IN KEEPING COMMUNITIES SAFE?

AI has proven to be a powerful crime-solving tool. Over 3,000 police departments worldwide are already utilizing image recognition technology to automatically identify license plates, car models, and even modifications such as aftermarket wheels or ski racks. This technology has been instrumental in various cases, including apprehending a mass murder suspect in Cobb County (May 2023) (Murphy, 2023), dismantling a catalytic converter theft operation (Flock Safety, 2022), and rescuing over 80 victims of human trafficking.

By enabling collaborative image-sharing between police departments, AI fosters seamless cooperation across jurisdictions, improving crime resolution outcomes. However, like body-worn cameras, the adoption of AI technologies requires thoughtful policy development. Key considerations include image retention periods, access to location data, and ensuring public awareness. A well-crafted policy framework can significantly enhance crime prevention by improving the efficiency and success of criminal apprehension.

AI's potential extends even further, offering predictive analytics to pinpoint areas at risk of criminal activity, social media monitoring to address emerging

community concerns, and DNA analysis to link individuals to evidence or crime scenes.

5. AI-GENERATED REPORTS IN LAW ENFORCEMENT

About half of a law enforcement officer's work is spent writing reports, which are required by law to be truthful, thorough, and objective. Reports are entered into computerized records management systems and contain details on occurrences, witnesses, victims, and suspects.

By automatically filling in report fields with speech-to-text, GPS alignment, and computer vision from bodycam footage, artificial intelligence (AI) can expedite this procedure. By evaluating previous report data, large language models (LLMs) may provide event summaries and classify participants, assisting in the creation of thorough, effective, and consistent reports while lessening the administrative burden on the officers.

Because AI-generated reports improve data analysis and decision-making, they have the potential to completely transform law enforcement (LE). Officers can find patterns, trends, and anomalies for investigations and crime prevention with their assistance because to their ability to handle massive datasets more efficiently. AI saves time by automating data input and report writing, freeing up officers to concentrate on important duties like complicated issues and community participation.

Furthermore, reports produced by AI can enhance comprehension of local populations, promoting improved communication and making it possible to create effective crime prevention measures. Officer efficacy, community trust, and general public safety are all improved by an all-encompassing strategy.

Despite the potential advantages of AI-generated reports, biases and legal problems are still present. Because AI uses pre-existing data, disparities in law enforcement (LE) may be sustained. Inaccurate or biased source data can lead to poor analysis, which can cause population misrepresentation, diminished community trust, and erroneous arrests.

Furthermore, there are issues with AI-generated reports' admissibility in court, particularly for opaque systems. Such reports might not fulfil validity and reliability criteria if private data and development details are not disclosed, which might hurt LE efforts if they are found to be inadmissible for prosecution.

For law enforcement (LE) to appropriately use AI-generated reports, interpretability is essential. It includes explainability, transparency, dependability, and auditing of AI systems to make sure their results are reliable and compliant with the law. Prior to deployment, the public, LE experts, and policymakers must carefully examine AI decision-making procedures.

Models ought to be built using counterfactual explanations or LIME-like approaches to explain their outputs. To evaluate dependability and correct biases, transparency regarding data sources, methods, and assumptions is essential. In

order to guarantee consistent results, reliability also necessitates training on representative data and conducting frequent audits to track performance and address problems like model drift.

However, it can be difficult to achieve interpretability, particularly when dealing with intricate algorithms like deep learning models. For AI to be successfully integrated into LE policies, trade-offs between interpretability and performance may need to be carefully balanced.

6. WHAT IS THE LATEST GENERATIVE AI, AND HOW DOES IT DIFFER FROM A SEARCH ENGINE?

Generative AI represents a specialized branch of artificial intelligence that creates entirely new content – such as text, images, music, or videos – by learning from extensive datasets. It identifies patterns and uses them to produce original outputs.

Examples of generative AI include:

- **Chatbots:** Tools like OpenAI’s ChatGPT, Microsoft Bing, and Google Bard, which generate cohesive, context-aware text.
- **Creative Platforms:** Applications such as Midjourney for creating art or photorealistic images; Character.ai for developing conversational agents that emulate real individuals (e.g., Stephen Hawking), historical figures (e.g., Rosa Parks), or fictional characters (e.g., Luigi from Super Mario Brothers); and Eleven Labs for producing natural-sounding speech.

The fundamental difference between generative AI and search engines lies in their functionality:

- **Search Engines:** Designed to locate and retrieve information from the web by indexing pages and displaying a list of relevant results based on user queries.
- **Generative AI:** Developed to hold conversations, solve problems, and create unique content. For instance, you could ask a chatbot to write an essay, compose a melody, or generate a computer program – tasks that extend beyond simply retrieving pre-existing information.

Generative AI is revolutionizing how we interact with technology, offering remarkable versatility and becoming a powerful tool for creative, professional, and everyday activities.

7. CAN THIS TECHNOLOGY ASSIST IN CRIME-SOLVING?

Maybe. Chatbots and generative AI tools are already proving useful in supporting officers with documentation tasks, such as drafting incident reports or creating presentations for city offices. These tools enhance communication by generating preliminary drafts, producing supplementary content like images, music, or videos, and customizing presentations for specific audiences. For

example, an officer could request a chatbot to “explain these ideas to elementary school students,” ensuring the message is both age-appropriate and engaging.

An emerging trend involves equipping generative AI systems with specific documents, enabling users to ask precise questions about the content. Google’s Talk To Books platform exemplifies this, allowing users to query databases with questions like “When was a convicted killer later exonerated based on new evidence?” to uncover relevant insights (Chen, 2023).

Looking ahead, these tools could revolutionize law enforcement by transforming vast data repositories – including police reports, depositions, and forensic evidence – into actionable intelligence. This technology holds the potential to greatly enhance investigative efficiency and accuracy, setting a new standard for crime-solving.

Across various nations intelligence (AI) in law enforcement is evident, for instance, in the United States, the Federal Bureau of Investigation (FBI) employs AI to analyse real-time surveillance camera footage, enabling the identification of criminals. AI also aids FBI agents in processing vast amounts of data to track individuals and forecast potential crime locations and timings (Zachek *et al.*, 2023). In the United Kingdom, law enforcement leverages AI to monitor social media and other open data sources to detect threats to national security. Similarly, in Germany, AI is utilized to uncover crimes involving financial transactions.

AI-powered facial recognition technology plays a significant role in identifying and verifying individuals. This technology is a vital asset for law enforcement, used in public spaces and airports to assist with investigations, tracking suspects, and confirming identities. For example, the Miami Police Department employs Clearview AI software to solve crimes by matching photos of individuals against a database and retrieving related online images. Clearview AI also supplied its technology to Ukraine to support its defence efforts against the Russian invasion. Initially deployed to Ukraine's Ministry of Defence, the technology was later made accessible to various other agencies, including the National Police of Ukraine.

Companies like Axon and Viewu have recently acquired AI technology to streamline tasks such as video analysis and redaction, saving time and effort for officers.

Law enforcement agencies face significant challenges in managing the sheer volume of video footage captured by body-worn cameras, in-vehicle systems, civilian devices, and surveillance cameras, especially during major incidents like the 2013 Boston Marathon Bombing. Reviewing such vast amounts of evidence is time-intensive, making AI an essential tool for easing this burden (Griffith, 2017).

Companies like Axon, through its acquisition of Dextro, have developed AI-powered tools that can scan videos for specific objects, actions, and even transcribe audio. Likewise, Veritone offers advanced video and audio search

technologies capable of quickly processing large quantities of footage to identify faces, objects, words, and more. These innovations significantly enhance investigative efficiency, allowing machines to assist in analysing footage and expediting evidence review. Axon and Veritone's systems are expected to reduce video review times by as much as 70–80%, improving law enforcement agencies' operational effectiveness. Law enforcement agencies face difficulties in video redaction, as body-worn cameras often capture sensitive individuals like minors, witnesses, or undercover officers. Redaction safeguards privacy by modifying video copies without altering the originals. Current tools require manual identification and tracking, but Axon aims to transform this process with its AI, promising improved accuracy and efficiency.

Additionally, Axon is advancing automated report generation from video evidence, reducing the time officers spend on data entry and streamlining operations. While full automation is still in development, the company is creating tools to extract data from videos, such as scanning IDs for record management systems (Griffith, 2017). These innovations could enable officers to dedicate more time to crime-fighting, boosting overall operational effectiveness in law enforcement.

Law enforcement AI integration encompasses a variety of uses, benefits, challenges, and anticipated advancements:

- **Predictive policing:** Artificial intelligence (AI) is widely used in surveillance, including behavioural analysis, object identification, and facial recognition. Proactive law enforcement activities are made possible by the analysis of historical crime data to identify possible hotspots.
- **Task automation:** AI increases productivity and frees up police personnel to work on more complex cases by automating routine chores like paperwork, data processing, and evidence analysis.
- **Crime prevention and investigation:** AI's ability to recognize intricate patterns in large datasets aids law enforcement in spotting trends, illegal tactics, and impending dangers.
- **Virtual assistance:** To increase public interaction, disseminate information, and expedite administrative tasks, police agencies are implementing AI-powered chatbots and virtual assistants.
- **Enhanced efficiency:** AI lowers resource costs and promotes more effective operations within law enforcement agencies by streamlining processes like data processing and documentation.
- **Improved judgment:** AI that has been trained on pertinent data helps law enforcement make fair, data-driven choices, which results in more effective and efficient policing.
- **Enhanced public safety:** By facilitating quick reactions to threats and illegal activity, surveillance and predictive policing improve public safety.

Traffic safety and operational efficiency by leveraging real-time data and sensor technology, it improves road condition assessment, predicts traffic patterns, and optimizes public safety efforts. This includes applications like predictive traffic and crime mapping, as well as assisting police and first responders through machine learning and in-vehicle AI systems. AI systems can enhance decision-making, optimize patrol routes, and provide insights during high-speed pursuits or emergencies. NASA's TruePAL (Lu *et al.*, 2022). TruePAL— an AI Assistant for First Responder Safety. system exemplifies this, offering real-time feedback to ensure safer, faster responses and even predicting potential accidents near stopped emergency vehicles. Roadway sensor technologies and AI tools, such as de-icing sensors and analytics for signage, contribute significantly to reducing traffic crashes and improving roadway safety. AI combines data collection, real-time analytics, and predictive capabilities to set new standards for public and traffic safety, adapting to trends like autonomous vehicles and ensuring a proactive approach to potential hazards.

Based on the aspect above the following topics need to be addressed:

- Discrimination and bias: AI systems may produce discriminating results if they reflect biases in the training data. Reducing algorithmic bias and maintaining fairness are necessary to meet this challenge.
- Privacy considerations: There are serious privacy concerns with the widespread usage of AI for spying. It's still difficult to strike a balance between the necessity for public safety and respect for personal privacy.
- Ethical issues: Careful thought must be given to the ethical issues raised by AI in law enforcement, including accountability, transparency, and the possibility of abuse. The need to create and follow ethical frameworks that address biases, privacy concerns, and other relevant ethical issues will only grow as AI technology advances.

The acquisition of AI by police in the future emphasizes how urgently strong governance regulations are needed. In order to improve resource management and emergency call priority, companies are incorporating AI into already-existing technologies, such as CAD systems, rather than launching whole new AI solutions. AI advancements are also spreading into fields including real-time field support through mobile devices, digital evidence processing, and investigation tools. The use of AI has been further hastened by cloud hosting, particularly in smaller police agencies. These agencies may swiftly access state-of-the-art AI technology without having to manage complicated infrastructure, frequently surpassing larger departments in deploying new capabilities.

Given the rapid development of AI's capabilities and its expanding impact, police chiefs have to take proactive steps to ensure that AI is used appropriately. These actions are in line with new developments in AI regulation, even if they are not yet required.

- **Clear Purpose in AI Use:** It's critical to have clear objectives for the use of AI. To guarantee safety and effectiveness, leaders must determine the issues AI seeks to solve and assess its goals. The basis for evaluating and controlling the technology is a well-defined goal.
- **Risk Assessment of AI's Human Impacts:** In addition to the dangers of not implementing AI solutions, policymakers must assess how AI may affect privacy, discrimination, and civil liberties. The use of personal data and the possible consequences of inactivity should receive particular consideration.
- **Procedures for Technology Assessment:** To gauge the efficacy, precision, and security of AI, police agencies require strong assessment frameworks. The technology lifecycle should include audits, metrics generation, and ongoing monitoring. Human interaction and transparency in design are essential.
- **Protocols for Human Review:** Human judgment must continue to be essential, particularly when making judgments pertaining to basic rights. By putting in place transparent review procedures, AI is guaranteed to enhance human skill rather than take its place. Biases in AI systems must be addressed.
- **Transparency in AI Use:** Law enforcement organizations need to be aware of and explain how AI systems work. Gaining the public's trust and demythologizing the workings of AI depend heavily on transparency and explainability.
- **Formal Governance Structure:** To handle AI responsibly, comprehensive governance is required. In order to support regulatory trends and promote community trust, policymakers should include stakeholders and follow established norms. These actions give law enforcement officials the frameworks they need to successfully handle the challenges posed by the application of AI.

8. ROMANIAN POLICE STATUS OF USING ARTIFICIAL INTELLIGENCE

Using artificial intelligence (AI), the Bucharest Police have started a creative online fraud prevention campaign. An instructional song with catchy lyrics that warns users about typical frauds like phishing and false communications was made with AI techniques as part of the campaign. Vigilance is emphasized in the advertisement, which cautions against sharing personal information such as verification codes or clicking on dubious websites.

The "Vote for Adeline" (Ion, 2025) scam is one instance that has been brought to light, in which victims are duped into granting hackers access to their WhatsApp accounts. To stop fraud, the police advise taking precautions like turning on two-factor authentication and confirming the legitimacy of messages.

Nearly 80% of Romanians experience frauds within a year, and the average cash loss from online fraud in 2024 was \$512 (Greening, 2022). Over \$1 trillion in damages have been caused by internet fraud worldwide, making this a pressing problem. Through creative and memorable approaches, the campaign seeks to decrease vulnerabilities and educate the public.

In order to improve emergency response, border security, and public safety, Romania's Ministry of Internal Affairs (MAI) will use cutting-edge technology including drones, robotics, and artificial intelligence (AI). By creating a digital centre for civil services, the MAI hopes to further its digitalization efforts. It is also considering partnering with Qatar (Penescu, 2025) to share best practices in AI applications and digital governance.

The strategy, which emphasizes innovation to address issues like personnel shortages while upholding high safety standards, involves the use of AI in police and civil defence services. The partnership aims to capitalize on Qatar's proficiency in digitization, which was proved by its sophisticated technologies used during the FIFA World Cup 2022, which showed effective crowd control and security procedures.

The implementation of artificial intelligence within the Romanian police force is not as advanced as in some other countries. However, with the ongoing evolution of the European Union's regulations on artificial intelligence, there is significant potential for improvement. These changes could drive the adoption of more sophisticated AI technologies, enhancing law enforcement capabilities while prioritizing the security and privacy of ordinary citizens. As the legal framework develops, it may foster greater accountability, transparency, and efficiency in AI usage, ultimately contributing to more effective public safety measures and building trust within the community.

9. IN CONCLUSION

Predicting the future is always a challenge, however, it's likely that within a few years, AI technology will be integrated into every aspect of policing, with personalized AI coaches becoming a standard tool for officers across all roles.

- For Patrol police: Artificial intelligence (AI) built into smart glasses or contact lenses may provide augmented reality overlays that let police recognize items like cars or buildings, evaluate dangers instantly, and retrieve past crime statistics for certain areas.
- For crime analysts and detectives: AI systems will expedite the examination of evidence, allowing investigators to make targeted queries such as "How compelling is this evidence for trial purposes?" or "What should I ask this informant based on previous cases?" AI may also arrange suspects and rank leads, emphasizing opportunities and motivations.

- For Police Leadership: AI has the potential to transform management by assisting leaders in finding exceptional candidates, providing individualized coaching, and making well-informed choices on hiring, promotions, and job modifications that are in line with community requirements.
- For public information officers, AI will improve public communication by offering knowledgeable and sympathetic answers. Already hailed for its practicality and compassion in the medical field, chatbot technology may be customized to promote trust and productive communication between law enforcement and the communities they serve.

By combating crime, increasing productivity, and building community trust, AI is already revolutionizing law enforcement. Designing systems that satisfy contemporary police demands while guaranteeing equal results is essential as this technology develops. In order to preserve safety and ethics, AI solutions should be seen as iterative, needing constant planning, observation, and modification. Police may utilize AI to improve their work without replacing qualified personnel if they have defined goals, measure effectiveness, and deal with reliable vendors. The development of AI programs that fairly benefit all stakeholders requires careful community interaction.

This vision demonstrates how AI has the potential to improve policing's efficiency while also making it more flexible and sensitive to societal demands.

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THE ENVIRONMENTAL PROTECTION IN THE CONTEXT OF THE EUROPEAN GREEN DEAL: THE ROLE OF ARTIFICIAL INTELLIGENCE

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Abstract

The climate crisis is one of the major challenges for Europe. In December 2019, European Union (EU) launched the European Green Deal (EGD). In accordance with the EU's environmental policies, one of the EGD goals is for Europe to become the world's first 'climate-neutral' continent, with net zero greenhouse gas (GHG) emissions by 2050. This goal is now also enforced by a legally binding regulation, the European Climate Law, an economy-wide framework law for the green transition, which requires to reduce Europe's net GHG emissions by at least 55% by 2030 compared to 1990 levels.

The aim of the paper is to analyze the progress in achieving EGD goals by EU countries after five years since the implementation of EGD and to highlight the role of artificial intelligence (AI) in accessing and interpreting the climate data. Presently, EU Member States are moving towards climate neutrality but if they want to meet this goal by 2050, they need to better synchronize themselves to a faster pace and more articulated measures. Measuring the results and anticipating future efforts to alleviate some of the most pressing sustainability issues of the twenty-first century requires adequate tools and technology, such as AI.

Keywords: *environmental protection; European Green Deal; AI.*

JEL Classification: F64; Q01; Q58.

1. INTRODUCTION

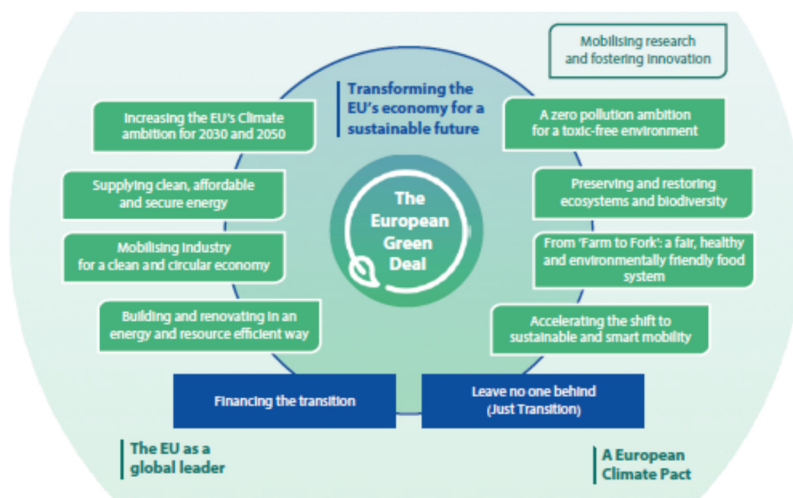
In the 21st century, environmental protection is an essential part of caring for humanity. Environmental protection (EP) includes all activities and actions which have as their main purpose the prevention, reduction and elimination of pollution and of any other degradation of the environment, according to the System of Environmental Economic Accounting (SEEA, 2016).

In December 2019, the European Environment Agency (EEA) warned about environmental challenges of unprecedented scale and urgency that Europe will have to face in the next years. According to EEA (2019, p. 9), if Europe does not take urgent action during the next 10 years to address the alarming rate of biodiversity loss, increasing impact of climate change and the overconsumption of natural resources, Europe will not achieve its 2030 goals.

In this context, the European Green Deal (EGD) was implemented in 2020 as an ambitious set of policy initiatives by the European Commission, strategies and legislative acts aimed at making the European Union (EU) climate neutral by 2050 (Negreiros and Falconer, 2021; Hayes *et al.*, 2022; Křemečková and Šreflová, 2024).

According to this objective, the EGD mentions three targets to be achieved by 2030, respectively: 1) minimum 55% cuts in greenhouse gas emissions; 2) above 32% shares of renewable energy; 3) at least 32.5% improvement in energy efficiency.

These targets are related to the eight key areas (Fetting, 2020) that make up the Green Deal, which are presented in Figure 1.



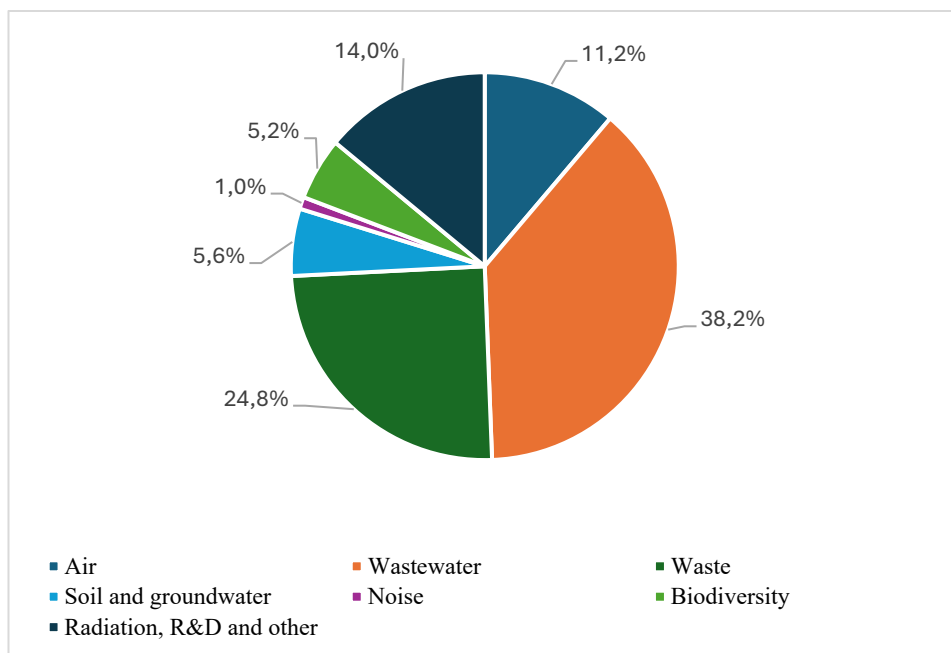
Source: Eurostat (2024, p. 24)

Figure 1. The European Green Deal

The European Green Deal highlighted investment as one of the key levers for the implementation of the EU's climate and environment-related policies. In 2024, the EU invested EUR 76 billion into assets essential to provide environmental protection services (Eurostat, 2025).

In Figure 2 we can observe the distribution of investments for environmental protection by environmental domain, made by all EU countries in 2024. We can

see that the largest number of investments was dedicated to wastewater (38.2%) and waste management services (24.8%). In 2024, only 14% was related to protection against radiation, to environmental RandD and other environmental protection activities, including general environmental administration and education, 11.2% went to air protection, 5.2% to biodiversity and landscape protection, 5.6% to soil and groundwater protection, and the remaining 1% to noise reduction.

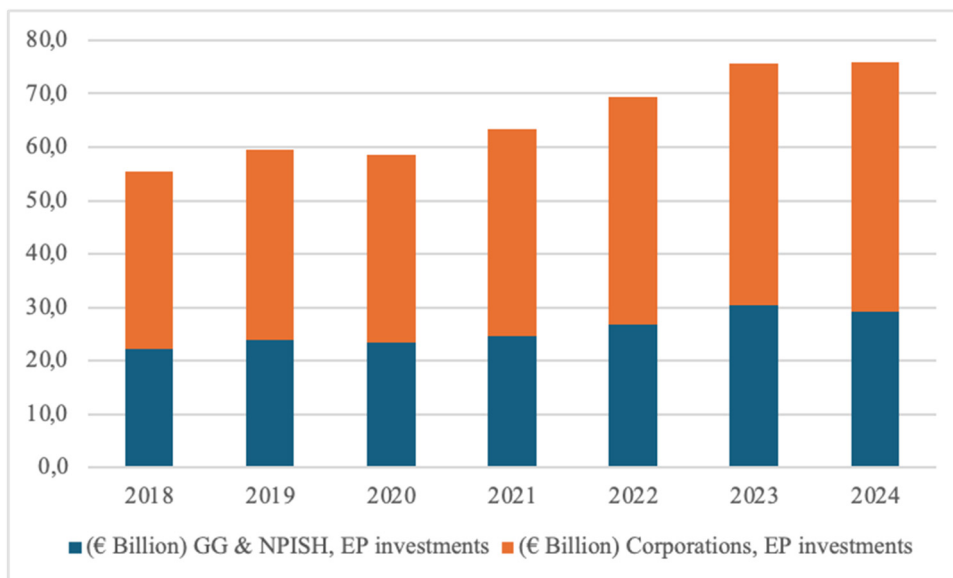


Source: Eurostat (2025)

Figure 2. Investments for environmental protection in EU-27 in 2024, by environmental domain (% of total EP investments)

If we analyze the evolution of investments in EU countries over the period 2018-2024 (Figure 3), we notice the upward trend after 2020, the year when EGD was implemented. Also, during the analyzed period about 59.9 – 61.4% of total environmental protection investments was spent by corporations and the difference 40.1 (2018) – 38.6% (2024) was spent by general government (GG) and non-profit institutions serving households (NPISH).

In this context, the realization of the EGD's multifaceted objectives will require major investments in cost-efficient solutions, beyond diverting former fossil fuel investments to energy efficiency and renewable.



Source: Eurostat (2025)

Figure 3. Investments for environmental protection in EU-27, 2018–2024

The paper is structured as follows. Section 2 reviews the literature regarding EGD and AI, section 3 analyses the progress in achieving the EGD goals and sections 4 presents the conclusions regarding the role of AI in accessing the climate data and interpreting correspondingly to the EGD targets.

2. LITERATURE REVIEW

The EGD is the growth plan for a climate-neutral Europe by 2050 (Koundouri *et al.*, 2024) and comprises distinct areas, including climate action, energy, agriculture, industry, infrastructure, environment and biodiversity, transportation, finance and development, and research and innovation. The EGD functions as an integrated environmental, social, and economic framework, encompassing a wide range of policy areas and initiatives designed to drive the transformation of the EU into a more sustainable and climate resilient society, while promoting economic growth and social equity.

Within this new growth strategy, the environmental dimension is no more undersized compared to the economic one (Paleari, 2022, p. 197), as it emerges from the eight key EGD policy goals, namely, achieving climate neutrality; supplying clean, secure and affordable energy; promoting sustainable mobility; encouraging the transition to a circular economy; supporting to build and renovate in an energy and resource efficient way; creating a toxic-free environment; preserving Europe's natural capital and designing a fair, healthy and

environmentally friendly food system. These goals are indivisible from the scientific point of view, so that we cannot achieve carbon neutrality without substantial progress in all the other thematic pillars (Charveriat and Holme, 2021, p. 8).

The EGD consists of eight major policy areas (as we saw in Figure 1), and each policy area consists of dedicated regulations, strategies and funding sources for related projects that have different stages of maturity but all aim towards the same objective required by “Fit for 55” (Hayes *et al.*, 2022):

- 1) *Increasing the EU's climate ambition for 2030 and 2050* requires at least 55% less net greenhouse gas emissions by 2030, compared to 1990 levels and becoming the first climate neutral continent by 2050.
- 2) *Supplying clean, affordable and secure energy* requires strengthening interconnections between energy systems through the development of modern infrastructure, enhancing energy efficiency, initiating the decarbonization of the gas sector, promoting cross-border cooperation, and fully exploiting the potential of offshore wind energy.
- 3) *Mobilizing industry for a clean and circular economy* necessitates a new industrial policy rooted in circular economy focusing on modernizing industrial sectors through the promotion of climate-neutral and circular products, with particular emphasis on energy-intensive industries.
- 4) *Building and renovating in an energy- and resource-efficient way* asks to construct and renovate energy-efficient buildings (the design should be in line with the circular economy, digitalization, climate-proof), and to develop innovative financing for renovations including social housing, schools and hospitals (leave no one behind strategy).
- 5) *A zero-pollution ambition for a toxic-free environment* means to preserve biodiversity, reduce pollution from excess nutrients, reduce microplastic pollution, review air quality standards, reduce pollution and improve prevention of industrial installations and sustainable alternatives for chemicals.
- 6) *Preserving and restoring ecosystems and biodiversity* requires targeted actions to rehabilitate degraded ecosystems, especially those with high potential for carbon capture and storage, while also aiming to prevent and mitigate the impact of natural disasters.
- 7) *From farm to fork: a fair, healthy and environmentally friendly food system* means to ensure sustainable food production and security, to reduce food loss and waste, to combat food fraud along the food supply chain and to support research, innovation, technology and investments in accelerating the transition to sustainable, healthy and inclusive food systems from primary production to consumption.
- 8) *Accelerating the shift to sustainable and smart mobility (90 percent reduction of GHG by 2050 in comparison with 1990)* supposes to “go

digital” – automated mobility, smart traffic management systems, smart applications; requires using different modes of transports, for example rail or water; means to end subsidies for fossil fuels; to introduce EU Emissions Trading System (ETS) for maritime, road transport and buildings.

Apart from these eight areas, Hayes *et al.* (2022) mentioned separately a ninth area, which refers to provide dedicated funds (Just Transition Fund) for regions with high carbon intensity, which will be disproportionately affected by the transition (*Leave no one behind – Just Transition Mechanism*).

Related to these eight key areas, Olczyk and Kuc-Czarnecka (2025) developed in their paper a composite indicator, the European Green Deal Index (which is a new indicator), to analyze the implementation of the EGD in the EU Member States. This index is based on 26 indicators (Olczyk and Kuc-Czarnecka, 2025, pp. 9-10) proposed by the European Commission, categorized under the three pillars of reducing climate impact, protecting our planet and our health, and enabling green and just transition. Developing a composite indicator is more useful and efficient compared to an individual analysis for all these 26 indicators, one by one, to identify the leading and lagging countries as well as the convergence/divergence between EU countries on their path towards a zero-emission and climate-neutral economy.

Countries that would not be able to achieve the “Fit for 55” targets could face significant consequences, such as financial penalties for noncompliance, which could be substantial (Brożyna, Strielkowski and Zpěvák, 2023, p. 13). Moreover, inadequate action on climate change may have serious environmental and social consequences, such as the rise in the frequency and intensity of natural disasters, shortages of food and water, and public health crisis. These could trigger social unrest and political instability, as people may hold governments responsible for failing to respond effectively to the climate crisis.

There are pros and cons for the EGD. For example, Montini (2021) stated that EGD lacks a coherent approach and fails to integrate its several goals and objectives within a single and comprehensive policy and legal framework. In his study, Montini (2021) highlighted the role that the environmental integration principle, as enshrined in Article 11 Treaty on the Functioning of the European Union (TFEU) may play in this context and, despite observing the negative present state of the environmental integration principle, it concludes with a proposal to give a renewed meaningful role to the principle in the implementation of the EGD.

As it was argued many times, even though it is ambitious, the Green Deal faces numerous major challenges because of its political, economic, social, and technical dimensions.

During the last few years, some of the specialists in the field started to analyze the potential use of artificial intelligence (AI) in order to accelerate towards the

goals of the Green Deal, especially because time is of the essence today more than ever.

Thus, it is believed that AI can enable the implementation of the EU Green Deal by making climate action smarter, faster, and more efficient across multiple sectors. Clean energy, sustainable and smart mobility, building renovation and efficiency, agriculture and the protection of biodiversity, circular economy, monitoring and enforcement, citizen engagement in environmental protection and behavior change are a few of the areas where AI could bring progress (Gailhofer *et al.*, 2021).

To understand how AI can help environmental pursuits, it is important to know what it is and what it can do. There are many and diverse definitions of the AI, depending on the field it can be used or its lifecycle's stages such as research, design, development, deployment, and utilization (UNESCO, 2020). AI systems are considered "technological systems which have the capacity to process information in a way that resembles intelligent behavior" (UNESCO, 2020, p. 4).

A broad language definition that is commonly used in the EU states that AI is based on "systems that display intelligent behavior by analyzing their environment and taking actions – with some degree of autonomy – to achieve specific goals" (European Commission, 2018, p. 2; High-Level Expert Group on Artificial Intelligence, 2019, p. 1). In fact, AI systems are comprised of algorithms and models that can provide the AI system with the ability to act with some level of autonomy (Zuiderwijk *et al.*, 2021). They generate abilities to learn, plan, predict, and control (UNESCO, 2020).

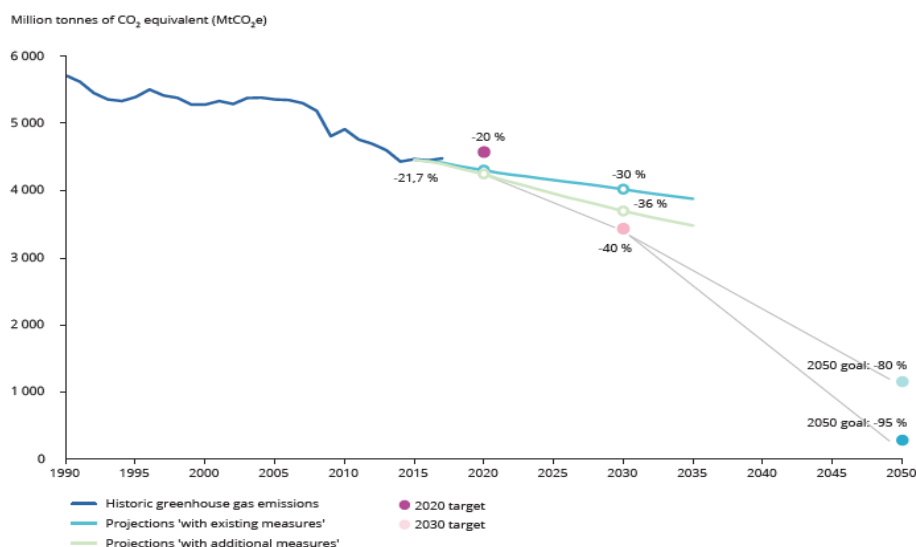
In order to have a successful outcome, the use of advance computing technology for meeting the Green Deal goals requires that AI systems themselves to be energy-efficient (O'Donnell and Crownhart, 2025). Also, public and private actors must share environmental data responsibly and the same EU ethical standards while using AI.

In this respect, the EU AI Act, adopted in 2024, is the first comprehensive legal framework for regulating artificial intelligence in the European Union. Its primary focus is on ensuring that AI systems are safe, transparent, non-discriminatory, and respect fundamental rights. However, critics say that the AI Act, in spite of introducing some environmental transparency (e.g. energy disclosure for general-purpose AI models), is primarily focusing on protecting people from AI risks and lacks binding environmental safeguards for AI developers (Pagallo, 2025).

3. ANALYSIS OF THE PROGRESS IN ACHIEVING EGD GOALS

The report of the European Environment Agency (EEA) highlighted that environmental pressures remain substantial despite the progress in reducing them (EEA, 2019, p. 13) and identified serious gaps between the state of the environment and existing EU near- and long-term policy targets (EEA, 2019, p. 7).

Figure 4 shows that between 1990 and 2017 the total greenhouse gas (GHG) emissions declined by 1.2 billion tons of carbon dioxide equivalent (CO₂e), which represents a reduction of almost 22 % in this period of 27 years. According to the EEA (2019, p. 159) the reduction in total GHG emissions since 1990 means that only the 2020 target was within reach. In this context, significant efforts will therefore be needed to reach the 2030 target and even more substantial efforts, to reach the 2050 objective (EEA, 2019, p. 159).



Source: EEA (2019a, p. 158)

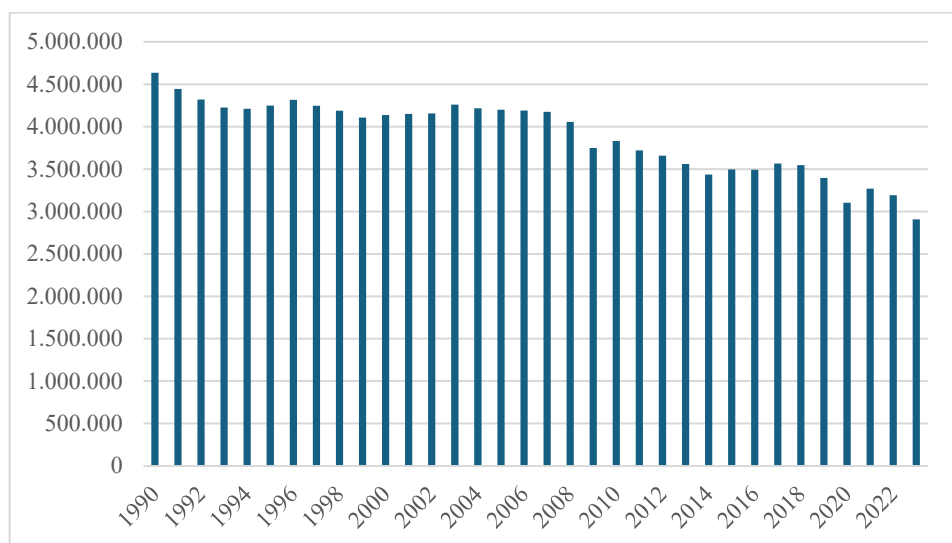
Figure 4. Greenhouse gas emission trends and projections in the EU-28, 1990-2050

The EU is the sum of its Member States, and most Member States have reduced emissions since 1990 (EEA, 2019a, p. 163). Approximately 50% of the EU's net reduction in greenhouse gas (GHG) emissions can be attributed to Germany and the United Kingdom. However, the overall progress made by the majority of Member States was partially counterbalanced by increased emissions in a few Member States. Thus, in the following years, EU and its Member States have to make important efforts in achieving the EGD goals.

According to Montini (2021), the transformation envisioned by the EU under the Green Deal is structured around several priority objectives, three of which are particularly significant for environmental protection. These include the decarbonization goal, aimed at achieving a climate-neutral Europe by 2050; the transition to a circular economy, which promotes a shift from a linear to a circular economic model; and the zero-pollution goal, which underscores the importance

of reviewing and updating environmental legislation, particularly concerning air, water, and soil, with the ultimate aim of creating a toxic-free environment.

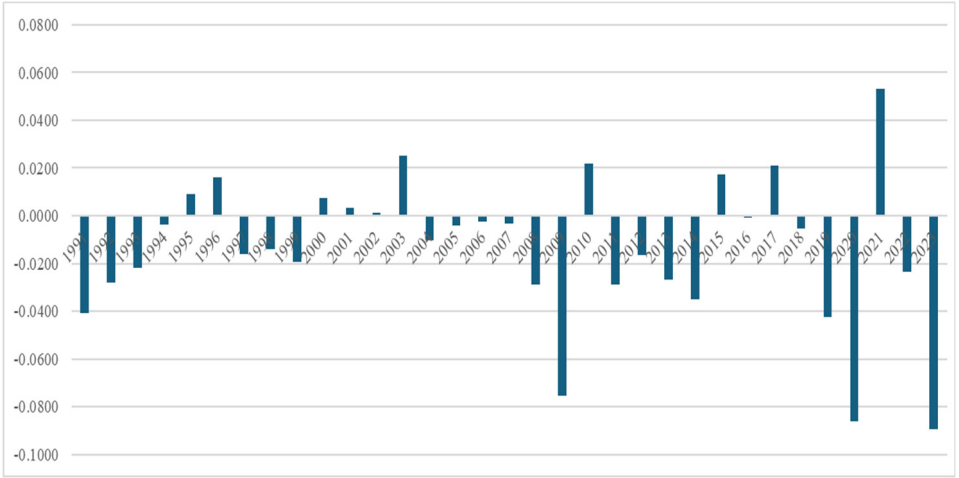
Correspondingly, we analyze and discuss three indicators, which we consider most important (but not sufficient) to highlight the trajectory of EU in the path of accomplishing the EGD targets.



Source: EEA (2025b)

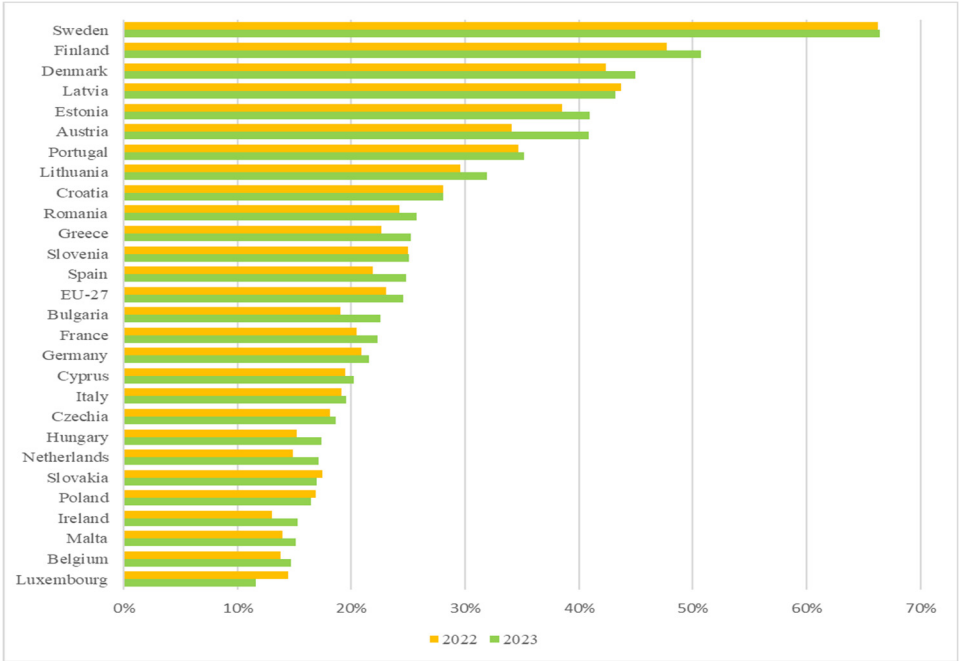
Figure 5. EU-27 emissions, 1990-2023, kt CO₂ eq

It is well established that the increase in CO₂ emissions has been directly linked to climate change. Thus, first, we analyze the evolution of emissions at EU level for the period 1990-2023 (Figure 5). We can observe the downward trajectory of emissions, with a minimum level recorded in 2023 (according to the latest official EU data submitted by the EEA), which represents a reduction by 9% in 2023 compared to 2022 (Figure 6), the largest relative reduction in greenhouse gas emissions in the EU since 1990. This is a good signal that confirms the EU's progress to reduce its share of global emissions.



Source: EEA (2025b)

Figure 6. Annual percentage change emissions in EU-27, %



Source: EEA (2025c)

Figure 7. Share of energy from renewable sources in EU countries in 2022 and 2023

In our opinion, another important indicator is represented by the share of energy from renewable sources (Figure 7) because increasing the renewable energy sources (RES) contributes to reducing CO₂ emissions, improving energy security and to achieving sustainable development goals.

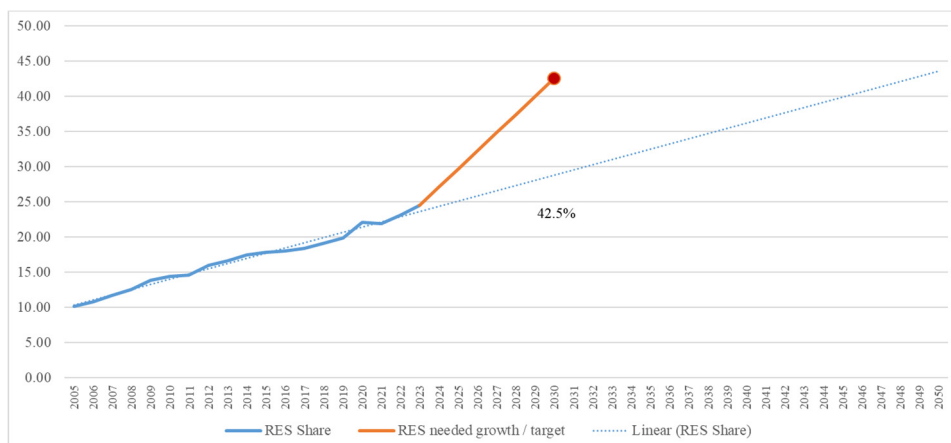
Figure 7 illustrates that in 2023, Sweden, Finland, and Denmark recorded the highest shares of renewable energy sources (RES) among EU Member States. This was attributable to robust hydropower industries in Sweden and Finland, alongside wind energy and extensive use of solid biofuels for district heating. In contrast, Luxembourg and Belgium reported the lowest levels of renewables, with respective shares of 12% and 15%.

Since 2005, Denmark, Sweden, and Estonia have recorded the most significant growth in RES shares, each achieving an increase of over 20%. In contrast, Croatia, Slovenia, and Romania have registered a modest progress, with RES shares rising by less than 9% between 2005 and 2023 (EEA, 2025a).

If we analyze the data on a short term, between 2022 and 2023, as illustrated in Figure 7, 22 EU Member States registered an increased their RES shares. Austria, Bulgaria and Finland dominate the ranking, having increased their RES shares by 3% or more in 2023. In contrast, Latvia, Slovakia, Luxembourg and Poland decreased their RES shares, compared to 2022.

If we analyze the progress towards RES targets at EU level (targets were not introduced for individual countries, but each Member State will contribute to this common target) we noticed that in 2023, the share of RES increased by 1% compared to 2022, reaching the level of 24.5%. This increase represents a historical high following the adoption of the revised Renewable Energy Directive.

As we have mentioned in the Introduction section, high levels of investment are needed to meet the 2050 goals of the EU Zero Pollution Action Plan. This plan aims that by 2050, the EU to reduce pollution to the extent that it no longer harms human health and natural ecosystems.



Source: EEA (2025c)

Figure 8. Progress towards renewable energy source targets for EU-27

The most recent report of EEA (2025c) presents the evolution of the zero pollution targets for 2030. There are six core targets and three of them have also sub targets and as we can see from Table 1, only target 1 and target 4b are on track to meet the target by 2030; target 4c, 4d and 5a indicate that the EU is likely on track, so they indicate that are chances to meet these targets by 2030; target 3, target 4a and target 6a indicate that the EU is unlikely on track and two targets, 5b and 6b are definitively showing that EU is off track to meet the target by 2030. Thus, progress is uneven and the best results have been achieved in reducing the health impacts (premature deaths) of air pollution and reducing the use and risk of chemical pesticides.

The answer to the question “will the EGD objectives be achieved in 2030 and 2050?” should not be based only on the synthetic analysis of three indicators (the evolution of emissions, share of energy from renewable sources and zero-pollution), but on a series of indicators whose processing is and will be much more efficient with the help of AI.

In this study we considered only a few indicators, but according to United Nations Environment Programme Data Catalogue (2025) there are 21637 total datasets available, which is difficult to analyze and interpret manually.

Although an unprecedented amount of climate data is now available, effective crisis management depends on how this data is accessed, interpreted, and utilized. AI plays a central role in enabling this process.

Table 1. Zero pollution target analysis for 2025

Target	Content	Value	Progress
Target 1	Reduce by more than 55% the health impacts (premature deaths) of air pollution	- 45% Baseline year 2005	On track
Target 2	Reduce by 30% the share of people chronically disturbed by transport noise	-2% Baseline year 2017	Off track
Target 3	Reduce by 25% the EU ecosystems where air pollution threatens biodiversity	-13% Baseline year 2005	Unlikely on track
Target 4	a) Reduce nutrient losses by 50%	Stable Baseline year 2012-2015	Unlikely on track
	b) Reduce the use and risk of chemical pesticides by 5 %	-46% Baseline year 2015-2017	On track
	c) Reduce the use of the more hazardous chemical pesticides by 50%	-25% Baseline year 2015-2017	Likely on track
	d) Reduce the sale of antimicrobials for farmed animals and in aquaculture by 50%	-28% Baseline year 2018	Likely on track
Target 5	a) Reduce plastic litter at sea by 50%	-29% Baseline year 2015	Likely on track
	b) Reduce by 30% microplastics released into the environment	+7 to +9% Baseline year 2016	Off track
Target 6	a) Reduce significantly total waste generation	-0.5% Baseline year: not defined	Unlikely on track
	b) Reduce residual municipal waste by 50%	-1.5% Baseline year: not defined	Off track

Source: EEA (2025b, p. 11)

According to Jensen, coordinator of the Digital Transformation subprogramme at the United Nations Environment Programme (UNEP, 2022), AI refers to systems or machines capable of performing tasks that traditionally require human intelligence, and which can progressively enhance their

performance over time by learning from the data they collect. Also, Jensen identifies several domains in which AI can contribute to addressing environmental challenges, ranging from the design of energy-efficient buildings to deforestation monitoring and the optimization of renewable energy deployment. He notes that AI applications can operate at various scales, such as using satellite data to monitor global emissions or, at a more detailed level, enabling smart homes to automatically switch off lighting or heating after a set period. One example in this respect is the UNEP's World Environment Situation Room (WESR), launched in 2022, which uses AI to analyze complex and multidimensional environmental datasets.

Overall, it is undeniable that AI has a strong potential to accelerate the achievement of EGD goals. However, EU needs to enhance its regulatory framework for AI use that will enable a deep coordination between technological innovation and EU environmental policy.

4. CONCLUSIONS

The present research showed that the road to achieving the EGD's ambitious objectives is not without its hurdles. We agree with Pisani-Ferry, Tagliapietra and Zachmann (2023) affirmation that stated that meeting the EU's climate-change mitigation goals will require EU countries to take increasingly challenging decisions in the next few years. To align the EU governance framework with increasing climate ambitions and challenges, greater centralization for ETS and stronger incentives are needed to ensure that Member States will follow the same unified plan. In addition to delivering direct benefits in terms of energy and climate outcomes, such an approach could also generate substantial benefits for other EU goals, including innovation, industry, competitiveness, nature conservation, digitalization, and public health (Pisani-Ferry, Tagliapietra and Zachmann, 2023, p. 18).

The overall success of the EGD will be based on the development and implementation of a wide range of strategies and regulations across its eight priority areas. The reduction of greenhouse gas emission illustrates the complexity of balancing diverse interests and the challenge of achieving the broader objective of contributing to the 2030 Agenda and the Paris Climate Agreement. While the 55% emission reduction target has been criticized by scientists and climate activists as being insufficient, stakeholders whose livelihoods depend on the fossil fuels view it as too ambitious (Fetting, 2020).

The EGD is a product of the EU's green and development policies, and the theory is currently a bit ahead of practice in this field, strategically aiming to promote sustainable development and green transition. The EGD main objectives consist of a wide set of parallel and concurrent goals (Montini, 2021, p. 97) and given the variety of those goals, it is not easy to predict whether it will be possible to achieve all of them within the fixed time frame. In this context, we consider

that AI could help accelerate the achievement of Green Deal goals through data-driven decision-making, precision solutions especially in agriculture, industry, and energy. It could also quantify the progress made and help making accurate climate predictions and scenario planning for policymakers.

At the same time, AI systems could track companies' emissions and resource use and thus could help to better monitor the implementation of EGD standards by companies, detecting "greenwashing" practices. Specialists are unsure if companies' current adoption and promotion of eco-standards reflect genuine commitment or merely serves as "greenwashing" (Gajović, 2024), a tactic to enhance profits through symbolic environmental actions. Alternatively, their attitude may indicate limited financial capacity or a lack of awareness regarding the long-term economic benefits of green investments.

However, the use of AI is directly linked to accurate environmental data and, since environmental protection is a global effort, the access to AI should be granted to all, ensuring that all regions, especially rural and underserved ones, can benefit from AI tools.

This paper contributes to the extensive discussion on EGD role in promoting Europe to become the world's first 'climate-neutral' continent, with net zero GHG emissions by 2050, by analyzing some of the key policies area, which have been set by the European Commission at European level. Future research can investigate comparatively the progress of achieving EGD goals by the EU-27 countries, using a composite indicator, similar to European Green Deal Index developed by Olczyk and Kuc-Czarnecka (2025), but which will comprise the three pillars of sustainability: environment, economy, and social needs.

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DIGITAL TRANSFORMATION AND DIGITAL MATURITY MODELS IN DIGITAL YOUTH WORK SECTOR: A CRITICAL REVIEW

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Abstract

Digital transformation represents a new paradigm across various sectors of activity, but its implementation in the youth work sector is still at an early stage of research. This article is a critical review of digital maturity and digital transformation models, exploring popular theories, dimensions and methodologies from corporate, public and EU education sectors. The purpose of the review is to outline strengths and limitations of existing models when applied in the context of youth organisations. While we identified common dimensions addressed, such as strategy, culture, technology and data governance, current models are tailored for profit-driven environments and neglect challenges faced by youth organisations, for example: resource limitations, dynamic evolution, participatory governance and the need for ethical practices in digital world. Furthermore, emerging trends (such as AR/VR, AI, blockchain, etc.) are under-represented in conventional maturity frameworks. This having the potential to reshape digital youth work, in conclusion we emphasize the necessity of a forward-looking model that is tailored for youth NGOs. The findings of this review lay the theoretical foundation for designing such a model, which should not only evaluate current digital capacity, but also suggest ways to navigate towards a more participatory, secure, inclusive and innovative digital future.

Keywords: *digital youth work; digital transformation; digital maturity; digital maturity model.*

JEL Classification: O14; O32; O33.

1. INTRODUCTION

Digitalization is a process which requires changes in organizations, at different levels of information and interactions, with the goal of making the overall activity more efficient (reduce costs, improve processing times, raise the

impact), through technology integration (Parviainen *et al.*, 2017). One recent study showed that the main focus in the area of digital transformation is on ensuring security and on creating implementation strategies (Gartner, 2025).

Depending on the sector of activity for an organization, there is a need to adapt this process to the sector. In the field of youth work, there are no models dedicated to digital transformation, not even a strategy to approach this process (Stefan, 2022). This conclusion is extracted from a research at European level, which involved Erasmus+ National Agencies working in the youth field. At the same time, even though there are different interpretations or perceptions in youth work (Siurala, 2022), the term “digital youth work” refers to “utilising digital media and technology in youth work, as a tool, activity or as content, in online interactions, face-to-face or both” (European Commission, 2017).

Studies show that non-governmental organizations (NGOs) feel the need to adapt and shift their activity towards the space where youths already are, which is the digital space. In a study, 87% of the interviewed non-profit representatives consider online communication and online presence as important in achieving their organisations’ missions (Twilio, 2024). In this context, at European level, the adoption of technology to empower young people has been set as a strategic direction (SALTO, 2024). This will facilitate their access to information, to active citizenship and to opportunities for connecting/speaking out. However, achieving this goal depends on different factors such as access to digital tools or the development of basic digital competences among young beneficiaries/youth workers (Council, 2017), otherwise the risk is to deepen digital divide in society.

While there is an international push towards digitalization in the youth sector, there are gaps in terms of assessing and guiding the digital transformation itself. First obstacle is the lack of a digital maturity model tailored to youth organizations. In this sense, digital maturity is defined as how organizations systematically adapt to digital change (Kane *et al.*, 2017). It is also about the adoption of emerging technologies such as Artificial Intelligence (implicitly Big Data), IoT, Blockchain, 3D Printing (Ochoa-Urrego and Peña-Reyes, 2021), but a first challenge in their adoption in organizations through a digital transformation process is the assessment of the current level of digital maturity or development (Blatz *et al.*, 2018) (UPCORE, 2024). At this point, a digital maturity model is a conceptual framework that can facilitate an initial assessment (by comparison with other organizations or with defined stages in the model) (Berghaus and Back, 2016). It can also determine an action plan to guide the digital transformation process (Ochoa-Urrego and Peña-Reyes, 2021). Each model has its particularities, with different dimensions, which may or may not include development measures (Aslanova and Kulichkina, 2020). Therefore, this article will provide different examples of digital maturity models identified in the literature, with features and dimensions, together with a critical analysis of the features needed by youth organizations in order to propose a tailored model in the future.

Youth organizations, thus youth professionals too, although they share the need of digital transformation (Pazer, 2024), they operate in a context described by: limited resources, staff represented by volunteers or few in number and a mission based on non-formal education, social inclusion, civic participation, and less on profit or cost efficiency (as are most models studied and operationalized predominantly in large commercial or institutional contexts) - (RAY-DIGI, 2024). Thus, in the absence of a tailored framework, digital transformation in youth work depends on contextual factors or individual initiatives, emphasizing the need for a unified digital maturity model designed for the realities of the youth sector.

2. METHODOLOGY

For this article we had a systematic approach in finding articles, journals, analysis or relevant reports, in order to have a larger view regarding digital transformation and digital maturity. The results were correlated to the intersection of the youth sector and the digital sector (digital youth work).

We established the keywords for the searches, those being: *digital youth work*, *digital transformation*, *digital maturity*, *digital maturity model*. The research questions we formulated are: 1. *What approaches are there in the youth sector regarding digitalization or digital transformation?* 2. *What such approaches from other fields of activity are suitable for the youth sector?* Initial results showed that there are no maturity models in the youth sector, therefore we proceeded to analyze in a critical way models from other sectors in order to identify traits, dimensions and levels suitable for the youth sector.

In order to identify the documents, keywords were used for searches on relevant platforms such as Scopus, Clarivate, Google Scholar and ResearchGate, filtering the results based on citations, availability and date of publication (last 20 years, to show recent evolutions and actual perspectives). Articles with no citations were excluded for relevancy reasons. Older studies were included to lay theoretic foundation, for example the ones about the first maturity models. Also, we consulted reports and studies from official European sources (documents from the European Commission, European Council, institutions working in the youth field, platforms such as SALTO or European Project Results Platform).

3. CONCEPTS RELATED TO DIGITAL TRANSFORMATION

The concept of digital transformation refers to the integration of technology across areas of an organization, generating changes in operations and value creation (Vial, 2019). Linked to this concept, there are 2 terms that are often confused and need to be differentiated: digitization (the conversion of information from analogue to digital format) and digitalization (the use of technology in redesigning activities or processes) – (Mikalef and Parmiggiani, 2022). While digitization and digitalization are initial technology-based steps, digital

transformation involves a strategic approach to drive change in the organization across multiple areas.

According to a definition found in the literature, "digital transformation is a process that improves an entity by triggering changes to its properties through combinations of information, computing, communication and connectivity related technologies" (Vial, 2019). It is not only about the adoption of technological tools, but it implies changes in structure, culture, strategy and decision-making. The digital shift can lead to new ways of working and redefining roles in the organization (Gimun *et al.*, 2011). Many organizations therefore have dedicated structures (digital transformation office, roles such as Chief Digital Officer, etc.) – (Jewer and van der Meulen, 2022). Another aspect is organizational culture. Organizations with a culture oriented towards collaboration, innovation, agility and data-driven decisions are more likely to leverage digital transformation - (Deep, 2023). Leadership has a central role to play. Although digital transformation is generally perceived as a linear process following a similar path across organizations, studies question this approach (Remane *et al.*, 2017), (Thordsen and Bick, 2023).

Sometimes, the concepts of digital transformation and digital maturity are used without considering the differences (Leipzig *et al.*, 2016). Digital maturity refers to the level of digital development that an organization has reached and, thus, to its ability to use technologies to achieve its mission. Although the views differ between authors, the concept integrates a holistic character, a multi-dimensional assessment (regarding technology, skills, processes, strategy, culture, etc.) and reflects a state of digital evolution at a certain point in time.

At this point, it is useful to distinguish digital maturity from other concepts often used together, such as digital readiness or digital capability. Digital readiness implies a forward-looking perspective and a willingness to change, assessing an organization's readiness to adopt digital technologies in its culture, strategies and operations, in order to be able to embark on the digital transformation journey. Digital transformation is the actual process of technology integration. Digital maturity focuses on the state achieved in the process. If readiness is about potential, transformation is about plan and action, and maturity reflects the cumulative outcome of digital efforts (Nasution *et al.*, 2018; Soomro *et al.*, 2020; Chounta *et al.*, 2024). Similarly, digital capability refers to the specific skills and resources (competencies, IT processes, infrastructure, etc.) that the organization has, indicating how these capabilities are organized and integrated for transformation / innovation (Khin, S. and Ho, T. C. F., 2019).

4. MODELS IDENTIFIED

Numerous conceptual models have been proposed in the literature to assess the digital maturity of organizations. Based on their purpose, there are different types of digital maturity models (the ones we identified being in table 1):

- Descriptive: it assesses the current situation in the organization;
- Prescriptive: it can suggest improvements for evolution;
- Comparative: it can calculate a score and benchmark.

Table 1. List of identified models according to sector of activity and purpose

Sector/Area	Model identified	Purpose
IT software	CMM, CMMI	Descriptive, prescriptive
Research	TRL	Descriptive
Business / corporate	MIT-Capgemini, Deloitte, McKinsey Digital Quotient, MIT CISR, Gartner, KPMG, Forrester/PwC	Comparative, descriptive
Manufacturing	Industry 4.0	Descriptive, prescriptive
Telecom	Valdez-de-Leon Telecom Model	Descriptive
Public Administration	DGMM (Layne & Lee, PPR, Di Maio & Cannon)	Descriptive
Education	DigCompOrg, SELFIE	Descriptive
NGO / nonprofit	NDMM (Gooyabadi), Salesforce Nonprofit Digital Index	Descriptive, comparative

Source: own representation

Following a review of the literature, among the first digital maturity models to emerge is the Capability Maturity Model (CMM) in 1986. It is inspired by the *6 Stages of Growth Model* - initiation, contagion, control, integration, data management, maturity (Nolan, 1993), as well as by Watts Humphrey's principles in *Managing the Software Process*. The term "maturity" refers to the organization's ability to coordinate maintenance and development processes, through effective internal communication, constant planning and monitoring, and improvements based on cost analysis and testing (Paulk, Curtis and Chrissis, 1993). Thus, the CMM defines 5 maturity levels: 1 – initial, 2 – repeatable, 3 – defined, 4 – managed, 5 – optimized. In 2006, In order to unify the maturity models that emerged later (with different orientations in different sectors of activity), the Capability Maturity Model Integration (CMMI) model appeared, extending CMM to more fields of activity. CMMI keeps the 5 maturity levels coming from CMM, but also introduces the concept of process capability, with a scale from level 0 to 3 for each individual process, evaluated separately (0 - incomplete, 1 – executed, 2 – managed, 3 – defined). Thus, the organization has a general maturity level (with a set of processes at each level), but also a capability level in process areas, grouped by categories such as project management, process management, engineering and support (Constantinescu, 2007). This allows general evolution and flexibility to develop specific process capabilities.

Another model identified in the literature is Technology Readiness Levels (TRL), which proposes to assess technological maturity. Initiated in 1970 by NASA (Héder, 2017), it is widely used in different domains, including research projects. In 2012, it was introduced as a benchmark in European funded programs (Horizon 2020 or Horizon Europe) to indicate how ready a research product is for the market and what further steps it should take. Thus, TRL adds the dimension of technological readiness. In the context of youth organizations, this would translate into assessing the readiness of the organization to adopt a particular digital technology or innovation.

According to a study, over the time digital maturity models have received increased interest since 2011-2012, first due to practitioners from industry and consulting companies, later joined by a larger number of researchers from academia since 2016 (Teichert, 2019). The same author notes that today there are multiple models for different business sectors, but they come with a number of limitations: they provide descriptive assessments (telling the level at which the organization is at), but do not provide guidance towards evolution.

In the business sector, an example is the MIT/Capgemini model, which introduces the idea of assessing companies along 2 axes: digital intensity (technology adoption in operations and customer experience) and the intensity of change management (in leadership, culture, governance). These two axes determine 4 quadrants: beginners (management experimenting but reluctant about the added value of technology), conservatives (having a slightly shaped digital vision as well as various basic digital capabilities at a mature level), fashionistas (with many digital functionalities developed according to trends, but no clear coordination or vision) and digirati (with vision, clear governance, initiatives and digital culture in the organization) (Westerman *et al.*, 2011).

Several specific frameworks have been developed in the consulting sector, often with an emphasis on a strategic dimension. Deloitte's Digital Maturity Model identifies a series of 7 digital pivots or capability areas that companies need to develop (Deloitte, 2019): flexible and secure infrastructure, data analytics, digital interest and talent, ecosystem interaction, intelligent workflow, consistent customer experience, adaptive business model. Deloitte believes the development of the above areas in a business leads to increased maturity overall and improved performance. At the same time, from their observations they also note the increasing importance of factors such as strong leadership or the existence of a digital mindset, in order to grow digital maturity. At the same time, the McKinsey Digital Quotient model provides a quantitative analysis of practices in the organization across 4 areas: strategy, culture, organization and capabilities, resulting in a score that is correlated to financial performance (Catlin, Scanlan and Willmott, 2015).

There are a number of digital maturity models that are domain specific. In Industry 4.0, which merges Internet of Things (IoT) technologies with the

manufacturing ecosystem, we identify a specific model for factories that embrace automation, computerization and smart connectivity. Another example that depends on the domain is the Telecom digital maturity model by Valdez-de-Leon in 2016. It identified 7 dimensions for telecom companies: customer experience, strategy, technology, operations, organization, ecosystem, and innovation, along with a scale of 6 maturity levels for specific industry descriptors (from 0 – not started to 5 – pioneer).

In the institutional public sector (in administration and government services) we identify digital transformation models, also known as *Digital Government Maturity Models* – DGMM (Wara, 2025). In this context, the focus shifts to the efficiency of public services and meeting citizens' needs. The need for digitalization stems from demographic limitations or society's expectations of fast online services and transparency. In the state education sector we identify some notable contributions such as the DigCompOrg framework, with a model for schools' digital capacity, but also SELFIE, a tool for self-assessment of maturity (European Commission, 2025). Focus here is more on digital learning support, but the structural approach is similar to models in business area.

In the non-profit or NGO sector we have not identified digital maturity models widely adopted in the sector, this field relying more on ad-hoc assessments through questionnaires, surveys or internal analysis. Recently, there has been growing awareness of the digital divide in the sector, and Salesforce.org has developed a tool to assess digital maturity index in nonprofit organizations. In 2022, only 12% of nonprofits had a high level of maturity, about 1 in 8 organizations (Salesforce, 2022). In this regard, knowing that digital tools are necessary for fundraising, service delivery and community engagement (CommunityForce, 2025), a model of nonprofit digital maturity, the *Nonprofit Digital Maturity Model (NDMM)* – (Gooyabadi *et al.*, 2022) – has recently been proposed. All in all, the models we reviewed are underneath (Table 2).

Table 2. List of identified models according to sector of activity and purpose

Sector/Area	Model	Short description
IT / Software	CMM	5 levels, process evaluation, rigid
Organizational	CMMI	Extends CMM, includes process capability, more flexible
Product research	TRL	9 technology levels, used in Horizon Europe
Business	MIT/Capgemini	2 axes: technology & digital leadership
Consulting	Deloitte	7 strategic areas, descriptive model
Consulting	McKinsey Digital Quotient	Score on strategy, culture, capabilities

Sector/Area	Model	Short description
Research	MIT CISR	4 dimensions: strategy, organization, processes, technology
Consulting	Gartner	5 dimensions, assessment and step by step progress
Consulting	KPMG	6 dimensions, holistic approach
Manufacturing	Industry 4.0	3 stages, factory specific
Telecom	Valdez-de-Leon (2016)	7 dimensions, 6 levels, adapted to the telecom industry
Public administration	DGMM (Layne, PPR, Di Maio)	3-5 dimensions, focus on public services
Education	DigCompOrg / SELFIE	Digital self-evaluation tool for schools
NGO/Nonprofit	NDMM (Gooyabadi <i>et al.</i>)	Adapted to non-profit environment
NGO / Nonprofit	Salesforce Nonprofit Index	Assessment tool

Source: own representation

5. COMMON DIMENSIONS AND LIMITATIONS

Despite the diversity of models, the literature highlights the recurring appearance of some dimensions addressed in digital maturity models. For the youth work sector, the most relevant common dimensions among the models discussed above are strategy, culture, technology and data management. For each we can name example of measure or activities related to youth work:

- Strategy and vision: the organizations have a digital strategy which aligns with the mission, therefore a dedicated plan for digital transformation and a leadership supporting it (or other empowered roles). Examples: digital plans for online communication, digitalized volunteers' management (with a platform and procedures), internal documents with the strategy of technology supporting social impact.
- Culture: the organization values innovation, it is open to change, knowledge sharing and continuous learning, such as in the agile principles. Examples: the team tests regularly new platform to attract youths, members are encouraged to participate in digital initiatives, constant networking and exchange of good practices are encouraged.
- Technology: this is related to the infrastructure needed to drive digital transformation or growth in digital maturity. It includes IT architecture and hardware (equipment, devices), software (applications, online platforms, management systems), but also cyber security. Examples: online platforms to coordinate members' work, tools for project-

management and internal collaboration, live-streaming from the youth events, safe storage of youth members data.

- Data management: this dimension is related to collecting, storing, protecting and analyzing data. Examples: databases with members and beneficiaries of the youth organization, monitoring indicators during the project, CRM instruments for managing human resources, internal policies regarding access, protection and usage of personal data collected.

At the same time, models identified have limitations when reported to the youth NGO environment. Those limitations are included in Table 3.

Table 3. List of limitations of the models analyzed from youth sector perspective

Limitation	Models affected	Comments
Financial/profit performance orientation	MIT/Capgemini, Deloitte, McKinsey Digital Quotient, MIT CISR, Gartner, KPMG	Focus on <i>customer experience</i> , profit, financial efficiency, inconclusive for NGO social impact
Assume large organizational size	CMM, CMMI, Industry 4.0	It needs dedicated departments and small budget or volunteering NGOs can't afford
Voluntary nature of the workforce	CMMI, MIT/Capgemini, Deloitte, NDMM, Salesforce Nonprofit Index	Lack of indicators on retention, training and digital competence of volunteers
Lack of sector specificity	CMM, CMMI, MIT/Capgemini, Deloitte, McKinsey, MIT CISR, Gartner, KPMG, TRL	It doesn't cover specificities of youth NGO, such as digital communities or participatory governance
Neglecting the participatory dimension	DGMM (Layne, PPR, Di Maio), DigCompOrg / SELFIE	Direct involvement or participation of beneficiaries / members in decisions are not measured

Source: own representation

6. CONCLUSIONS

The youth sector is developing a more clear vision regarding digital transformation. Recent EU policy frameworks such as Smart Youth Work which sets out the role of digital for youth empowerment (Council of the European Union, 2017), or digital capability self-assessment initiatives are emerging (only as a questionnaire for the time being) - (SALTO, 2023). Without a digital maturity

model recognised as a standard, it is difficult to assess a youth organization which wants to develop a digital transformation project or initiative. When applying for funding, such a recognised framework would be needed, for organizations and for funding entities. For example, European Commission could benefit from a more efficient and structured way to allocate project funding if organizations come already with a standard assessment.

This critical review revealed that the maturity models for corporate, public and other environments provide valuable examples, but do not exactly fit the ecosystem of youth organizations. On the one hand, they share a common core of dimensions – strategy, culture, technology, data – which are the pillars of any digital transformation. A clear digital strategy and an organizational culture supporting innovation are necessary for both an NGO and a company. On the other hand, the strengths of existing models can become limitations as the context changes: the corporate area focuses on profit and efficiency, and it does not reflect the mission and social impact of youth NGOs; governmental models risk ignoring direct youth beneficiary consultation or participation; educational models require institutional infrastructures that small NGOs do not have. In addition, being general in their approach to innovation, the models suffer from a lag in keeping up with new technological realities (AR/VR, AI, blockchain, etc.), which may lead organizations to embark on a digitization path in aspects that are already technologically outdated.

Therefore, the need for developing a youth NGO sector-specific digital maturity model emerges, a conclusion supported by other reports identified during the research. This model should have a bottom-up building approach, starting from the realities and objectives of the youth and the youth organizations. Also, the proposed future model should take into account the following principles that can be extracted as a result of the analysis: participative approach towards digital transformation (youths being co-creators), adaptation to scale and resources (the model being flexible for small youth NGOs or big federations), constant evaluation of perceived impact and innovation (with indicators for how quick they learn to use a new technology or integrate new trends) and online safety (while also inspiring digital ethics).

Future research is needed in order to establish if a new maturity model is more suitable to be tailored on the NGO sector or the more specific youth sector. Variables such as age, gender, interests, cultural heritage or others need to be analysed to find out if they represent differentiators in such a model.

As digital transformation goes on in society, the youth sector has the opportunity and the responsibility to follow this trend. A sector-specific digital maturity model would act as a roadmap for this journey, helping organizations to realistically assess where they stand and plan development on key dimensions needed for the future.

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THE DIGITAL ERA AND ITS IMPACT ON MONEY LAUNDERING

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Abstract

This article analyses, from an interdisciplinary and contextual perspective, the issue of money laundering, with a particular focus on its occurrences in the digital context, especially via the use of online platforms – known in the legal literature as cyber laundering. The article presents the main ways in which this type of criminal behavior materializes, such as cryptocurrency transactions, online banking, online auctions, and online gambling, thus illustrating the methods used by cybercriminals in order to cover up the illicit origin of the funds.

The issue of money laundering portrays, from an economical perspective, a facet of the informal, covert, underground economy, which legally translates into a series of operations aiming to confer an illusion of legality to the profits resulting from criminal activity. The effects of this scourge are destructive for the harmonious functioning of society, distorting the market economy and the competitive market, while generating financial instability and leading to an increase in corruption and organized crime.

Within the context of the digital era, this article explores the impact of technology on the evolution of the practice of money laundering and discusses the new methods used in such criminal activity, while simultaneously dealing with the way in which the new technologies, such as artificial intelligence, can be used in order to prevent and counter the practice of money laundering.

Keywords: *money laundering; artificial intelligence; cybercrime; cyber laundering; crypto-assets.*

JEL Classification: K14; K24; K42.

1. INTRODUCTION

The digital era we are living in, is a period in which new technologies, such as the Internet, computers, artificial intelligence and communication networks, have become frequent in social, economic, cultural and institutional life and it influences the way people communicate, work, learn and access information.

Technological progress brings numerous benefits and facilitates the development of contemporary society, but at the same time, it creates new criminal opportunities. Crimes committed in cyberspace have been defined by the Council of Europe, through the Convention on Cybercrime (2001), as “those

committed against the integrity, availability and confidentiality of information systems and telecommunications networks or those committed by using them to commit traditional crimes” (Niță *et al.*, 2024, p. 572).

The crime of money laundering is associated with organized crime and it affects the social and economic order and the Rule of law. Criminal activity undermines the economy, affects trade activities, harms the system of free competition, supports the activities of organized crime and obstructs the proper administration of justice.

The specialised doctrine considers that the prosecution of money laundering activities and the seizure of the proceeds of the crime, can be regarded as a new strategy in the fight against organized crime, as it targets directly the engine of organized crime development (the money or goods obtained from criminal activities and the funds used for criminal purposes) (Jurj and Șaguna, 2022, p. 7).

The fight against money laundering has a dual objective, namely preventing the development of organized crime by depriving them of funds, as well as creating a solid, integral and stable economic and financial system. (Dobrescu and Cucu, 2023, p. 15)

From a legal perspective, money laundering is defined as “the operation of disguising profits resulting from committing crimes, transferring money that came from illicit activities, through various transactions with the role of concealing their real source and origins” (Urda, 2016, p.116). From an economical perspective, it represents a “way of manifestation of the informal, hidden, underground economy” (Hotca, 2019, p. 10).

According to the Council of the European Union (2023), it is estimated that between 715 billion euros and 1.87 trillion euros are laundered annually, which is between 2% and 5% of the Global GDP. In this context, it can be stated that the phenomenon of money laundering currently represents one of the most serious problems the global economy is facing.

2. CYBERLAUNDERING AND MODERN TECHNOLOGIES

The impact of technology on contemporary society has facilitated the emergence of new techniques and methods of money laundering, enclosed in the concept of cyber laundering, which refers to “the use of the Internet in cyberspace to conceal the illicit origin of values money or other assets) obtained from criminal activities” (Coman, 2022, p. 118).

According to the specialized literature, cyber laundering represents “the use of an information system in order to carry out a transaction involving property or profit, whether tangible or intangible and originating from criminal activities” (Leslie, 2014, p. 56, cited in Moise, 2016a, p. 278).

Investigating money laundering in cyberspace involves proving the existence of a predicate offense from which the illicit funds were obtained, demonstrating the activity through which the criminal proceeds were hidden, for example,

performing a transaction through an information system, as well as proving knowledge or suspicion regarding the illicit origin of the funds, and the intentional use of these illegal funds in various transactions, carried out in order to create an appearance of legality (Moise, 2016a, p. 279).

2.1. Crypto-assets

Electronic payment systems can be characterized as one of the most widely used money laundering activities. In the case of multiple transfers made in order to hide the illicit origin of the funds, the payor and the real receiver may be one and the same person, while using false identities or intermediary people to make these transfers (Jurj and Şaguna, 2022, p. 146).

While efforts are made to provide information regarding the payor and the receiver in electronic money transfers, there are difficulties in investigating money laundering cases when these systems include not only banks, but also currency exchange houses or other financial institutions that have multiple access points and that facilitate anonymous exchanges and rapid transfers (Jurj and Şaguna, 2022, p. 146).

The National Office for the Prevention and Combating of Money Laundering in Romania (2025) indicates in a report the existence of a significant difficulties in the efforts made to prevent and combat money laundering in the field of crypto-asset transactions, due to the virtual characteristics, which allow anonymity, as well as the rapid and global transfer of value

Europol has drawn attention to the use of crypto-assets for the purpose of making payments connected to corruption and money laundering activities, being an area that generates real concern, due to the absence of a common regulatory framework and the level of anonymity that these products offer (Europol, 2021). Specialised studies reveal that the efforts to combat money laundering at the global level are only 0.1% away from a total failure (Cassara, 2017, p. 5), especially in the new era of crypto-assets (Jurj and Şaguna, 2022, p. 1).

At European level, constant efforts are being made to adapt the legislation to the new challenges determined by technological evolution, which has offered new criminal opportunities, such as terrorist financing, drug trafficking, tax evasion and other illegal activities in the financial sphere.

In Romania, the regulatory framework managing the prevention and the combat of money laundering and terrorist financing, Law no. 129/2019 (Official Gazette no. 589/2019), was recently amended by the legislator through Government Emergency Ordinance no. 10/2025 (Official Gazette no. 225/2025), by transposing the requirements of Regulation (EU) 2023/114 on crypto-asset markets into national legislation. The main changes that have been introduced relate to: updating of terminology and the expansion of definitions, the classification of crypto-asset service providers as financial institutions, imposing on them obligations similar to those of banks or investment firms, the clarification of certain supervisory and control powers incumbent on the National Bank of

Romania and the Financial Supervisory Authority, as well as additional customer due diligence obligations (NOPCML, 2025).

2.2. Online banking

Online banking involves the use of the internet, by financial institutions, in order to conduct regular banking operations. It is one of the most frequent methods used in cyber laundering activities, in cases of opening online bank accounts and conducting multiple transactions, where the operation model involves the technique of smurfing (Coman, 2022, p. 118).

Smurfing is carried out at the placement stage of the money laundering process and is used to avoid reporting and bank record-keeping requirements (Moise, 2016b, pp. 317-325).

Large-value transactions between two accounts are often automatically reported in accordance with the legal regulations of each state. As a result, large amounts are divided into smaller transactions and transferred through multiple money couriers, called “smurfs”. This method makes it more difficult to detect illicit money flows, because the origin of the funds is hidden and small-value transactions appear less suspicious (Deprez *et. al.*, 2025, p. 1).

For example, the amount of 100.000 euros coming from drug traffic is split among 15-20 transactions (all under the mandatory reporting threshold), all made by different individuals (“smurfs”), who make deposits at different banks. In this way, the bank does not immediately report the transactions and the money is subsequently transferred to various accounts belonging to the criminal.

2.3. Online gambling

Cyber Laundering through gambling, presumes laundering money obtained from illegal activities within online casinos. In this context, an existing online gambling website can be used, or creating a new website for cyber laundering, which would imply more risks (Golonka, 2024, p. 218)

The specialised literature has presented a situation where a cyber launder creates a gambling website and distributes the illegal funds through the smurfing technique. In this context, it is irrelevant whether the cyber launder wins or loses at online gambling, as all funds obtained from illegal activities ultimately return to the cyber launderer (Moise, 2016a, p. 281).

The use of gambling or sports betting services in money laundering operations is easy, especially due to the cross-border and anonymous nature of the internet, as well as the lack of international consolidated regulations, in some countries gambling being considered a legal activity, and in other states illegal (Coman, 2022, p. 118).

2.4. Illustrative cases from judicial practice

In Romania, the authorities identified and prosecuted an organized criminal group that carried out activities specific to the notion of cyber laundering, using online banking transactions and crypto-asset transactions in their criminal activity, in order to hide the illicit origin of the criminal proceeds (Vâlcea Tribunal, Decision no. 43/2025).

The members of the group posted false advertisements for the sale of movable property, especially cars, on specialized websites, such as the online platform eBay, property that they did not actually own, illegally introducing in this way, computer data that was not in accordance with the truth and thus harmed several people in the European Union through acts of deception. At the same time, the members of the criminal group or intermediaries opened bank accounts in the country and abroad, using false documents, where the deceived parties transferred the amounts of money in order to purchase the goods, without receiving the agreed consideration or the refunds. Subsequently, the members of the organized criminal group recruited other people, with a precarious financial situation and a low level of education, in order to have them open bank accounts with real data, so they can transfer the criminal proceeds on a regular basis. Ultimately, the sums of money were withdrawn from bank cashiers or ATMs by the intermediaries and used to purchase crypto assets, the intended purpose being to launder the proceeds of fraud.

In South Africa, members of an organized crime group conducted multiple crypto-asset transactions for criminal purposes, successfully transferring 108,352,900 U.S. dollars (equivalent to 11,960 bitcoins) abroad. Initially, before purchasing the virtual assets, the cyber launderers carried out multiple layering of the funds, depositing the money into accounts opened at various financial institutions. Subsequently, the amounts were transferred via electronic payments to various accounts, and finally were purchased from local virtual asset service providers (VASPs). One of these local providers submitted suspicious transaction reports, due to the doubts raised by the purchase of large amounts of bitcoins by various individuals and their rapid transfer to virtual asset service providers in foreign jurisdictions. Also, many of the wallet holders had the same home address, and most of the addresses related to the virtual assets were accessed from the same IP address, which created suspicion regarding the use of "money mules" for money laundering purposes (FATF, 2020, p.6).

3. ARTIFICIAL INTELLIGENCE

In addition to the methods already established in the procedures for preventing, detecting, investigating and combating money laundering, technological advances outline the possibility of using a new tool, namely artificial intelligence, which can be a determining factor in streamlining the processes (Urdă, 2016).

An artificial intelligence system is defined as "a machine-based system that is designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment, and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments" (Regulation UE 2024/1689, p. 46).

In theory, artificial intelligence must be viewed from two perspectives, in the sense that it can be "an invaluable tool for criminal prosecution bodies and forensic specialists, but at the same time it is a sophisticated and extremely effective weapon in the hands of criminals" (Niță *et al.*, 2024, p. 595).

The integration of artificial intelligence and machine learning technologies can significantly contribute to increasing the efficiency of financial institutions, reducing the time and costs generated by manual human inspections (Basu and Tetteh, 2024, p. 5).

The efficiency of artificial intelligence mechanisms is presented in the specialized literature, which could play an essential role in procedures for preventing and combating money laundering by automating the verification of suspicious transactions, given the huge volume of data reported daily (Coman, 2022, p. 120).

For example, based on customers' transactional behaviour history, each customer can be given a money laundering benchmark score, alerts for suspicious or unusual transactions being generated if the customer's current behaviour is different from their previous transactional pattern (Basu and Tetteh, 2024, p. 5).

In the case of money laundering, the analysis criteria cannot be limited to certain distinct transactions, it requires the assessment of the entire factual context (people, the relationships between them, the complex system of exchanges), based on the principle of "follow the money" (Agapito *et al.*, 2021, cited in Coman, 2022, p. 122). In this regard, it is stipulated that "the quality of investigations and the implementation of appropriate sanctions can never be limited exclusively to the decision of automated information systems".

However, we cannot forsake the risks generated by the use of artificial intelligence and machine learning technologies. A report by the International Monetary Fund (IMF) draws attention to the significant threat that artificial intelligence can constitute to the stability of the entire financial system. Among the main risks are the violation of data confidentiality, the difficulty of explaining decisions generated by artificial intelligence (lack of transparency) and the vulnerabilities generated in cybersecurity (Basu and Tetteh, 2024, p. 6).

The use of AI by law enforcement is also constrained by a number of legal, ethical and technical limitations. Issues related to data privacy and risks of excessive surveillance create a "tension between the need for security and the protection of fundamental human rights" (Niță *et al.*, 2024, p. 596).

Artificial intelligence can generate significant risks and it can affect public interests and the fundamental rights protected by European Union regulations, causing material or moral damage, with physical, psychological, social or economic impact (Regulation EU 2024/1689).

According to a report generated by the European Parliament, on artificial intelligence in criminal law and its use by the police and judicial authorities in criminal matters, it is emphasised that Member States need to make sure customers are informed when they are subject to the use of AI and that citizens and consumers are provided with simple, effective and easily accessible complaint and redress procedures in order to allow them to effectively defend their rights in Report 2020/2016 (European Parliament, 2021). In regard to the integration of technology into the judicial system, the general option that I also support is that "digitalization should be neither total nor completely mandatory" (Ciurea, 2022, p. 179).

4. CONCLUSIONS

At the European level, as well as in Romania, we can observe the consistent steps taken by the legislator to improve the legal provisions in the matter, in order to streamline the procedures for preventing and combating the phenomenon of money laundering. In the context of technological evolution, it is imperative that the legislators, who are constantly forced to adapt to the challenges generated by the emergence of new money laundering techniques, demonstrate due diligence.

In addition to the traditional money laundering techniques, such as the purchase of real estate and movable assets (luxury objects, precious metals) or the falsification of tax documents, cyber launderers are currently using the internet to conceal the criminal proceeds, through operations with crypto-assets, online banking or online gambling.

Given that modern technologies are used for criminal purposes; to camouflage the illicit origin of sums of money or assets, it is necessary for judicial bodies to adapt and use new technologies to identify and combat cyber laundering activities in a timely manner. The expanding evolution of artificial intelligence outlines the need for its consolidation into the judicial system and law enforcement, as it can bring real contributions in terms of efficiency.

The use of artificial intelligence-based systems can represent a real support in certifying suspicious transactions, nonetheless, the human factor of decision-making and control cannot and should not be completely replaced by artificial intelligence-based systems.

In order to avoid errors and misjudgements and to ensure the security and safety of economic transactions, to respect the fundamental rights, such as the right to privacy and the protection of personal data, it is necessary to have a balanced approach that combines technology and manual oversight.

It is essential to create a consistent regulatory framework at international level, regarding the conditions and manner in which artificial intelligence is used and controlled, and the persons who are the object of the use of artificial intelligence must be informed and have at their disposal simple and accessible legal complaint mechanisms.

I believe that the use of artificial intelligence in the act of justice should be limited only to outputs in the form of predictions, content and recommendations, without allowing decisions to be made that could harm fundamental human rights.

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ADVANCED DATA MODELING IN BUSINESS USING DYNAMIC ARRAYS AND TRIPLE MATRICES

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Abstract

Recent developments in Microsoft Excel, particularly the introduction of Dynamic Arrays, have significantly enhanced the capabilities of this ubiquitous tool in financial and accounting analysis. This paper explores the application of modern Excel functions such as MAP(), LAMBDA(), SEQUENCE(), MAKEARRAY(), and LET() in automating complex tasks, minimizing formula redundancy, and enabling advanced modelling without VBA scripting. A structured application of these functions is demonstrated through real-life accounting and finance use cases, including budget projections, data reconciliation, scenario modelling, and error detection. Additionally, a novel methodology termed the “Triple Matrix” is introduced. Inspired by triple FOR loop logic, this approach enables multidimensional evaluation and aggregation directly within Excel using only native functions. The method systematically generates and processes combinations of values across three axes, allowing the implementation of iterative logic and scenario simulations without macros. This approach is tested in various use cases and evaluated based on automation efficiency, clarity of formulas, performance, and adaptability. Results highlight the added value of combining Dynamic Arrays and Triple Matrix logic for accountants and financial analysts, improving automation, accuracy, and process scalability using only standard Excel functionality.

Keywords: *Dynamic Arrays; Triple Matrix; financial modelling; spreadsheet analysis; no-code solutions.*

JEL Classification: M15; G19; H75.

1. INTRODUCTION

Functional programming might sound like something reserved for hardcore developers, but at its core, it’s just a way of solving problems by using functions, small, reusable pieces of logic. Traditionally, this approach has been more

common in academic or data science environments than in everyday business tools. But that's starting to change, especially with recent updates to tools we all know, like Microsoft Excel (Greavu, 2024).

With the launch of Dynamic Arrays (Bartholomew, 2020) and Lambda functions in Excel's cloud version, functional programming concepts are now available right inside the spreadsheet. That means users can build powerful, flexible models without writing a single line of VBA code. Even better, these functions make it easier to collaborate in real time on the same file, something that's becoming the norm in today's hybrid workplaces. These features have also been added to Google Sheets, making the two tools more compatible than ever.

While functional programming (Bartholomew, 2023) isn't the most common approach in commercial software, it's become increasingly important in areas like big data, machine learning, and AI. Languages like R, known for their data crunching power, are now widely used in both universities and businesses. Microsoft, too, has gotten in on the action with Power Query M, a language designed for importing and transforming data in Excel and Power BI. Then there's Python, which supports multiple ways of thinking, including functional techniques like LAMBDA, MAP(), AND FILTER().

In this article, the authors walk through a few classic algorithmic challenges – like sorting, counting combinations, and making smart decisions using greedy algorithms (García, 2025) and show how they can be solved using modern Excel tools.

The goal is to show how far spreadsheet tools have come, and how one can apply powerful programming logic, often associated with advanced programming languages, directly in Excel, for Financial Modelling (Bastick, 2024). No macros, no scripts, just smart use of what's already built in.

2. STUDY CASES OF ADVANCED MODELLING IN BUSINESS

Specifically, this article will display the following subjects from the financial sector by using functional programming:

Sorting problems like MaxProductOfThree and Triangle

The Caterpillar method, applied to the CountTriangles problem

Greedy strategies, using MaxNonoverlappingSegments as an example

2.1. Sorting Algorithms in Functional Spreadsheets: The

MaxProductOfThree Problem

MaxProductOfThree problem consists in identifying the maximum product obtainable by multiplying any three values from a given array of real numbers. Mathematically, given a finite list of real values.

$R = \{r_1, r_2, \dots, r_n\}$, the goal is to compute:

$$\max_{i < j < k} (r_i \cdot r_j \cdot r_k)$$

This is a classical sorting-based algorithmic problem often used to test numerical reasoning, array manipulation, and computational efficiency.

The use case in Finance that we want to use is Portfolio Growth Potential. Thus, in financial modelling, this problem is directly applicable to portfolio optimization scenarios. Given a list of estimated relative returns for various assets, the objective is to identify a triplet of assets whose combined multiplicative return yields the highest potential compounded growth. This serves as a simple model for identifying positively correlated high-growth combinations in investment portfolios.

Let $R=\{1.12,0.95,1.25,1.08,1.30,0.90,1.15\}$, representing expected returns for seven financial instruments. We seek to determine the triplet (r_i, r_j, r_k) such that $r_i \cdot r_j \cdot r_k$ is maximized.

Modern versions of Microsoft Excel now support Dynamic Arrays (Bartholomew, 2020) and Lambda functions, which allow this problem to be solved without scripting (e.g., VBA). The following is an example implementation leveraging SEQUENCE, INDEX, LET, LAMBDA, MAKEARRAY, and BYROW.

The solution is based on the following three steps:

Step 1: Store the relative returns in a named range, e.g., Returns referring to the range B2:B8.

Step 2: Generate all combinations of three different elements. This can be done using a custom lambda function:

```
=LET(
  n, ROWS>Returns),
  combos, MAKEARRAY(n^3, 3, LAMBDA(row, col,
    INDEX>Returns,
    SWITCH(col,
      1, INT((row-1)/(n*n))+1,
      2, INT(MOD((row-1), n*n)/n)+1,
      3, MOD(row-1, n)+1
    )
  )
),
  filtered, FILTER(combos,
    (INDEX(combos,,1) <> INDEX(combos,,2)) *
    (INDEX(combos,,1) <> INDEX(combos,,3)) *
    (INDEX(combos,,2) <> INDEX(combos,,3))
  ),
  BYROW(filtered, LAMBDA(row, PRODUCT(INDEX(row, 1), INDEX(row, 2),
    INDEX(row, 3))))
)
```

The above computes all valid 3-element combinations, excludes duplicates, and calculates their product.

Step 3: Extract the maximum product:

```
=MAX(
  LET(
    ...
    BYROW(filtered, LAMBDA(row, PRODUCT(INDEX(row, 1), INDEX(row, 2),
INDEX(row, 3))))
  )
)
```

This approach allows financial analysts to compute potential growth-maximizing asset triplets directly within Excel, avoiding both iterative logic and scripting. It exemplifies how algorithmic logic – traditionally requiring code – can be executed within a functional spreadsheet environment using native tools.

Such an application is useful in:

- Portfolio selection, where combinations of assets are evaluated for compounding effects.
- Stress testing scenarios, simulating various groupings of high/low performance instruments.
- Heuristic modelling, as a basis for more complex Monte Carlo simulations or optimization models.

By applying a classic sorting problem through Excel's new Dynamic Array (Rubin, 2024) capabilities, the solution is both transparent and auditable, supporting financial compliance and collaborative workflows.

2.2. The Caterpillar Method in spreadsheets: the CountTriangles problem

The *CountTriangles* problem involves determining how many unique combinations of three values from a given array can form a valid triangle. Formally, for a sorted array of positive real numbers $A = \{a_1, a_2, \dots, a_n\}$, a triplet (a_i, a_j, a_k) , with $i < j < k$, can form a triangle if and only if $a_i + a_j > a_k$.

The above is a classic algorithmic problem often solved using the Caterpillar Method, an efficient technique based on two-pointer traversal over sorted arrays. The method avoids brute-force enumeration by leveraging the sorted order to incrementally evaluate only feasible combinations.

In a business context, the CountTriangles logic can be applied to evaluate the stability of multilateral partnerships, such as trade alliances between countries or corporations. The triangle condition can be interpreted as a constraint ensuring balance or mutual reinforcement between the parties involved.

Given a list of countries and their respective export volumes, we want to determine how many combinations of three countries could form sustainable trade

partnerships, based on the assumption that the combined export of any two members must exceed the third. This models economic synergy, where no single participant dominates or destabilizes the partnership.

Such modelling can help:

- Assess the feasibility of trilateral economic agreements
- Design balanced regional trade blocks
- Evaluate cooperation strength in supply chain networks or international coalitions

Modern Excel does not support explicit pointer-based loops as in traditional programming. However, the Caterpillar logic can be implemented functionally by:

- Sorting the input array (to leverage the triangle inequality)
- Generating all possible combinations of three elements
- Filtering combinations that satisfy the triangle condition

Let's assume the input list of export volumes is in a named range Exports, defined as A2:A10.

Step 1: Sort the array

= SORT(Exports)

Step 2: Generate all 3-combinations

It is recommended to use MAKEARRAY() to simulate nested loops, then FILTER to exclude duplicates and apply the triangle condition.

```
= LET(
  arr, SORT(Exports),
  n, ROWS(arr),
  combos, MAKEARRAY(n^3, 3, LAMBDA(row, col,
    INDEX(arr,
      SWITCH(col,
        1, INT((row-1)/(n*n))+1,
        2, INT(MOD((row-1), n*n)/n)+1,
        3, MOD(row-1, n)+1
      )
    )
  )),
  valid, FILTER(combos,
    (INDEX(combos,,1) < INDEX(combos,,2)) *
    (INDEX(combos,,2) < INDEX(combos,,3)) *
    (INDEX(combos,,1) + INDEX(combos,,2) > INDEX(combos,,3))
  ),
  ROWS(valid)
)
```

The above expression solves the initial problem as it enumerates all possible triplets (1), ensures $i < j < k$ (2), applies the triangle condition $a_i + a_j > a_k$ (3) and returns the count of valid combinations (4).

Through this approach, Excel becomes a platform for network viability analysis, leveraging functional programming logic to process combinations and validate constraints.

This method can be applied in:

- Geopolitical simulations involving trilateral cooperation agreements
- Corporate alliance analysis, determining stable joint ventures
- Supply chain planning, ensuring balance in distributed production or trade volumes

The elegance of the Caterpillar method lies in its efficiency – traditionally $O(n^2)$ as opposed to $O(n^3)$ and its suitability for spreadsheet environments when adapted with dynamic array logic.

To conclude, by adapting the CountTriangles problem using modern Excel features like LAMBDA, LET, MAKEARRAY, and FILTER, we demonstrate how functional programming patterns can be applied in financial and economic modelling. This strengthens the role of Excel as a lightweight, transparent, and powerful tool for computational tasks traditionally reserved for programming environments.

2.3. Greedy algorithms in functional spreadsheets: the MaxNonoverlappingSegments problem

The *MaxNonoverlappingSegments* problem seeks to determine the maximum number of non-overlapping intervals that can be selected from a given set of segments on a one-dimensional timeline. Formally, given a set of segments defined by pairs (a_i, b_i) , where $a_i \leq b_i$, the goal is to select the largest subset of segments such that no two overlap.

This is a classic greedy algorithm problem, typically solved by applying the following steps:

1. Sorting the segments by their end time b_i
2. Iteratively selecting the next available segment that starts after or at the end of the previously selected one

The greedy (García, 2025) approach is optimal for this specific problem because choosing the segment that ends earliest leaves the maximum possible room for future selections.

In real-world financial planning, organizations often face temporally constrained opportunities, such as funding rounds, market openings, tax benefit windows, or budget cycles. Capital and risk constraints frequently prevent overlapping investments. Therefore, selecting the maximum number of non-

overlapping investments allows organizations to maximize capital deployment without exceeding risk or resource boundaries.

Suppose we have a list of investment opportunities, each active during a specific period (start_date,end_date). The objective is to choose as many investments as possible without overlapping periods, thus avoiding simultaneous risk exposure or budgetary strain. This model can also be applied in:

- Multi-year capital project planning
- Allocation of resources in public budgets
- Scheduling of grants or R&D initiatives with temporal dependencies

While greedy algorithms (Greavu, 2025) are traditionally implemented using loops, *Excel's Dynamic Array* and *Lambda functions* allow for a functional emulation of the greedy selection logic.

Let us assume the following input in Excel as seen in Figure 1 where StartDates and EndDates are defined as named ranges.

	A	B	C
1	Investment	Start Date	End Date
2	A	01.01.2025	15.03.2025
3	B	01.02.2025	30.04.2025
4	C	01.05.2025	31.07.2025
5	D	20.03.2025	15.05.2025
6	E	01.08.2025	15.10.2025

Figure 1. The model to be solved

The solution involves applying the following three steps.

Step 1: Sort intervals by end date which arrange the segments in ascending order of their end date, an essential step in greedy selection.

=SORTBY(A2:C6, C2:C6, 1)

Step 2: Greedy selection using functional filtering

While Excel lacks native iterative constructs, we can simulate the greedy selection using a recursive LAMBDA with helper columns or named recursive Lambdas (e.g., using SCAN or REDUCE in Office 365).

However, a practical and auditable approach is to create a helper column with the earliest available time to select a segment.

```
=LET(
  sorted, SORTBY(A2:C6, C2:C6, 1),
  startList, INDEX(sorted,,2),
  endList, INDEX(sorted,,3),
  result, SCAN(DATE(1900,1,1),
    SEQUENCE(ROWS(sorted)),
    LAMBDA(acc, i,
      IF(INDEX(startList,i)>=acc,
        INDEX(endList,i),
        acc
      )
    )
  )
)
```

This creates a cumulative selection where each interval is chosen only if its start is after the end of the last accepted segment.

To count how many intervals were selected, we can use:

```
=LET(
  sorted, SORTBY(A2:C6, C2:C6, 1),
  startList, INDEX(sorted,,2),
  endList, INDEX(sorted,,3),
  selected, SCAN(DATE(1900,1,1),
    SEQUENCE(ROWS(sorted)),
    LAMBDA(acc, i,
      IF(INDEX(startList,i)>=acc,
        INDEX(endList,i),
        acc
      )
    )
  ),
  COUNTUNIQUE(selected) - 1
)
```

In the above, the -1 excludes the initial dummy value.

By applying greedy logic in a functional way, this model provides an efficient, transparent means to plan investment sequences within Excel. It enables analysts to:

- Maximize the utilization of non-overlapping investment opportunities
- Design risk-aware capital deployment calendars
- Improve decision-making in contexts with time-sensitive constraints

This approach also supports policy-level planning – such as government spending or institutional grants – where no two commitments should occur simultaneously due to compliance or logistical limitations.

To conclude, the *MaxNonoverlappingSegments* problem illustrates how a well-known greedy algorithm can be effectively implemented in Excel using pure functional constructs, without relying on procedural scripting or macros. This enables professionals in finance and economics to model and solve time-constrained optimization problems using familiar spreadsheet environments – enhancing both accessibility and auditability.

3. CONCLUSION, LIMITATIONS AND FUTURE PATHS

While the adoption of functional programming in Excel introduces new modelling capabilities, it also exposes several limitations. Complex formulas based on Dynamic Arrays and Lambda functions can lead to performance issues, especially when processing large datasets or generating numerous combinations in many domains including Financial Modelling (Rubin, 2024). Excel is not inherently optimized for iterative or recursive logic, and although functions like SCAN and REDUCE offer partial solutions, they lack the full flexibility of traditional control structures.

Another challenge lies in readability and maintainability. As models grow in complexity, the nested and abstract nature of functional formulas can hinder understanding, especially for users unfamiliar with this paradigm. Additionally, Excel offers limited tools for debugging or tracing functional logic, which can complicate development and auditing processes.

Despite these constraints, the article demonstrates that classical algorithmic problems can be effectively translated into Excel using purely native functions. This expands Excel's role from a data analysis tool to a platform capable of lightweight, functional computation suitable for financial and economic modelling. Future work should explore hybrid models integrating Power Query and Python, as well as ways to simplify and document functional workflows to make them more accessible to non-programmers.

In conclusion, functional programming in Excel is a promising direction for building transparent, flexible, and auditable models, especially in business contexts where specialized programming tools are not always available.

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ANAF DIGITALIZATION – A DETERMINING FACTOR IN REDUCING TAX EVASION AND CORRUPTION IN ROMANIA

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Abstract

In this article we will analyze the share of tax revenues in GDP for Romania compared to other EU countries, in order to identify how an increase in the tax burden defined as the ratio between tax revenues and gross domestic product, would influence the way in which taxes are collected in the state budget and to what extent the digitalization of ANAF could contribute to reducing tax burden and corruption among authorities, respectively, increasing tax compliance on the part of the private sector. In research, tax evasion must also be analyzed from the perspective of human behavior, since the individual's mode of action towards a tax increase is not without rationality. Regarding the share of tax revenues in GDP, Romania, with a percentage of 27%, is at the bottom of the ranking compared to the EU average, which is almost 40%. The inefficiency of tax revenue collection, especially VAT, is caused by the high percentage of tax evasion, and the avoidance of paying taxes, which in Romania has become a phenomenon whose upward trend from year to year records a worrying percentage for decision-makers in the state. The continuation of the tax reform, especially the elimination of tax inequities for certain sectors of activity (i.e., construction, agriculture), ordered by the government at the beginning of 2025, followed by a process of digitization of the institution responsible for managing the country's finances, should, at least on paper, lead to more efficient collection

Keywords: *tax evasion; corruption; fiscal pressure.*

JEL Classification: H21; H26; H30.

1. INTRODUCTION

Regarding the relationship between the level of tax evasion and compliance with the payment of taxes by the private sector, it can be said that in general there are several influencing factors that can influence the level of tax evasion and compliance with the payment of taxes by the private sector. In research, various studies that have considered the analysis of the impact that a high level of taxation can have on the phenomenon of tax evasion, starting from the question of whether changing tax rates would lead to an increase in the phenomenon of tax evasion, have often obtained contradictory results. In fact, these results demonstrate that in

essence, the relationship between the degree of collection/proportion of tax revenues as a percentage of GDP and the level of tax evasion is much more complex and requires an analysis of the main factors that determine the reduction of this negative phenomenon and the increase in the degree of collection, without creating additional pressure on honest taxpayers. In 2024, the status revenues were 32.6% of GDP, and if we are to analyze the possibilities that Romania has at its disposal to improve this indicator, we have to choose between:

- tax increases, thus the tax regime in Romania provided until recently, exemptions and exemptions that reduced the tax base, sectors of activity or classes of taxpayers that benefited from preferential tax regimes, respectively reduced tax rates compared to those in the EU states. However, at least at the Romanian level, a high level of taxation would have the effect of increasing the tax pressure on honest taxpayers and will determine an increase in the level of tax evasion, therefore decision-makers are forced to adopt effective measures that could lead to an increase in the level of tax collection and compliance with their payment, by maintaining a fair and adequate taxation system for all taxpayers.
- more efficient collection of taxes and fees. The structure of budget revenues in Romania is mainly oriented towards indirect taxes and income from social contributions (together they represent 82.6% of tax revenues, the highest value in the EU), while, at the European level, there is a tendency to balance the share of direct, indirect taxes and social security contributions (respectively, an EU average of 32.3%, 33% and 34.7%). Reducing the VAT GAP registered by Romania could constitute an important step in increasing the level of VAT collection (the main source of fiscal budget revenues), an aspect that will be analyzed below.
- attracting money from resources such as European funds. However, the objective at first glance seems difficult to achieve since of the funds made available by the EU until 2027 (approximately 86 billion euros), only 16% (14.1 billion euros) have been accessed. Due to the failure to meet the conditions related to the lack of reforms undertaken by the Government, in 2024 Romania missed out on approximately 5 billion euros available from the PNRR.

2. ASPECTS FROM THE SPECIALIZED LITERATURE IN THE FIELD OF TAX EVASION

Studies conducted by (Kircher *et al.*, 2008) have highlighted the existence of several factors that influence taxpayers' voluntary compliance with taxes, determining honest behavior in their relationship with tax authorities. Among the essential factors are collective opinions related to subjective tax knowledge, myths and legends about the tax system, the tax behavior of other people, perceived opportunities to not comply with the rules, as well as perceptions of the fairness

of the tax system. Research on taxpayer tax behavior is generally based on a model built on two main pillars: trust in authorities and perception of their capacity to exercise effective control over taxpayers. The interaction between these factors can lead to various types of tax behavior: voluntary compliance, forced compliance, non-compliance. Later, in the study conducted, (Kircher *et al.*, 2008) starting from the two determinants of the “slippery slope” model proposed by the authors: trust in authorities and the power of authorities, highlighted the fact that the increase in compliance with tax obligations is determined at least at a theoretical level by the following factors:

- Taxation rate. This indicator influences differently, depending on the level of trust in authorities, thus a high rate of a tax can be perceived by the taxpayer as a violation of his patrimonial rights, considering it unfair in the fiscal relationship between him and the authorities.
- Audit probabilities. Most studies that have examined the impact of audit probabilities on tax compliance have proven ineffective. The author suggested that the subjective probability of being audited could serve as an indicator of the power of tax authorities, but one must take into account the perception of an individual's risk aversion, which is relevant depending on the level of trust in the authorities.
- Fines. Other studies have shown that fines do not directly influence compliance with tax obligations, but are linked to perceptions of trust and authority of the state. Thus, fines that are too small can be interpreted as a sign of weakness on the part of tax authorities, which can undermine the trust of honest taxpayers in the state's ability to combat tax evasion. On the other hand, excessively large fines can affect the perception of the fairness of sanctions and can stimulate evaders to look for ways to recover their "losses", thus intensifying tax avoidance behaviors.
- Knowledge of tax compliance and participation. The authors argue that a high level of knowledge about taxes and fees is associated with higher tax compliance and a higher degree of trust in the authorities. Conversely, a weaker understanding of the tax system is correlated with an increased tendency to not comply with tax legislation and a higher level of distrust. It also highlights the essential role that information policies implemented by tax authorities play in stimulating voluntary compliance.
- Attitudes towards taxes. Studies have shown that skills related to tax issues explain to a certain extent self-reported tax evasion, but they do not have a significant relevance in predicting actual tax behavior. In the case of a taxpayer who has a positive attitude towards the phenomenon of tax evasion, it is assumed that he will comply with his tax obligations to a small extent and “per a contrario”, an honest taxpayer with a negative attitude towards evasion, will comply with his tax obligations to a greater extent, but all this must be correlated with trust in the authorities, because

a higher level of trust will increase the level of voluntary tax payment behavior.

- Personal, social and national norms. Studies have shown that, in addition to attitudes, norms are essential factors in determining tax compliance. Individual norms are influenced by factors such as moral reasoning, authoritarian tendencies, Machiavellianism, selfishness, attachment to norms and values, with a significant correlation between these norms, personal values and tax ethics. In turn, social norms reflect the behaviors of reference groups, such as friends, acquaintances or colleagues. If a taxpayer perceives that tax evasion is a frequent and accepted behavior in his reference group, he is more likely to adopt non-compliant behavior. In the current context, norms integrate both the power and trust dimensions. On the one hand, national norms are manifested through tax legislation and the authority conferred on tax institutions, directly influencing their capacity to act. On the other hand, social norms - such as the perception that tax evasion is a minor and frequent act - can undermine the efficiency of tax authorities, especially in the absence of social sanctions or a form of collective recognition. A social norm in which every citizen is perceived as a correct taxpayer, who pays his fair share, could significantly strengthen public trust in tax institutions.
- Perceived fairness. The perception of fairness is closely linked to the level of trust, because fair treatment of taxpayers contributes to building and maintaining it. Retributive justice is also associated with the dimension of power, as it involves identifying and sanctioning mistakes. At the same time, the abusive or inconsiderate exercise of power can be perceived as intrusive and can lead to a decrease in trust.

McBarnet (2001) has identified several forms of tax compliance: committed compliance, compliance by capitulation and creative compliance. Committed compliance refers to the taxpayer's attitude to pay taxes without hesitation, in contrast, compliance by capitulation involves paying tax obligations as a result of a concession on the part of the taxpayer, who may initially be reluctant. On the other hand, creative compliance is characterized by the taxpayer's efforts to reduce the tax burden by using the possibilities of adjusting income and reducing expenses. Thus, a distinction can be made between voluntary compliance and imposed compliance, which results from coercive measures. Tyler (2006), following the study conducted, identified several similarities in the approach to rule violations, namely, the procedural justice model, the restorative justice model and the study of moral development, each of which has as a long-term objective in rule violation situations to motivate those who have committed violations to become more capable of self-regulation in their future behavior. This goal is compromised by sanctioning models based exclusively on punishments, having negative consequences for the individual who violates the law, and it is

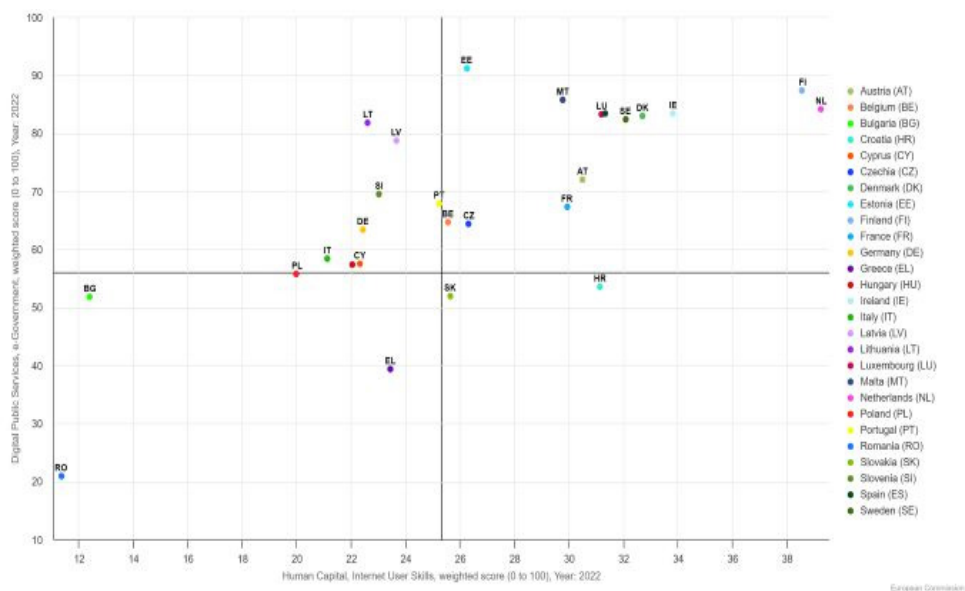
recommended to try a psychological approach that activates their internal moral values that determine correct behavior in the future.

Baldry (1987) believes that the perception of fiscal inequity favors non-compliance, while the perception of equity strengthens trust and stimulates voluntary compliance. Kircher *et al.* (2008) conclude that the position adopted by the authorities in relation to the taxpayer is essential for ensuring compliance with tax obligations by the latter, moreover, most authors agreed that fiscal pressure is fully felt by tax payers, thus an honest taxpayer voluntarily consents to paying tax obligations, but the problem arises when the level of taxes and duties exceeds the bearable limit, which determines that taxpayer to change his behavior, being "obliged" to resist the competitive economic environment, to seek different methods of evading taxes and duties. This behavior was best captured by economist Arthur Laffer, who in 1980, starting from an idea experimented by the famous Adam Smith, graphically transposed the so-called "Laffer curve", according to which "too high tax rates destroy the basis on which taxation acts", respectively, the income resulting from taxation increases more sharply at low levels of taxation" (Laffer, 1980). Most studies led to the formulation of two main hypotheses. A first hypothesis was that a high level of tax knowledge would determine taxpayers to have a higher degree of voluntary compliance in paying taxes, while a second hypothesis led to the conclusion that a high level of tax knowledge may represent a better opportunity for taxpayers to evade paying taxes. However, the general conclusion of most studies was that if the role of these taxes for the smooth running of a society were understood, then the degree of voluntary compliance by taxpayers in paying tax obligations would certainly increase, which would primarily lead to an increase in the level of collection and a reduction in the budget deficit.

3. GENERAL ASPECTS REGARDING ROMANIA'S DIGITAL PERFORMANCE IN THE EUROPEAN CONTEXT AND ANAF DIGITAL TRANSFORMATION

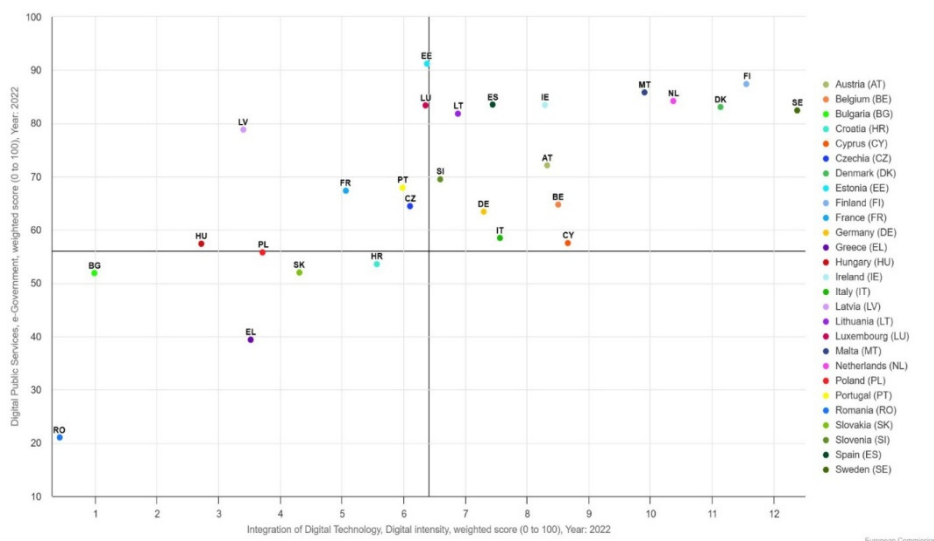
The Digital Economy and Society Index (DESI) is the index that summarizes the main indicators relating to Europe's digital performance. It monitors the progress of the European Union member states in four essential areas: human capital, connectivity, integration of digital technologies and digitalization of public services. The experience of developed OECD member countries in the digital transformation process of tax administrations highlights multiple advantages, namely modern and efficient tax treatments appropriate for increasing compliance with tax obligations, identifying the most suitable tax solutions adaptable to the compliance process accompanied by a correct risk assessment, increasing taxpayer confidence that will result in reducing the risks of tax non-compliance. The DESI report prepared at the European Commission level for 2021 highlighted the gaps recorded by Romania following the analysis of the 4

DESI indicators compared to European Union countries. The analysis of the axis on digital public services highlights that Romania consistently records low performances compared to other EU member states, with all specific indicators being significantly below the European average. As for Romanian internet users, only 16% of them actively interact with e-government services, compared to the EU average of around 64%. As for the "pre-filled forms" indicator, Romania obtains a score of only 6 points, compared to the EU average of 63. In the case of digital public services, the score for taxpayers is 44 points compared to the EU average of 75, and for commercial companies 49% compared to the EU average of 84%. The report highlights that the lack of interoperability of IT systems in public administration remains a chronic problem, despite the sporadic progress recorded during the pandemic. Even in 2022, Romania is not making progress in the field of digitalization, so if we analyze the 2 indicators considered essential for improving the degree of tax collection (human capital and digitalization of public services), we can observe, as can be seen from Figure 1 and 2, that Romania, with a score between 21 and 23, still occupies the last position, far from the average of EU countries.



Source: European Commission-DESI (2022)

Figure 1. Human capital



Source: European Commission, DESI (2022)

Figure 2. Integration of digital technology

According to data provided by the fiscal structure with IT responsibilities within the Ministry of Finance, the central element of the entire IT system is the Registers and Nomenclatures system, which includes the Register of Taxpayers for Individuals, the Register of Taxpayers for Legal Entities and a series of Nomenclatures, among which the one of the territorial administrative structures should be mentioned. The Ministry of Finance uses an intranet network based on Ethernet technology, which, through encryption technologies, allows the secure transmission of data, conversations and images between all territorial units and the central level. The centralization of databases and applications was mainly accompanied by the centralization of the hardware and software infrastructure within the Secondary Data Center. The latter functions both as a backup center for centralized systems and as a continuity center for the electronic document submission platform called DEDoc. Each civil servant within the Ministry has access to all the data for which he holds rights in accordance with his job description and his duties within the fiscal structure, regardless of the location where this data was uploaded to the system. In this way, IT systems such as the personal income tax administration system, the system for monitoring and recording tax inspection and anti-tax fraud activities, the system for receiving and managing declarations, as well as other IT platforms administered by ANAF are operated.

Outdated technologies within the Ministry allowed insufficient use of data and information held by the various fiscal structures subordinate to the central

structure, this situation was caused by the lack of an integrated IT application that would allow the efficient management and exploitation of all data and information available both at the level of territorial fiscal structures and from external sources. Changing the taxpayer's fiscal domicile, as well as changing their administration competence, involves an electronic exchange of information and the physical transfer of the tax file, accompanied by the tax certification certificate and the payer record sheet from the former fiscal administration body. However, this process requires a significant effort to manage and verify the fiscal information related to economic agents and in most cases generates an additional administrative burden for them. According to the information made available to the public by representatives of the Ministry of Finance, the IT systems used for the administration of both natural and legal persons (DECIMP, VECTOR, SACF, NOES, SERADN, SERADA) are based on outdated technologies. For this reason, their consolidation at the central level is required, in order to create a single and centralized database, which would ensure complete supervision of taxpayers' tax obligations. It should be noted that the National Center for Financial Intelligence (CNIF) represents the central IT structure that centralizes all tax databases both in the ministry and in the territorial structures with subordinate IT responsibilities.

In 2023, specific activities were carried out to design, implement and ensure the sustainability of digitalization projects, including the expansion of the national electronic invoicing system RO e-Factura for B2B transactions. The information collected through this system will constitute the basis for detailed predictive analyses regarding economic evolution, the identification of imbalances in the economy and the formulation of appropriate tax policies, aimed at supporting the sustainable development of the business environment. The primary objective is to improve the degree of collection, by combating tax evasion, having as subjects, economic agents registered as VAT payers, the system itself ensures the exchange of information regarding intra-community deliveries. This system was implemented at the beginning of August 2024, for operations carried out during July 2024 and contains a pre-filled statement containing the data and information regarding economic operations declared by taxable persons and transmitted in the IT systems of the Ministry of Finance and ANAF (RO e-Invoice, RO e-Seal, RO e-Transport, RO e-SAF-T, RO e-Case de marcat electronice, the integrated customs IT system). If, after submitting the value added tax return, differences are identified (which exceed the significance threshold and meet the cumulative conditions of at least 20% in percentage and an absolute value of at least 1,000 lei), between the pre-filled values through the pre-filled RO e-TVA return and the values declared by the taxpayers, ANAF will notify the taxable person through SPV (form Differences in taxable operations RO e-TVA), the taxpayer having the obligation to submit the electronic form called: Justification note regarding RO e-TVA differences, as a result of the checks carried out on the communicated differences. It should be noted that from January 1, 2025, electronic invoicing

between companies and final consumers (B2C) becomes mandatory. Ensuring the sustainability of the SAF-T system (Standard Tax Control File) and its extension to medium-sized taxpayers, and through various updates to the application, it was ensured that SAF-T declarations contain correct and complete data.

The AEOI_RO (Automatic Exchange of Information) information system was also updated and expanded, ensuring the exchange of tax information (accounts held by individuals, corporations, trusts and other information about account holders) between international tax authorities, with the main objective of reducing tax evasion and tax transparency. The Central Electronic Payment Information System (CESOP) was implemented starting from 01.01.2024, which centralizes information on cross-border payments and their beneficiaries, in a European database. This data is made available to European anti-fraud experts through the Eurofisc network, with the mention that the reporting obligation falls on service providers from the beginning of 2024.

4. ASPECTS CONCERNING THE ACTIVITY OF BUDGET REVENUE COLLECTION

For the period 2021-2024, according to the ANAF Strategy, several directions have been established regarding the increase in revenue collection to the Consolidated General Budget:

- a simplification of tax administration procedures in order to increase the voluntary compliance of taxpayers in declaring tax obligations;
- a real support of the entire compliance process in paying tax obligations;
- differentiated tax treatment depending on the tax behavior of taxpayers.

Regarding the activity of collecting taxes and duties, given the objective declared and assumed by ANAF: increasing voluntary compliance, in the first quarter of 2024, revenues to the general consolidated budget were recorded in the amount of 97,127.2 million lei, which represents an increase of 16.3%, respectively 13,594.2 million lei compared to the same period in 2023. In table no. 1 we can observe the structure by type of tax reported as a percentage of GDP in Romania in the period 2013-2023 and from which it results that Romania continues to be in the last positions in direct and indirect taxes in EU countries.

Table 1. Structure by type of tax % as of GDP in Romania

Type of tax	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Ranking EU
Indirect taxes	12.9	12.8	13.4	11.6	10.5	10.4	10.6	10.4	10.8	10.7	10.5	25
Direct taxes	6	6.2	6.6	6.5	6.1	4.9	4.8	4.7	5.1	6.1	6.5	27
Social contributions	8.7	8.5	8.1	8.1	8.5	10.5	10.5	11	10.5	10	10	19

Source: own calculations, based on Eurostat (2024)

Analyzing the tax regime in Romania in relation to other 27 EU states, through the lens of the structure of tax revenues as a percentage of GDP in the period 2013-2023, we can see that Romania, with a percentage of 27%, continues to occupy the penultimate position among EU states in this indicator, although the European average of the ratio of taxes and contributions to GDP is 40.6%.

Table 2. Tax Revenue-total as % of GDP

Countries	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Austria	42.8	43.2	41.8	41.9	42.3	42.7	42.2	43.4	43.2	43.5
Belgium	45.7	45	44.2	44.7	44.8	43.5	43.4	43.2	43.3	44.8
Bulgaria	28.4	28.9	29.2	29.8	29.7	30.4	30.5	30.8	31.1	29.9
Czech Republic	34.1	34.3	35.1	35.4	36	35.9	35.9	35.9	35.3	34.1
Cyprus	33.6	33.1	32.2	32.8	33.1	34.2	33.7	34.8	36.5	38.8
Croatia	37.4	37.7	38	37.9	38.4	38.4	37.7	36.7	37	37.3
Denmark	48.9	46.4	45.7	45.7	44.4	47.1	47.4	47.6	41.9	44.1
Estonia	32.1	33.3	33.5	32.8	32.9	33.3	33.3	33.8	32.9	34
Finland	43.5	43.5	43.7	42.9	42.4	42.3	41.8	43.2	43.1	42.7
France	45.7	45.7	45.7	46.4	46.3	45.3	45.4	45.1	46.2	45.6
Germania	38.3	38.8	39.2	39.3	39.9	40.1	39.6	40.9	40.8	40.3
Grecia	36.7	36.9	39.2	39.7	40.3	39.5	39.5	40	41.2	40.7
Irlanda	28.8	232	23.7	22.5	22.3	21.9	19.8	20.7	20.9	22.7
Italia	42.9	42.8	42.1	41.8	41.6	42.2	42.5	42.5	42.7	41.7
Letonia	29.7	29.8	30.7	31.1	31	30.7	31	30.7	30.3	33.4
Lithuania	27.5	28.9	29.7	29.4	30	30.2	31.2	31.9	31.6	32.4
Luxemburg	36.2	34.9	35.5	36.8	39.5	39.6	38.3	38.3	38.4	42.8
Malta	31.5	29.6	30.6	30.2	30.3	29.5	29	29.3	28.6	27.1
Polonia	32.3	32.5	33.6	34.2	35.1	35.2	35.6	36.7	34.5	36
Portugal	34.2	34.4	34.1	34.1	34.7	34.5	35.2	35.2	36	37.6
Romania	27.5	28	26.3	25.1	25.8	25.9	26.1	26.4	26.9	27
Slovakia	31.7	32.4	32.9	33.8	33.9	34.4	34.6	35.2	34.8	35.5
Slovenia	37.4	37.6	37.6	37.3	37.4	37.7	37.8	38.4	37.5	36.9
Spania	33.9	33.9	33.7	33.9	34.7	34.8	37	37.9	37.7	37
Sweden	42.2	42.6	44.1	44.1	43.8	42.8	42.4	42.6	41.8	42.1

Countries	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Netherlands	37	36.9	38.4	38.7	38.8	39.3	39.9	39.2	38.5	39.1
Hungary	38.4	38.7	39.1	37.9	36.9	36.3	36	33.9	35.1	35.1

Source: own calculations, based on Eurostat (2024)

Although almost 2 decades have passed since joining the EU, tax specialists are increasingly asking themselves where this difference of approximately 13% of GDP compared to the European average comes from. The lack of digitalization of ANAF in recent years may be an answer, although in recent times the digitalization process has recorded an upward trend, the collection percentage still remains very low compared to EU countries. The structure of budget revenues in Romania is predominantly oriented towards indirect taxes and income from social contributions (together they represent 82.6% of tax revenues, the highest value in the EU), while, at the European level, there is a tendency to balance the share of direct, indirect taxes and social security contributions (respectively, an EU average of 32.3%, 33% and 34.7%). Another answer would be the very low degree of tax compliance on the part of taxpayers, since the Romanian tax system is very thick, has numerous exceptions and does not present long-term predictability, an aspect that can induce the taxpayer that it is unfair, thus decreasing trust in the authorities and implicitly resulting in an increase in the risk of voluntary non-compliance.

If we were to make a comparison between Romania and Bulgaria, countries that do not show differences between taxes and fees actually collected, we can see that VAT not collected by the state in the neighboring country records a percentage of only 4.9% of GDP, compared to approximately 36% recorded by Romania. One explanation would be the solutions adopted by Bulgaria, materialized by the reform of the IT system based on an integrated revenue management system and the development of an information database available at national level.

Table 3. Tax and tax collection in Romania vs Bulgaria

	% from PIB -2023		Tax rates % -2023	
	Romania	Bulgaria	Romania	Bulgaria
Tax revenues	27.1	31.1		
VAT	6.6	9.1	19	20
Excise duties	2.4	5.7		
Personal income tax	2.6	3.1		
Corporate income tax	4.7	2.9	10	10
Social security contributions	10	8.3	39.96	32.7
Non-tax revenues	2.7	2		

Source: own calculations, based on Eurostat (2024)

In Table 3. we can see that although in Romania and Bulgaria, the tax rates are almost similar, there is a difference of 4 percentage points between the tax revenues collected by Bulgaria compared to Romania

Table 4. VAT not collected at the state level Romania vs. Bulgaria

VAT not collected to the budget % of the total VAT payment obligation (2023)	
Romania	Bulgaria
35.7%	4.9%

Source: own calculations, based on Eurostat (2024)

Table 4. presents the uncollected VAT in Romania and Bulgaria in percentages. If the level of VAT collected in Romania were to approach that recorded by Bulgaria, tax revenues as a percentage of GDP would increase by approximately 2.8 percentage points, or 44 billion lei, respectively. As for the effects of the digitalization of ANAF on the degree of collection of taxes and duties to the state budget, according to statistical data, it resulted that in the first 3 months of 2025, net VAT receipts amounted to 28.57 billion lei, down 2.7 percent compared to the same period in 2024, but this decrease can be justified by VAT refunds in the first quarter, which recorded an increasing trend of approximately 21% compared to the quarter. I of the year 2024 and which were postponed by the government to the end of the year in order to meet the budget deficit target. As for the other taxes, they recorded substantial increases in receipts, namely Insurance Contributions +10.4% (49.80 billion lei), excise taxes +12.3% (12.35 billion lei), taxes on salaries and income +31.3% (15.11 billion lei), but here the dynamics of dividends distributed in 2024 with the withholding tax of 8% comes into question, while non-tax revenues were around the amount of 12.35 billion lei, increasing by 12.3%.

Regarding the effect of digitalization of the fiscal structure on corruption, most studies have highlighted the fact that a reduced interaction between tax inspectors and taxpayers can only positively influence the risk of corruption, while (Martinez-Vasquez *et al.*, 2006) concluded that the phenomenon of corruption is present in every country (developed or less developed), but the level of this phenomenon is influenced by the country's management systems and the general fiscal structure, but addressing this topic requires more elaborate documentation and will be the subject of future research.

5. CONCLUSIONS

Romania's biggest problem in terms of tax collection remains the VAT deficit, which cannot be analyzed only from the perspective of the amounts collected by the tax authority and must also take into account the VAT policy gap that quantifies the fiscal impact of fiscal policy measures, as well as exemptions

and reduced VAT rates, reflecting the difference between the revenues actually collected and those that would have been obtained through the generalized application of the standard rate. The reduced rates maintained by the Romanian state for certain goods and services only have a negative distributive impact that can distort consumption decisions and influence taxpayers' tax compliance behavior.

Increasing tax revenues as a share of GDP could be achieved through more efficient tax administration, reducing the VAT gap and stimulating voluntary compliance of taxpayers in paying tax obligations, by improving tax assistance and collection activities. Taxpayers view paying taxes as a duty, but they may have a different behavior in terms of the degree of tax compliance determined by certain economic and social factors. Most studies have highlighted the fact that citizens are willing to pay taxes, so the state should not start from the premise that they are trying to avoid paying them, but should take a different approach to tax regulations through measures to ensure increased trust in authority, the predictability of tax rules and the maintenance of a balanced coefficient of the level of taxes that allow for an increase in the level of tax compliance.

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THE IMPACT OF ARTIFICIAL INTELLIGENCE ON COMPETITION IN THE EU DIGITAL MARKET: AN ANALYSIS OF REGULATORY CHALLENGES AND OPPORTUNITIES

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Abstract

The rapid development and deployment of artificial intelligence (AI) across digital markets is reshaping competitive dynamics in the European Union. This article examines the legal implications of AI-driven transformations for EU competition law, with a focus on both risks and regulatory opportunities. As dominant digital platforms increasingly integrate AI into pricing, ranking, and decision-making systems, concerns arise regarding market concentration, algorithmic collusion, and abuse of dominance. The paper explores how the existing legal framework – centered around Articles 101 and 102 TFEU – interacts with emerging instruments such as the Digital Markets Act and the AI Act. It further assesses the adequacy of current enforcement tools in addressing the opaque and autonomous nature of AI systems. It also explores the impact of the digital economy on the nature of competition, which is undergoing profound changes, particularly due to the unique features and applications of artificial intelligence.

By analyzing the intersection of competition law and digital regulation, the study identifies key legal gaps and proposes policy recommendations aimed at fostering a fair, innovative, and competitive digital environment in the EU.

Keywords: competition law; digital market; legal framework.

JEL Classification: K21; K23; L40; L41.

1. INTRODUCTION

In recent decades, rapid technological advancement has fundamentally reshaped the functioning of global markets. Among the most transformative innovations, artificial intelligence (AI) stands out as a disruptive force with the potential to profoundly influence both economic structures and the dynamics of market competition. Within the European Union's (EU) digital market, AI raises critical questions about how to balance the promotion of innovation with the preservation of fair and effective competition.

Competition is a cornerstone of market economies and a central pillar of the EU's economic policy framework. It fosters innovation, increases efficiency, and offers consumers greater choice and better prices. Moreover, robust competition

prevents the formation of monopolies and the abuse of dominant positions, thus supporting the fair and efficient functioning of the internal market.

2. ARTIFICIAL INTELLIGENCE AND COMPETITION LAW: KEY CONCEPT DEFINITION

In the context of the rapid evolution of information technologies and the exponential growth of online economic activities, the concept of the „digital market” is becoming increasingly important in the analysis of competition law and consumer protection. Although European Union legislation does not provide an exhaustive definition of this notion, the existing regulatory framework allows for the development of an operational understanding of the concept of the digital market.

An essential reference point is Regulation (EU) 2022/1925 on digital markets, known as the Digital Markets Act (DMA), which aims to ensure fairness and contestability in digital markets where platforms act as „gatekeepers”. Regulation (EU) 2022/1925 of the European Parliament and of the Council of 14 September 2022 on contestable and fair markets in the digital sector and amending Directives (EU) 2019/1937 and (EU) 2020/1828 began to apply from the date of May 2, 2023. The preamble to the legislative act states that: „core digital platforms have become key players in the internal market, playing a systemic role between businesses and consumers.” Thus, the digital market is conceived as a regulated economic space in which commercial and competitive interactions are mediated by digital platforms, covering a wide range of activities: „social networks, payment systems, price comparison sites, online commerce, mass media, application platforms, search engines, etc.” (Digital Markets Act, 2022).

However, the Digital Markets Act does not define the concept of a digital market, but simply states in point 1 of the preamble that „Digital services in general and online platforms in particular play an increasingly important role in the economy, in particular in the internal market, by enabling businesses to reach users throughout the Union, by facilitating cross-border trade and by opening entirely new business opportunities to a large number of companies in the Union to the benefit of consumers in the Union”. Therefore, although the DMA does not provide an explicit definition of a „digital market,” it defines the legal framework for online gatekeeper platforms that operate in digital markets and exert significant influence over access for other businesses and consumers (Irinescu, 2024).

A digital market refers to an economic environment in which goods, services, or platforms are accessed, delivered, or mediated through digital technologies – especially online platforms, algorithms, and data-driven processes.

Although the term „digital market” is frequently used in EU legislation and policy documents – particularly in the context of the *Digital Markets Act* and the *Digital Single Market Strategy* – there is no single, universally accepted

definition of it in official EU sources. In the absence of an explicit legal definition, I consulted ChatGPT (version GPT-4o, OpenAI, 2025) to obtain a working interpretation of the term, which provided the following working definition: *„A digital market is an economic environment in which the exchange of goods, services, or value is enabled, facilitated, or mediated through digital technologies – particularly the internet, data infrastructures, and software platforms. It typically involves interactions between businesses, consumers, and digital intermediaries (such as online platforms or marketplaces), and is characterized by features like network effects, data-driven personalization, and algorithmic decision-making.”*

This definition aligns with how the term is implicitly used in EU digital regulation and offers a useful conceptual framework for analyzing the impact of artificial intelligence on competition (Bostoen, 2025).

Artificial intelligence is defined for the first time in the Artificial Intelligence Act (adopted by the European Parliament and the Council on June 13, 2024, which will be fully applicable from August 2, 2026), in Article 3(1) as *„a machine-based system that is designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment, and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments”* (Artificial Intelligence Act, 2024).

Therefore, in this context, we aim to highlight how the transformation of markets from traditional structures to digital ecosystems and the emergence of artificial intelligence systems can affect competition. It is becoming clear that competition law is undergoing a continuous process of transformation, determined by the complexity of economic phenomena in the digital space.

Although the regulatory architecture of the European Union, through instruments such as the TFEU, DMA, and DSA, is designed to ensure the fair functioning of the digital market, its effectiveness is often diminished by the difficulty of precisely defining the relevant markets, the lack of transparency in the functioning of algorithms that influence the economic behavior of digital actors, as well as the slow pace of the legislative process in relation to the accelerated dynamics of technological innovation.

In the context of maintaining market integrity and promoting fair competition, the intervention of institutions with responsibilities in this area plays a fundamental role, as they are responsible for balancing the economic dynamic by implementing strict regulations and preventive measures tailored to the specificities of modern markets. In this perspective, a central role falls to the competent authorities, such as the Competition Council at the national level and the European Commission at the supranational level, which are responsible for the effective enforcement of the legal regime governing anti-competitive practices

through investigation, decision-making, and sanctioning mechanisms, thus ensuring compliance with competition rules and protecting market stability.

3. ALGORITHMIC COLLUSION AND ANTICOMPETITIVE PRACTICES IN DIGITAL MARKET

The digital transformation of markets has introduced a new dimension to anti-competitive practices: the use of algorithms and artificial intelligence to coordinate the economic behavior of companies. Unlike traditional forms of collusion, which involved explicit agreements between operators, algorithmic collusion can occur in the absence of any direct communication, being generated by the autonomous interaction of digital systems programmed to maximize profit and optimize response to competition. The increasing use of algorithms and artificial intelligence in digital markets has brought both economic efficiencies and novel risks to competition. One of the most concerning developments is the emergence of algorithmic practices that may facilitate or constitute anticompetitive behavior – some of which fall outside the scope of traditional competition law enforcement tools.

Therefore, digital markets allow for a high degree of transparency, which a competitor can use to distort competition. The algorithms behind the platforms can be programmed to the detriment of competitors and consumers. For example, in the case of prices, monitoring them was difficult in the context of traditional markets, but today an algorithm can instantly analyze all competitors' prices and adopt a pricing policy by correlating them. For example, in Romania, the company Altex launched a campaign with the slogan *„The lowest price in Romania! If you find it cheaper elsewhere, you get twice the difference back”*. In fact, this could not have happened because the algorithms analyzed all competitors' prices for that product in real time and automatically adjusted the price of the product sold by Altex. In fact, consumers immediately perceived that Altex was selling products at the best prices on the market, and in such situations, consumers are tempted not to check competitors' prices and to make their purchasing decision based solely on the subliminal message of the slogan.

In November 2021, the Romanian National Authority for Consumer Protection (ANPC) sanctioned electronics retailer Altex for engaging in misleading commercial practices during a promotional campaign. The campaign, titled *„The Lowest Price in Romania! If you find a lower price elsewhere, you get double the difference”*, was found to be deceptive.

ANPC's investigation revealed that Altex falsely advertised discounts on over 1,000 products during the Black Friday period. The company failed to correctly apply the reference price (the lowest price in the last 30 days), which misled consumers about the real value of the discounts. As a result, Altex was fined 50,000 lei and ANPC proposed the suspension of the company's commercial activity until the misleading practices were corrected. The campaign in question

– offering double the price difference – was suspended by ANPC, as it was not applied transparently or in accordance with consumer protection rules. Altex later complied with ANPC's recommendations and announced its commitment to improving its pricing and marketing practices. The case highlights the regulatory challenges of price transparency and algorithmically managed discount campaigns in the digital retail space.

So, it remains to be seen to what extent the algorithms behind the platforms are programmed to function in such a way as to create a competitive advantage. An algorithm can be used to sell a product more cheaply, which is to the advantage of consumers but to the disadvantage of competitors, or it can be used to raise prices, which is detrimental to consumers.

In other situations, the data that can influence how algorithms operate does not come from competitors, but from consumers. Some algorithms are designed to artificially increase the price of a product – for example, in the case of airlines – when the consumer makes multiple price inquiries. In fact, in these situations, the algorithm perceives this as an artificial increase in demand, which will lead to higher prices. These practices are known as *dynamic pricing*.

Dynamic pricing is driven by algorithms that process large volumes of real-time data to determine the „optimal” price a consumer might be willing to pay. Common inputs include search frequency and user behavior (e.g., repeated visits to a product page), geographic location and device type, purchase history and customer segmentation, supply and demand fluctuations. The rationale behind dynamic pricing is economic efficiency: it allows companies to maximize revenue, better manage inventory, and respond flexibly to market conditions. In theory, this benefits both sellers (through higher profit margins) and buyers (through more competitive pricing during low-demand periods). Notably, in the airline industry, it is well known that prices can increase merely as a result of repeated searches for the same route, especially from the same IP address or browser. This has led to widespread consumer suspicion and prompted recommendations such as browsing in incognito mode or clearing cookies to avoid price hikes.

In other cases, algorithms are used to compare prices and rank products based on the best price. Platforms such as Amazon Marketplace, Google Marketplace, and Emag use this feature. As long as this classification is accurate, we cannot identify any issues of unfair competition, but when algorithms are used to display the platform's own products first, both competitors and consumers will be affected.

In 2021, the Competition Council fined Dante International SA 32.28 million lei (approximately 6.7 million euros) for abuse of its dominant position on the market for intermediary services through online marketplace platforms and imposed a series of corrective measures on the company to restore normal competition and prevent such acts from occurring. As the owner and administrator

of the eMAG Marketplace online platform (www.eMAG.ro), it abused its dominant position between January 2013 and June 2019, in particular by positioning and displaying its own product offerings more favorably than those of partners selling on the platform and with whom it was in direct competition (Competition Council, 2020).

In addition, the competition authority required the company to adopt a series of measures regarding the algorithms used by the platform, with Dante being obliged to fully and accurately inform its partner merchants about how the algorithms work, such as those for listing and positioning products on the platform, and to limit manual interventions in the operation of the relevant algorithms.

This case highlights the risks posed by self-preferencing algorithms in digital marketplaces, where platform operators can act both as competitors and gatekeepers. It also demonstrates the increasing willingness of national competition authorities in the EU to scrutinize algorithmic conduct and impose structural remedies in the digital economy. It aligns with broader EU initiatives under the Digital Markets Act, which prohibits self-preferencing by gatekeepers and requires transparency in ranking mechanisms and data access (EU DMA (2024)).

Amazon created the „Buy Box” on an Amazon product page, which allowed users to quickly add the product to their shopping cart. Since multiple merchants can sell the same product, Amazon's algorithm could automatically decide which offer appears in the Buy Box – which decisively influences sales, as most consumers buy directly from this section. In reality, only products sold by Amazon or certain sellers approved by the platform benefited from this quick purchase option.

Following an investigation launched by the European Commission in December 2022, Amazon made a series of commitments, primarily to stop using third-party merchants' data for its own retail purposes, to ensure equal treatment for all offers in the „Buy Box” and to create a second, alternative purchase box when there is another competitive offer. The commitments are binding and valid for seven years in all EU member states for a period of seven years. (European Commission, Case COMP/AT.40462 and Case COMP/AT.40703).

The E-Turas case is another example of algorithmic collusion and the use of digital platforms as tools for coordination between competitors. Eturas UAB is a Lithuanian company that ran an online booking platform for travel agencies. It let agencies manage and sell travel deals through a centralized system. E-Turas sent an automated message to all users of the platform announcing that a general limit on price discounts to a certain percentage would be implemented and, as a result, modified the software system so that agencies could no longer apply discounts above that threshold unless they made these changes manually (Surblytė-Namavičienė, 2020).

Several agencies tacitly accepted this change and did not contest it, which led to the alignment of market behavior. Therefore, although there was no communication or agreement between the agencies, they adopted the same prices as a result of a common IT system.

In this case, the Court of Justice of the European Union clarified that the administrator of a digital platform may be considered a participant in a cartel if it promotes, facilitates, or imposes coordination between competitors. The mere fact that an economic operator receives information about a practice restricting competition and does not actively reject it may be interpreted as tacit agreement if there is behavioral evidence to that effect: “where the administrator of a computer system designed to enable travel agencies to sell trips on their websites in accordance with a uniform booking method sends those economic operators, by means of a personal email, a message warning them that the discounts on products sold through that system will in future be capped and that, following the sending of that message, the system in question undergoes the technical modifications necessary to implement that measure, it may be presumed that those economic operators, from the moment they became aware of the message sent by the system administrator, participated in a concerted practice within the meaning of that provision if they did not publicly distance themselves from that practice, did not report it to the administrative authorities, or did not provide other evidence to rebut that presumption, such as evidence of a systematic application of a reduction exceeding the ceiling in question”. National courts must verify whether each economic operator was aware of and accepted that practice, even passively (C-74/14).

4. CONCLUSION

Given that digital markets have opened up numerous new business opportunities for companies and provided consumers with access to an infinite range of products, regardless of the geographical area in which the trader is located, it could be argued that competition law should also adapt its policies to the new trends. We welcome the European Union's legislative initiatives to address the new challenges posed by the digitization of commerce, but competition law may undergo significant changes. A rethinking of competition law, through adaptation to innovative technology, is certainly needed. European Union member states are already making efforts to protect consumers from all competitive pressures that inevitably lead to the deterioration of their well-being.

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ZERO TRUST ARCHITECTURE AND DATA SOVEREIGNTY. A COMPARATIVE ANALYSIS OF ROMANIA AND ITALY

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Abstract

Zero Trust Architecture (ZTA) and data sovereignty have become central pillars of governmental information technology (IT) strategies. in the constantly evolving landscape of the European Union (EU) digital market, challenged by cyber threats and geopolitical tensions around technological control, However, due to a lack of long-term vision, these frameworks can sometimes be misapplied.

In parallel, data sovereignty has gained increasing relevance due to states' growing reliance on global providers of digital infrastructure, further amplified by the rise of sovereigntist discourse across Europe. Significant risks raised out of this dependency: the potential loss of control over data, exposure to extraterritorial jurisdictions, power imbalances between users and providers, and potential ethical and democratic consequences.

This paper offers a comparative analysis of Romania and Italy, examining how each country addresses challenges related to digital security and data sovereignty. It proposes recommendations for coherent European digital governance, in alignment with initiatives such as GAIA-X, and seeks to identify mechanisms by which member states can balance innovation, security, and strategic autonomy. As our data show, Romania has begun implementing Zero Trust principles in public administration, aligning with EU and ENISA standards, while Italy has recently rejected collaboration with the Starlink network, citing risks to national control over governmental communications. This decision reinforces the urgency of achieving real digital autonomy within EU.

Keywords: *Zero Trust Architecture; data sovereignty; EU digital policy; cybersecurity.*

JEL Classification: H83; L86; F52.

1. INTRODUCTION – THE DIGITALIZED EUROPEAN CONTEXT

The member states of the European Union (EU) have gradually encountered various types of challenges. However, when focusing solely on the European digital sphere, one can easily observe an accelerated increase in interconnectivity in recent years, accompanied by a constant exposure to cyber risks closely associated with this context.

According to the data presented in the 2023 report of the European Union Agency for Cybersecurity – ENISA Threat Landscape 2023 (ENISA, 2023), cyber threats have become increasingly diverse, while attempts to compromise critical infrastructures have grown both in intensity and frequency. Ransomware, digital supply chain attacks, and identity theft are identified as the primary risks facing EU member states. At the same time, geopolitical tensions between the EU and other states, especially in the context of the war in Ukraine, have directly heightened concerns regarding the control and security of digital infrastructures. The effort to punish Russia is not limited to Washington and Brussels and EU member states. Several other countries, including the UK, Japan, Australia, South Korea, Canada, and others, joined in those efforts to impose a cost on Russia for its behavior. These likeminded democracies share the values that the United States and EU leaders applaud during TTC meetings (Burwell and Propp, 2022).

Regardless of the EU's aspiration for its data to remain within its borders and depend exclusively on internal actors, dependence on extra-European cloud and telecommunications providers is gradually exerting its influence. Moreover, in an EU where extremism is reaching alarming levels year after year, a new debate has emerged concerning data sovereignty and the capacity of member states to safeguard critical information against unauthorized access. The European Commission itself reiterates in its Cybersecurity Strategy that the lack of coordination among member states may undermine the resilience of the entire European digital ecosystem (European Commission, 2025).

Consequently, two fundamental concepts have become the cornerstone of all cybersecurity policies: Zero Trust Architecture (ZTA), based on the principle “never trust, always verify”, and data sovereignty, which emphasizes national control over data generated and processed across the European territory. According to a recent systematic review, Zero Trust is based on the principle of “never trust, always verify”, replacing the traditional perimeter-based security model with continuous authentication, conditional access, and granular privilege control - which, in practical terms, means restricting users access to data based strictly on their operational role (Gambo and Almulhem, 2025; Hummel *et al.* 2021) highlight significant risks tied to this dependency: the potential loss of control over data, exposure to extraterritorial jurisdictions (e.g., U.S. legislation), power imbalances between users and providers, and potential ethical and democratic consequences. It must be noted that digital protection is an equally critical issue for the business sector, where many platforms store significant

volumes of user data. The Global Cybersecurity Outlook 2023 report, developed by the World Economic Forum in collaboration with Accenture (World Economic Forum, 2023), highlights the extent to which certain industries suffer from labor shortages and a lack of digital security skills. The most affected sector is Energy, with a reported skills gap of 25%, while the public sector registers around 15%.

Our paper presents the theoretical foundations for the Zero Trust Architecture, including literature review and methodology (section 2), addresses the Concept of Data Sovereignty right (section3), presents the comparative perspective on Italy and Romania and ends with some conclusions and future direction for research.

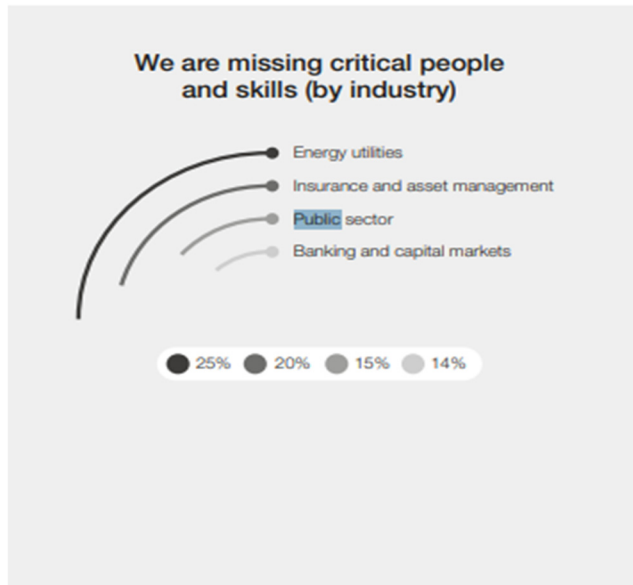
2. ZERO TRUST ARCHITECTURE – THEORETICAL FOUNDATIONS

Zero Trust Architecture (ZTA) is an approach developed in recent years and is considered revolutionary in the field of cybersecurity. Unlike traditional security models, in which both users and devices were regarded as “trusted” once they were inside a network, Zero Trust Architecture is built on a fundamentally different premise: no access is inherently secure, even if it originates from within the network. Every connection, whether from inside or outside the system or organization, must be verified and authenticated each time.

The core elements of Zero Trust include multi-factor authentication, micro-segmentation of networks, continuous monitoring of user behavior, and strict control over the information that individuals are allowed to access. Together, these mechanisms significantly reduce the risk that an attacker could compromise the entire system through a single-entry point. Several deployment scenarios and use cases lend themselves readily to a zero-trust architecture. For instance, ZTA has its roots in organizations that are geographically distributed and/or have a highly mobile workforce. That said, any organization can benefit from a zero-trust architecture (Rose *et al.*, 2020).

Organizations such as Microsoft and Palo Alto Networks have developed guidelines and best practices necessary for implementing the ZTA model, emphasizing the need for a gradual transition (Palo Alto Networks, 2024). This transition requires the adoption of policies grounded in user identity and the specific context of each access session. In an era where remote work and cloud infrastructures have already become the norm, Zero Trust Architecture emerges as an essential pillar in safeguarding critical data and systems. There are several ways that an enterprise can enact a ZTA for workflows. These approaches vary in the components used and in the main source of policy rules for an organization. (NIST, 2020) In the academic literature, the concepts of Zero Trust Architecture (ZTA) and data sovereignty are increasingly analyzed as fundamental pillars of European digital governance. According to the report developed by the National Institute of Standards and Technology (NIST, 2020), Zero Trust is based on the principle of “never trust, always verify,” which requires continuous verification

of each access, regardless of its origin. This approach is considered revolutionary as it replaces the traditional perimeter-based model, in which users inside the network were implicitly trusted.



Source: World Economic Forum (2023)

Figure 1. Industries and the shortage of critical people and skills

Recent studies underline the importance of implementing ZTA within organizations, particularly in the context of remote work and the growing use of cloud infrastructures (Microsoft, n.d.; Palo Alto Networks, 2024).

By adopting mechanisms such as multi-factor authentication, granular network segmentation, and constant monitoring, ZTA becomes an essential instrument in reducing security risks. As highlighted by Gambo and Almulhem (2025), “Based on the existing literature studied, it is evident that Zero Trust Architecture is being implemented across various sectors, each with unique security needs. In healthcare, the ZTA enables organizations to safeguard their patients’ sensitive medical records and health data with robust access controls, secure data exchange protocols, and real-time monitoring of electronic health records (EHRs). ZTA in the finance sector helps to combat cyber threats like financial fraud through encrypted communications, strong identity verification, and network micro-segmentation.”

In parallel, data sovereignty has become a central theme in the debates on the European Union’s digital autonomy. Celeste (2021) argues that this is not only a technical issue, but also a geopolitical one, with direct implications for democracy

and state sovereignty. Similarly, Carrapico and Farrand (2025) emphasize the “autonomy–interdependence dilemma,” whereby member states must strike a balance between reducing dependence on extra-European providers and leveraging global services for efficiency and innovation. Celeste (2021) further underlines that “to assess the autonomy–independence gap in EU data sovereignty, it is necessary to first outline what ambitions the EU has in this field, as they relate to the political, legal, and operational criteria.” Prokscha (2021, p. 48) adds that: “This claim for leadership can be divided into two parts. On the one hand, it implies being at the forefront of the development of digital technology, seizing its potential and developing economically strong European companies that play a globally relevant role. On the other hand, the claim for being a leading instance is associated with representing the decisive authority on how to govern digital technology. Whereas the former relates mostly to economic aims, the latter is rather associated with promoting European ideas on how to shape and regulate the digital space. Thus, leadership, in this context, is not only related to mere economic growth, but also to normative visions and a desired outlook of power relations in the digital realm.”

Reports such as ENISA Threat Landscape 2023 or Global Cybersecurity Outlook 2023 confirm the intensification of attacks on critical infrastructures as well as the shortage of digital skills in both the public and private sectors. The existing body of literature therefore provides a strong theoretical foundation, but lacks comparative analysis applied to specific national cases. This paper seeks to address this gap, focusing on Romania and Italy.

Our research, whose results are presented in this paper, uses a multidisciplinary approach and implements a coherent and rigorous methodology. This study employs a qualitative comparative case study approach, focusing on Romania and Italy. The objective is to analyze how these states have integrated the principles of Zero Trust and the concept of data sovereignty into their governmental digital transformation strategies.

The analysis relies on secondary data, including official documents (Romania’s National Cybersecurity Strategy 2022–2027, Italy’s Law No. 90/2024), reports from international institutions (ENISA, OECD, European Commission), Eurostat statistics, and relevant academic studies (Celeste, 2021; Carrapico and Farrand, 2025; Kudriasova, 2025).

The methodology is structured into three dimensions:

1. Institutional dimension: examining the legislative framework and institutions responsible for cybersecurity.
2. Financial dimension: assessing investments in security and digitalization (PNRR for Romania, data center and cloud investments for Italy).
3. Human capital dimension: analyzing the availability of ICT specialists and digital competences, with emphasis on the global shortage of cybersecurity professionals.

This integrated methodological framework ensures a comprehensive understanding of the similarities and differences between Romania and Italy and situates the results within the broader European context of digital autonomy and initiatives such as Gaia-X and the Cyber Resilience Act.

3. DATA SOVEREIGNTY – CONCEPT AND IMPLICATIONS

Data sovereignty has become a new epicenter of debate, closely linked to European digital governance (Vatamanu and Tofan, 2025). The relative weakness of the EU tech sector is bound to intensify EU's aspirations for technological sovereignty, which in turn may further amplify tensions within the transatlantic relationship (Bjola, 2023). This concept refers specifically to the control exercised over data, focusing on the jurisdiction of the state in which the data is generated or stored. Sometimes referred to as data residency, data sovereignty is rapidly becoming an essential component of legal, privacy, security, and governance strategies for enterprises that manage the storage, processing, and transfer of data. Developing a strong approach to data management and international data flows, a key dimension of data sovereignty, enables organizations to protect their most sensitive information against cyberattacks and other threats (IBM, 2024).

In practice, however, the concept of data sovereignty becomes more complex due to overlapping legal frameworks. The most illustrative example is the U.S. CLOUD Act (Clarifying Lawful Overseas Use of Data Act), a federal law adopted in 2018 that provides a legal framework allowing American authorities to access data held by U.S. companies, even when such servers are located on European Union territory (Center for Strategic and International Studies, 2023).

This collides with European legislation, particularly with the General Data Protection Regulation (GDPR). In response, the EU has adopted the Data Act (European Commission, 2024) and the Data Governance Act, designed to establish a legal framework that ensures data portability, interoperability, and protection against unauthorized access. Furthermore, initiatives such as Gaia-X and EuroStack complement this European effort by proposing independent infrastructures aimed at reducing the indirect monopoly of American technologies and companies, while also providing genuinely “local” cloud solutions. As Celeste (2021) further emphasizes, “regaining sovereignty on its portion of the digital ecosystem is seen in the EU as a potential solution to preserve its unique DNA of rights and values,” highlighting that Europe's claim for digital leadership goes beyond economic growth and extends to normative visions about shaping power relations in the digital realm.

Following this trajectory, it becomes clear that the issue of data sovereignty is no longer solely a technical matter, but rather a geopolitical one - an essential dimension of strategic autonomy for all partners and member states of the European Union.

4. DETAILED COMPARATIVE ANALYSIS

The comparative study between Romania and Italy seeks to provide a concrete perspective on how these key concepts are implemented at the national level, as well as how they can contribute more effectively to the (re)construction of European digital governance closely aligned with contemporary realities.

4.1. Institutional and legislative framework

Romania adopted for the first time the National Cybersecurity Strategy for the period 2022–2027 through Government Decision No. 1,321 of December 30, 2021 (Romanian Government, 2021), which approved both the new strategy and the action plan for its implementation. This Government Decision simultaneously repealed the previous National Cybersecurity Strategy, which dated back to 2013 (Romanian Government, 2013) and had not undergone significant revisions until the end of 2021. The new strategy envisages a coherent framework for cyber governance, combined with the protection of critical infrastructures and institutional interconnectivity. A central role in both legislation and practice is played by the National Cybersecurity Directorate, the entity responsible for coordinating responses to incidents and for ensuring the national application of cybersecurity standards. In essence, Romania's strategy for 2022–2027 identifies five objectives of national importance: (1) secure and resilient information networks and systems; (2) a consolidated legal and institutional framework; (3) pragmatic public–private partnerships; (4) resilience achieved through proactive measures and deterrence; and (5) Romania as a relevant actor in the system of international cooperation. Their joint implementation depends on adequate coordination among authorities, public administration institutions with responsibilities in the field, the private sector, academia, and citizens (OECD, 2024). Moreover, Romania benefits from hosting the headquarters of the European Cybersecurity Competence Centre (ECCC), established in 2021. The ECCC aims to increase Europe's cybersecurity capacities and competitiveness by working with a Network of National Coordination Centers to build a strong European cybersecurity community (European Union, 2021).

On the other hand, Italy revised its legislation more recently, in 2024, modifying the legal framework initially introduced in 2021. These amendments came in a period when cyberattacks had significantly increased, unlike Romania, which waited from 2013, when the issue of cybersecurity was not yet as pressing, until 2021 to radically reform its strategy. Article 10 of Law No. 90 of June 28, 2024, redefined the functions of the Italian National Cybersecurity Agency (Agenzia per la Cybersicurezza Nazionale, ACN), originally established by Decree-Law No. 82 of June 14, 2021, converted with amendments into Law No. 109 of August 2, 2021. The Agency was created to safeguard national interests and security in the field of cybersecurity and to facilitate the implementation of

the National Recovery and Resilience Plan, approved by the Council of Ministers on April 29, 2021 (Kudriasova, 2025).

Therefore, Italy has taken more concrete steps from a legislative perspective, with the ACN establishing a comprehensive legal framework and acting as a central institution with clearly defined mandates and responsibilities, illustrating a more advanced maturity in cybersecurity governance compared to Romania.

4.2. Investments and financing

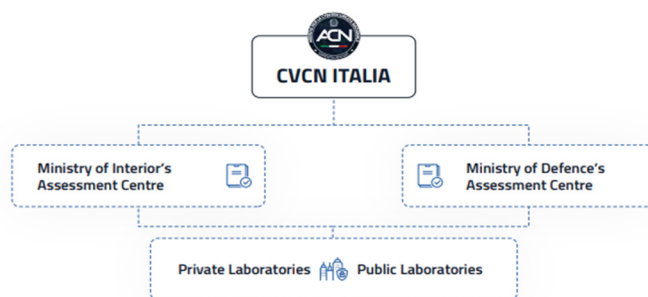
Analyzing Romania first, digital strategies are currently supported financially through the National Recovery and Resilience Plan (PNRR). The Authority for the Digitalization of Romania (ADR) has taken a significant step in advancing the country's digital transformation by initiating a public procurement process to migrate at least 30 key government IT systems and applications to the Government Private Cloud. This initiative aims to improve the delivery of digital services to citizens while ensuring enhanced security and scalability for public sector IT infrastructure (U.S. International Trade Administration, 2025).

Romania's government cloud project is required to be fully operational by December 31, 2025, and the funding comes exclusively from the PNRR. On September 11, 2024, the Romanian Prime Minister declared: "From my point of view, not only as Prime Minister but also as a simple citizen, the digitalization of public administration is among the most important things when we say we want a country like abroad." At the beginning of 2023, Police Commissioner Cătălin Giulescu, head of the General Directorate for Personal Records, stated that a system for interoperability of data within the directorate would be created: "It concerns the current national information system for personal records and the integrated information system for issuing civil status documents, which will become operational in the autumn of this year. We are speaking about interoperability of information systems. The ordinance stipulates that these interoperability procedures will continue. We are considering the system managed by the National Agency for Cadastral and Real Estate Publicity, along with other systems from which we will automatically retrieve information, thus relieving citizens from the obligation to present certain documents." (EuroNews, 2023)

In the same interview, it was mentioned that Romania would cover the cost of approximately five million electronic identity cards through the PNRR. However, the coherence of these measures did not last long: a first issue was the absence of the domicile printed on the new electronic identity card, combined with the lack of infrastructure in public institutions to read data electronically. As a result, the Ministry of Internal Affairs has promoted a certificate that can be requested electronically to certify domicile. Thus, the new Romanian electronic identity card is the first in the European Union that will include an annex, a PDF file certifying domicile.

By contrast, Italy, through its National Cybersecurity Strategy 2022–2026 presented by the Agenzia per la Cybersicurezza Nazionale (ACN, 2021), outlined its actions in detail. It is evident how important public–private partnerships are considered, with private laboratories included on the same level as public laboratories in the organizational structure.

To implement the National Cybersecurity Strategy for the period 2022–2026, Italy allocated €623 million, according to the data presented in the previously analyzed document. Moreover, a report published under the auspices of the Politecnico di Milano and cited by Reuters at the beginning of 2025 (Reuters, 2025) estimates that investments in data centers across Italy are set to double, reaching approximately €10 billion in 2025–2026. The main actors in this process are Microsoft, which has announced investments of €4.3 billion, and Amazon Web Services, with plans to invest an additional €1.2 billion in the coming years. The CAN organizational charter presented below integrates both public and private collaboration data.



Source: CAN (2018)

Figure 2. The CAN organizational chart

The Italian digital transformation market itself is valued at €75.4 billion in 2025 and is projected to grow to €166 billion by 2030 (Mardor Intelligence, 2025).

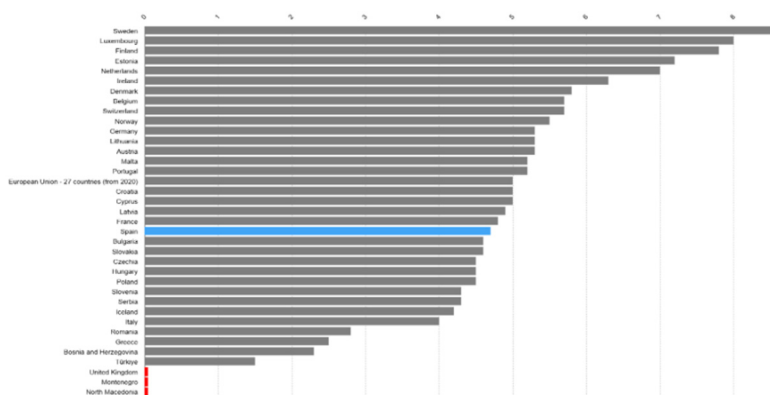
From an institutional perspective, Romania has adopted the National Cybersecurity Strategy 2022–2027, coordinated by the National Cybersecurity Directorate, and hosts the European Cybersecurity Competence Centre (ECCC) in Bucharest. This positioning provides Romania with a strategic role within the European ecosystem. Nevertheless, implementation remains challenging, as the previous strategy (2013) was not updated for nearly a decade, and the shortage of human and institutional resources limits the effectiveness of the new measures. Italy, by contrast, has recently reformed its legislation through Law No. 90/2024, which reinforced the competencies of the Agenzia per la Cybersicurezza Nazionale (ACN). This central institution has a clear mandate, dedicated resources, and a direct role in implementing the National Recovery and Resilience

Plan. Thus, Italy demonstrates a more advanced maturity in terms of its institutional framework.

From a financial standpoint, Romania relies heavily on European funds allocated through the National Recovery and Resilience Plan (PNRR). Its flagship project, the migration to a government cloud, has a budget of approximately USD 530 million and must be completed by the end of 2025. Although this represents a significant step forward in the digitalization of public administration, the lack of coherence in implementation and the recent challenges associated with electronic identity cards expose the limitations of this approach. Italy, on the other hand, has allocated EUR 623 million solely for the implementation of its 2022–2026 cybersecurity strategy, in addition to massive investments announced for data centers: approximately EUR 10 billion for 2025–2026, driven by major actors such as Microsoft (EUR 4.3 billion) and AWS (EUR 1.2 billion). Italy’s digital transformation market is valued at EUR 75.4 billion in 2025 and is projected to reach EUR 166 billion by 2030. In comparison, Italy demonstrates a much stronger capacity to finance, from its own resources and through public–private partnerships, a coherent digital strategy.

4.3. Human resources and competences

According to Eurostat data, in 2024 Romania had 2.8% of its population employed as ICT specialists, compared to Italy with 4.0% in the same field, without since Italy’s total population is approximately three times larger than that of Romania. In addition, the study *Towards Understanding the Skill Gap in Cybersecurity* (Groupil *et al.*, 2022) estimated the global deficit in the field of cybersecurity at around three million jobs worldwide (about 5% in EU, in 2024).



Source: Eurostat (2025)

Figure 3. The share of ICT specialists

4.4. Sovereignty versus extra-European providers

Continuing our analysis in terms of the countries' attitudes toward extra-European providers, Romania, as previously noted, is financing its own government cloud, but it maintains an open attitude toward solutions provided by global actors such as Microsoft. Projects of the "sovereign cloud" type are currently being developed in parallel. Funding for such "sovereign" projects through the National Recovery and Resilience Plan (PNRR) is aimed at enhancing digital resilience, without completely excluding external technologies that provide added value.

By contrast, Italy has withdrawn from high-level negotiations, rejecting cooperation with Starlink. The Italian government justified this decision on the grounds of security and digital sovereignty, choosing instead to rely on local solutions and those aligned with the European initiative Gaia-X (CSIS, 2023).

4.5. Remote work in the aftermath of the COVID-19 pandemic and implications for cybersecurity risk

The COVID-19 pandemic revolutionized many sectors and forced change wherever such practices could be adopted. In the European Union, in 2019, the proportion of regular or occasional remote workers was 14%. By 2021, given the context of the COVID-19 pandemic, this figure had rapidly increased to 24%. In total, according to EU data, more than 44 million people were working remotely (Zucconi *et al.*, 2024).

This surge in remote work during and after the pandemic significantly amplified cyber exposure, as in most cases organizational networks were accessed through personal devices, unsecured networks, and locations that complicated monitoring. All these factors increased the risks of phishing, compromised credentials, and even infiltration of critical infrastructures via remote workers with access privileges. Moreover, following the "sovereigntist" model, the widespread reliance on cloud solutions provided by major U.S. companies further heightened the risk of losing control over data, particularly under the legal framework of the CLOUD Act. In early 2020, the emergence of the COVID-19 virus made even more clear Europe's vulnerability to global disruptions and the actions of others. (Burwell and Propp, 2020)

In this turbulent context of the pandemic and post-pandemic period, the Zero Trust Architecture (ZTA) has become essential. The current paradox shows that while remote work increases the likelihood of cyberattacks, it also provides the necessary impetus for advancing cyber defence mechanisms through continuous authentication, real-time monitoring, and the principle of "least privilege", ensuring that everyone has access only to the data strictly necessary for their role.

During the pandemic, Italy recorded an increase of approximately 40% in phishing attacks, according to data published by the cybersecurity company ESET (CMIT Solutions, n.d.).

5. CONCLUSIONS

The comparative analysis of Zero Trust Architecture and the concept of data sovereignty in Romania and Italy, within the context of the digital transformation of European public administration, highlights a series of similarities but, more importantly, significant differences between the two states. The study demonstrates that both countries have recognized the urgency of strengthening cybersecurity resilience and control over digital infrastructures; however, the strategies adopted reflect distinct economic, institutional, and cultural realities.

With respect to human resources and digital competences, Eurostat data reveals clear disparities: in 2024, Romania had 2.8% of its population employed as ICT specialists, whereas Italy reported 4.0%. Given that Italy's population is approximately three times larger than Romania's, the absolute difference in the number of specialists becomes overwhelming. Romania faces a chronic deficit of cybersecurity and digitalization experts, a phenomenon exacerbated by workforce migration toward the private sector or other EU member states. Italy encounters similar challenges, but it benefits from stronger university-level training capacity and partnerships with major technology companies, which contribute to the consolidation of its human capital.

Attitudes toward extra-European providers may represent the most striking difference. Romania adopts a pragmatic approach, financing its own government cloud through PNRR, while remaining open to collaborations with Microsoft, AWS, or Google. Italy, instead, takes a firm and sovereigntist stance, rejecting cooperation with Starlink and promoting local or European solutions, like Gaia-X and EuroStack. This divergence underscores two distinct models of digital governance: Romania seeks rapid integration and the closing of gaps through global solutions, while Italy prioritizes autonomy and national control over data.

Remote work in the post-pandemic era has further amplified vulnerabilities in both countries. In Italy, phishing attacks increased by 40% during the pandemic, according to ESET reports, while groups such as Noname057(16) targeted governmental and financial infrastructures through DDoS attacks. In Romania, the Killnet group orchestrated massive attacks in 2022 against government, ministerial, and airport websites, temporarily disrupting critical services. These cases demonstrate that teleworking and reliance on global cloud solutions, i.e. Microsoft 365, Google Workspace, Zoom, have heightened the risk of losing control over data and have reinforced the necessity of Zero Trust Architecture.

At the European level, the analysis suggests that Romania and Italy represent two complementary extremes. Romania adds value through the speed of adopting EU policies and its role as a regional hub, but it requires greater investment and human resources. Italy contributes legislative stability, major investments, and a firm position on digital autonomy, but risks slowing innovation through an overly restrictive attitude toward global providers.

To express a general recommendation, Romania must increase domestic funding for ICT specialist training programs to reduce dependency on EU funds and external technologies. Investments in the government cloud should be accompanied by genuine interoperability and infrastructures capable of supporting electronic identity cards and other digital services. Italy, for its part, must balance its sovereigntist policies, as waiting indefinitely for the development of purely domestic solutions could generate irreversible stagnation. Collaborations with major global providers can deliver know-how and advanced technology, and their integration into local projects could accelerate digital transformation without undermining control over data.

The EU could recognize that the experiences of Romania and Italy illustrate the need for a common strategy that combines funding and support for more vulnerable states with respect for the autonomy principles promoted by stronger states. Initiatives such as Gaia-X and the Cyber Resilience Act should be consolidated through closer cooperation and by standardizing Zero Trust architectures at the European level.

The future of European cybersecurity will depend on the Union's ability to integrate innovation, security, and strategic autonomy. Romania and Italy, through their distinct approaches, can become complementary examples: Romania through rapid integration and adoption of modern solutions; Italy through the consolidation of independence and resilience. Together, these models may contribute to the construction of a robust European digital governance framework, capable of addressing the geopolitical and technological challenges of the future.

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QUANTITATIVE ANALYSIS OF THE RELATIONSHIP BETWEEN MATHEMATICAL AND COMPUTATIONAL THINKING IN THE CONTEXT OF AI INTEGRATION

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Abstract

This research explores the relationship between Mathematical Thinking (MT) and Computational Thinking (CT), two forms of reasoning that are often defined differently but share conceptual similarities. We propose a novel approach to studying this relationship by comparing the metalanguages – the general-purpose vocabulary and structures used to express ideas – across various fields in Mathematics and Computer Science.

Our main hypothesis is that if different fields share similar metalanguages, this reflects a deeper connection between them, which may influence understanding and success across domains. To test this, we analyzed multiple text corpora from a range of mathematical and computational disciplines. Using advanced Natural Language Processing (NLP) techniques, including lemmatization and tokenization, we filtered out domain-specific terms to reveal the underlying metalanguage.

We applied several clustering algorithms – K-Means, PAM, Density-Based Clustering, and Gaussian Mixture Models – to group fields based on linguistic similarity. Since clustering results can be sensitive to parameters and distance metrics, we further validated the outcomes using a Neural Network-based AI model. This AI integration helped assess the consistency of the clusters and provided a second layer of insight into the linguistic structures across fields.

To further evaluate the hypothesis – that fields with similar metalanguages may promote similar levels of comprehension – we combined this computational analysis with both quantitative and qualitative data from student participation. This paper presents the results of the quantitative component, highlighting how AI-assisted analysis can reveal meaningful connections between MT and CT through their shared linguistic foundations.

Keywords: *mathematical thinking; computational thinking; undergraduate students; education skills; metalanguage.*

JEL Classification: C6; A22.

1. INTRODUCTION

Computers and programming have significantly transformed the modern world, establishing technological literacy as an essential skill for academic and professional success in the digital age (Shute *et al.*, 2017). As a result, computational thinking (CT) – a mode of problem-solving applicable across diverse disciplines – has gained increasing attention in education.

There is a growing need to equip students, as future professionals, with complex thinking capabilities essential for addressing societal and business challenges. This necessitates the integration of both mathematical thinking (MT) and computational thinking (CT).

One of the major challenges lies in developing effective methods for evaluating thinking processes. We propose examining the linguistic dimension of thought, recognizing that thinking is embedded within language (De Saussure, 1916; Heidegger, 1927). Noam Chomsky, widely regarded as the father of modern linguistics, emphasizes the profound connection between language and thought (Chomsky, 2006).

Given that both Mathematics and Computer Science are structured around formal languages, and individuals employ metalanguage in cognitive processes, it becomes possible to analyze the relationships among these metalanguages to better understand thinking. As defined by Alfred Tarski, metalanguage refers to the language used to discuss the properties and rules of another language, including its expressions, sentence construction, syntax, and truth conditions (Tarski, 1944; Gruber, 2016).

To formulate a clearer hypothesis about the relationships between capabilities in specific domains of Mathematics and Computer Science, we adopted a novel approach – comparing the metalanguages used in various subfields within each discipline. In this Data Mining phase (Hand, 2007; Cheng, 2017), we analyzed numerous text files drawn from distinct areas of Mathematics and Computer Science.

The Mathematical domains examined included: Linear Algebra, Abstract Algebra, Combinatorics and Probability, Mathematical Analysis, Set Theory, and Logic. For Computer Science, the areas studied were: Functional Programming, Imperative Programming, Object-Oriented Programming, Data Structures and Algorithms, Automata and Formal Languages, and Operating Systems. These subjects represent core components of most Computer Science curricula.

The following steps were undertaken:

- Text classification and vectorization using the FastText model.
- Distance computation between vectors (Cohen *et al.*, 2009; Van Dongen and Enright, 2012).
- Application of clustering algorithms (Broder *et al.*, 1997).

As a result, groups of fields in Mathematics and Computer Science with closed metalanguages were received. Because clustering results can be influenced

by parameter choices and distance metrics, we used XLNet – an AI model based on a neural network to further validate the findings. This AI-based approach helped check the stability of the clusters and offered additional insights into the linguistic structures shared across different fields.

To test the hypothesis that fields with similar metalanguages may support similar levels of understanding, we combined this computational analysis with both quantitative and qualitative data gathered from student participation. This paper focuses on the quantitative findings, showing how AI-assisted analysis can uncover meaningful links between Mathematical Thinking (MT) and Computational Thinking (CT) through their common linguistic features.

2. DATA MINING RESEARCH STAGE WITH AI INTEGRATION

This section presents the clustering process and the use of XLNet – an AI model based on neural networks. The aim of both processes is to derive a division of fields in Mathematics and Computer Science according to the similarity of their metalanguages.

2.1. Clustering process

After converting the texts into vectors and calculating the distances between them, four clustering algorithms were applied: K-Means, PAM, Density-Based Clustering, and Gaussian Mixture Models. The process began with K-Means, as it is widely regarded as one of the most commonly used and effective algorithms. However, a key challenge is that K-Means performs optimally with the Euclidean distance metric. Since our analysis focuses on correlations, we opted to use the Pearson distance metric instead.

Although K-Means remains a valuable method due to its relative simplicity, the results were not entirely logical or consistent, possibly due to its inherent reliance on Euclidean assumptions, as noted earlier. After running all four algorithms, the PAM (Partitioning Around Medoids) algorithm produced the most coherent and meaningful clusters. The results are presented in Figure 1.

Operation Systems	63	23	9	5
Data Structures and Algorithms	59	10	30	2
Functional Programming	17	21	58	5
Imperative Programming	65	5	9	20
OOP	58	14	14	15
Automata and Computation Theory	20	7	63	10
Abstract Algebra	16	67	9	8
Analysis	8	9	8	75
Combinatorics And Probability Theory	62	12	14	12
Linear Algebra	15	65	10	10
Logic	17	10	52	21
Set Theory	30	9	51	10

Figure 1. Division of fields into clusters

The analysis resulted in the following four clusters:

Cluster 1: Operation Systems, Data Structures and Algorithms, Imperative Programming, OOP, Combinatorics and Probability.

Cluster 2: Linear Algebra, Abstract Algebra.

Cluster 3: Functional Programming, Automata and Computation Theory, Logic, Set Theory.

Cluster 4: Analysis.

2.2. Using XLNet – a neural network-based AI model

XLNet is a transformer-based language model that captures the meaning and context of words within text (Yang *et al.*, 2019). In this study, XLNet is used to analyze the metalanguages found in texts from different fields in Mathematics and Computer Science. By converting these texts into numerical representations (vectors), XLNet allows us to compare and group fields based on similarities in their metalanguages. This helps reveal underlying connections between disciplines through their shared or distinct ways of expressing concepts.

After training the XLNet model on our domain-agnostic text segments, we achieved an overall accuracy of 86% on the test set. The results obtained using the model are presented in the Figure 2.

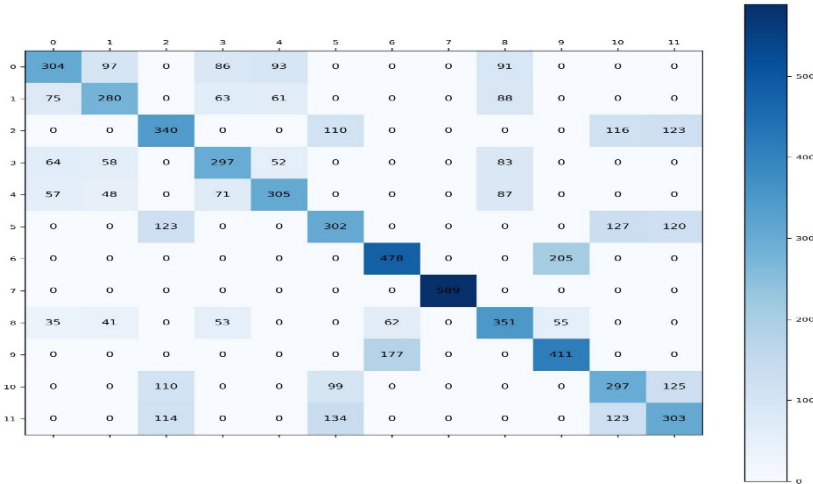


Figure 2. Outcomes of applying the XLNet Model

All the disciplines were labeled from 0 to 11, with the Computer Science domains labeled from 0 to 5 (e.g., Operating Systems is labeled as 0), and the

Mathematics domains labeled from 6 to 11 (e.g., Abstract Algebra is labeled as 6), following the order shown in Figure 1. If we examine the first line, which represents the data labeled as Operating Systems, we find a total of 671 samples. Approximately 45% of this data was correctly identified as related to Operating Systems, while the remaining samples were classified under domains 1, 3, 4, and 8. This distribution suggests a similarity in the metalanguages of Operating Systems and these domains. The result is consistent with the previously shown cluster division, supporting the reliability of the clustering process. A similar pattern can be observed across the remaining lines, indicating a consistent regularity in the data classification.

It can be observed that the distribution of groups closely resembles the one produced by the clustering process. The purpose of this dual approach is to verify that the outcome of the clustering process is not random. Based on this comparison, it can be concluded that the grouping derived from the clustering process is both reliable and meaningful.

3. EXPLORING STUDENT RESPONSES: A QUANTITATIVE APPROACH

After obtaining the results of text clustering in the previous stage of the research, the next step was to test the hypothesis that students would demonstrate a similar level of understanding in areas that share similar metalanguages. To examine this, a study was conducted involving student participation.

3.1. Participants profile

Both primary and secondary data were utilized in this study (Hox *et al.*, 2005). The secondary data consist of students' grades in Mathematics and Computer Science courses offered throughout the duration of the engineering degree at a college of engineering. These data were obtained from the faculty secretary, in accordance with ethical guidelines and confidentiality regulations. The research participants were approximately 200 students who had completed their studies in Software Engineering at a College of Engineering.

To gather primary data, questionnaires were constructed containing questions from each of the 12 topics (6 from Mathematics and 6 from Computer Science). These questionnaires were administered in class with the participation of about 150 final-year students studying software engineering at a college of engineering. These students were chosen in their final academic year of studies, so they had already studied the courses taken as representative fields in Mathematics and Computer Science. They also bring a varied background level in Mathematics and Computer Science from school education.

Participants received comprehensive information about the research's purpose, and they were informed that their participation was voluntary and that

their anonymity would be maintained. Additionally, the research was conducted with the approval of the college ethics committee.

3.2. Questionnaires and data collection

The questionnaire was designed to assess understanding in Mathematics and Computer Science domains in order to evaluate thinking. Before distribution, it underwent expert validation. The questionnaires consist of a series of problem-solving exercises, such as developing new algorithms, writing code in various programming languages, improving and debugging existing code, and proving the correctness of algorithms. We chose to use questionnaires because they allow for the systematic collection of data to assess understanding in specific domains and evaluate higher-order thinking

Questionnaires are widely used in research involving Mathematics and Computer Science for several key reasons. First, they enable the collection of large-scale quantitative data efficiently, which is essential for identifying patterns and drawing statistically significant conclusions (Creswell, 2014). Second, questionnaires allow researchers to assess participants' perceptions, experiences, and conceptual understanding across diverse topics, supporting cross-domain comparisons (Rach *et al.*, 2013). Third, structured questionnaires can be replicated or adapted for longitudinal studies, enhancing the reliability and generalizability of findings (Cai and Wang, 2010).

As a result, we received data consisting of 12 grades for each of the 150 students. For each discipline, students received a grade ranging from 0 (lowest) to 100 (highest), with 55 considered a passing grade. The 0–100 grading scale is widely used due to its clarity, flexibility, and fine level of granularity, allowing educators to differentiate student performance with precision. It provides a familiar and intuitive framework for both instructors and students, making it easier to interpret results and compare outcomes across assessments and institutions (Brookhart, 2011; McMillan, 2014).

4. RESULTS

This chapter presents the results of a quantitative analysis to test the hypothesis that fields with similar metalanguages may support similar levels of understanding.

4.1. Secondary data analysis

The analysis of secondary data did not yield significant results. A possible reason for this is that grading does not always reflect knowledge. Sometimes instructors use factors and adjustments, making it difficult to conduct a clean analysis of the relationship between mathematical thinking and computational thinking.

4.2. Primary data analysis

The analysis includes interpreting the results of questionnaires with exercises in the fields of Mathematics and Computer Science.

To examine if the grades of 12 fields can be divided into clusters, principal-component exploratory factor analysis with orthogonal rotation was conducted (Jolliffe and Cadima, 2016; Brown, 2009). The analysis yielded three factors, explaining 65.9% of the variance. The results are presented in Table 1.

Table 1. Rotated Component Matrix

	Component		
	1	2	3
Logic	.783		.103
Set Theory	.681	-.138	.113
Automata and Computation Theory	.635		
Combinatorics and Probability Theory	.624	-.141	-.157
OOP	-.163	.682	
Data Structures and Algorithms	.107	.647	
Imperative Programming	-.133	.614	
Functional Programming		.561	
Operation Systems		.497	
Linear Algebra		.105	.821
Modern Algebra			.690
Analysis			.686

The table shows a division of the fields into three groups based on color. This division matches 75% of the clustering made according to the meta-languages. This is a very important result that can certainly support the main hypothesis that fields with similar metalanguages may support similar levels of understanding.

Another interesting result emerged from the correlation analysis between prior knowledge in Computer Science and grades in core programming courses. Figure 3 clearly shows a strong correlation, indicating that prior knowledge in Computer Science significantly influences interest and abilities in the field.

	Prior High CS Level
Analysis	0.041895
Set Theory	-0.152997
Linear Algebra	0.084848
Modern Algebra	-0.020629
Logic	-0.053952
Combinatorics and Probability Theory	-0.108896
Imperative Programming	0.841845
OOP	0.242819
Data Structures and Algorithms	0.152565
Operation System	0.059551
Automata and Computation Theory	-0.019092
Functional Programming	0.256233

Figure 3. Outcomes of applying the XLNet Model

5. CONCLUSIONS

As shown in Table 1, the results of grade distribution across different fields were divided into three groups based on similarity in success. 75% of the data match the clusters obtained in the previous stage, according to the fields division based on similarity in metalanguages. There is also a reasonable explanation for fields that were grouped differently. For example, two types of programming (Imperative Programming and Functional Programming) are expected to differ in concept and clearly have different metalanguages. However, since both fall under the category of programming, it is possible that someone who is good at programming performs well in all its types. Another example is Analysis: although the data suggest that its metalanguage is relatively unique and unlike the others, students study Analysis and the two Algebra courses (which were grouped into the same cluster) in the same semesters. Therefore, the level of effort in these courses may be similar, which could result in similar levels of success. Still, the 75% alignment with the metalanguage-based grouping strongly supports the validity of the main hypothesis that fields with similar metalanguages may support similar levels of understanding.

A possible continuation of this research could be to design a questionnaire with exercises in a specific field where a student struggles, but framed in the style of a field where the student performs well. If performance improves, it would suggest a strong connection between thinking and language.

Another interesting finding is the correlation between prior knowledge in Computer Science and success in programming courses, which are considered

core courses. This can be seen as a strong recommendation for those who want their children to pursue a popular and in-demand profession like Computer Science. The suggestion is to teach children programming in school, as this may increase their interest and, according to the research, also improve their success in the field.

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UNIFORMIZATION OF MOLDOVAN JURISPRUDENCE
REGARDING THE RECOGNITION AND ENFORCEMENT
OF FOREIGN ARBITRAL AWARDS – PREMISE FOR
CONSOLIDATING LEGAL CERTAINTY

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Abstract

The Republic of Moldova has undertaken clear commitments regarding the improvement of the legal framework in the field of arbitration and alternative dispute resolution, both through the Strategy for ensuring the independence and integrity of the justice sector and through its European integration path assumed in the National action plan for accession to the European Union 2024-2027 and the RM-EU Association Agreement. The uniformization of judicial practice in the field of recognition and enforcement of foreign arbitral awards is a fundamental pillar for ensuring legal certainty, administering justice, and achieving sustainable development. International experiences demonstrate the utility of instruments for consolidating and uniformizing judicial and arbitral practice to enshrine the principles of international commercial arbitration in ordinary courts and to promote it as a preferred method for resolving cross-border commercial disputes. The last act of uniformizing judicial practice in the field of recognition and enforcement of foreign arbitral awards in the Republic of Moldova dates back a decade, with no subsequent actions taken in this regard. This paper aims to analyze the legal framework and current practice of the Republic of Moldova regarding the recognition and enforcement of foreign arbitral awards.

Keywords: *foreign arbitral award; recognition; enforcement; legal certainty.*

JEL Classification: K38; K38; Q54.

1. INTRODUCTION

International arbitration is recognized as an essential method for resolving cross-border commercial disputes, offering flexibility, confidentiality, and specialized expertise. Its effectiveness crucially depends on the capacity of arbitral

awards to be recognized and enforced in various jurisdictions, an aspect largely guaranteed by the 1958 New York Convention.

The uniformization of judicial practice in applying the New York Convention is a fundamental pillar for ensuring legal certainty and creating a favorable investment climate. In the Republic of Moldova, although an adequate legislative framework exists, the quality and coherence of judicial practice in this area have, at times, posed challenges, being affected by the uneven application of the Convention.

Aware of this necessity, the Supreme Court of Justice of the Republic of Moldova adopted Plenum Decision No. 9 of December 9, 2013, amended by Decision No. 2 of April 25, 2016. This decision explicitly aimed to uniformize the practice of national courts regarding the recognition and enforcement of foreign judicial and arbitral awards. However, almost ten years after its initial adoption, the persistence of divergent interpretations and applications remains a relevant issue.

Advanced judicial practices in European Union member states, such as France and Germany, demonstrate a pro-arbitration approach and a restrictive interpretation of grounds for refusing enforcement, offering a model of predictability and efficiency. Correlated analysis of relevant jurisprudence and periodic publication of jurisprudential compendia, especially significant decisions of judicial review courts, represent an effective tool for disseminating uniform interpretations and applications of the New York Convention and national legislation. This endeavor would contribute to the dissemination of best practices, clarification of controversial aspects, and reduction of knowledge gaps, ensuring increased predictability in judicial decisions.

This paper aims to analyze the legal framework and current practice of the Republic of Moldova regarding the recognition and enforcement of foreign arbitral awards. It will assess the extent to which this practice contributes to consolidating legal certainty and supporting economic development, identifying best practices, challenges, and formulating concrete recommendations for greater uniformization.

2. DATA AND METHODOLOGY

For this analysis, a legal methodological approach will be used, combining normative and doctrinal study of international legal instruments and national legislation, with an in-depth analysis of domestic and international legal doctrine. The methodology also integrates elements of comparative analysis, examining best practices from jurisdictions with developed judicial systems in the field of arbitration. The research is based on legal sources at international and national levels, as well as on evaluating the impact of judicial decisions on the predictability and efficiency of the recognition and enforcement process. This composite methodology allows both conceptual exploration and the formulation

of practical recommendations for advancing uniform jurisprudence and a predictable legal climate.

1.1. International and national normative framework for the recognition and enforcement of foreign arbitral awards in the Republic of Moldova

The 1958 New York Convention on the Recognition and Enforcement of Foreign Arbitral Awards (NYC, or the New York Convention) is often considered the "cornerstone" of the international commercial arbitration system, being qualified as the most successful multilateral treaty in legal and commercial matters, 67 years after its adoption. Professor Albert Jan van den Berg, one of the prominent figures in arbitral law, emphasizes that this convention revolutionized international practice by establishing a simple and efficient mechanism for the enforcement of arbitral awards. Thus, the New York Convention not only regulates the recognition and enforcement of arbitral awards but also establishes a legal paradigm promoting a proactive and positive approach by national courts in supporting international arbitration (Cojocaru and Lazăr, 2018). Adopted at the United Nations Conference on June 10, 1958, the Convention entered into force on June 7, 1959, and has subsequently been ratified by over 170 states, including the Republic of Moldova in 1998.

The essential principles regulated by the Convention include:

Principle of equal treatment: enshrined in Article III, it stipulates that contracting states undertake to recognize and enforce foreign arbitral awards without imposing more restrictive conditions than those applicable to their own domestic arbitral awards.

Principle of minimal procedural requirements: provided for in Article IV, it obliges the interested party to furnish the original or a certified copy of the arbitral award and the arbitration agreement, accompanied by certified translations if applicable.

Principle of exceptionality of grounds for refusal: established by Article V, which exhaustively lists the grounds for rejecting an application for recognition or enforcement, such as incapacity of the parties, invalidity of the agreement, lack of notification, violation of jurisdiction, or conflict with the public policy of the requested state.

A fundamental principle recognized in doctrine and jurisprudence is that of "*in favorem arbitrandum*," which promotes an extensive and favorable interpretation of the rules regarding the recognition and enforcement of arbitral awards (Lazăr and Plotnic, 2023).

1.2. The framework of the recognition and enforcement of the foreign arbitral awards in the Republic of Moldova

In the Republic of Moldova, the procedure for the recognition and enforcement of foreign arbitral awards is primarily regulated by the Civil

Procedure Code (CPC), Articles 475-476. These provisions faithfully reflect the requirements and standards of the New York Convention, establishing a clear and detailed procedure for admitting applications for recognition and enforcement, explicitly respecting the limits and principles of the international convention.

Complementary to the CPC, the Republic of Moldova also has Law No. 23/2008 on Arbitration, which provides the general framework and principles of domestic and international commercial arbitration. The Republic of Moldova is also a party to a series of bilateral and multilateral agreements on mutual legal assistance, but the New York Convention retains primacy and represents the mandatory standard for international arbitral awards.

1.3. Comparative aspects and the influence of the regional framework

Although arbitration is explicitly excluded from Brussels I bis Regulation (EU 1215/2012), this does not diminish the indirect relevance of the EU acquis and European jurisprudence in arbitration for the Republic of Moldova, especially in the context of its European integration aspirations. The jurisprudence of some member states, such as France and Germany, is often invoked as a benchmark in interpreting and applying the standards of the New York Convention, particularly concerning the notion of public policy and the limits of judicial control over arbitral awards.

The influence of the European Union also manifests through the jurisprudence of the Court of Justice of the European Union (CJEU), even if it does not have direct competence over the interpretation of the New York Convention (Gribincea, 2018). Also, the jurisprudence of the European Court of Human Rights (ECtHR), particularly concerning the guarantees of a fair trial through article 6 is fundamental. This can be invoked in the context of verifying compliance with public policy, ensuring that the arbitral procedure and, subsequently, the recognition and enforcement process, respect minimum standards of procedural fairness and access to justice.

At the European and international levels, various initiatives and instruments exist to promote uniformization and dissemination of best practices in arbitration. The ICCA Advisory Committee (International Council for Commercial Arbitration), for example, publishes reports and guides that offer clarifications and recommendations regarding the application of the New York Convention. Also, numerous renowned arbitral institutions and professional organizations develop and publish model rules, jurisprudential analyses, and thematic compendia (e.g., ICCA Yearbook Commercial Arbitration) that contribute to creating a common understanding and coherent practice globally.

Thus, the Republic of Moldova has the opportunity and necessity to closely follow European and international developments and best practices, adapting them to the national legal context to consolidate the uniformity of interpreting the norms of the New York Convention and implicitly relevant national legislation,

thereby contributing to strengthening legal certainty and national economic attractiveness.

3. ANALYSIS OF JUDICIAL PRACTICE IN THE REPUBLIC OF MOLDOVA

1.4. Evolution of judicial practice in the recognition and enforcement of arbitral awards

Over the last two decades, the judicial practice of the Republic of Moldova regarding the recognition and enforcement of international arbitral awards has undergone progressive development, reflecting both international trends and internal efforts to align with the standards of the 1958 New York Convention. As analyzed by Prof. Pierre Lalive, international commercial arbitration is "the work of practitioners, but also of judges and researchers" (Lalive, 1986). Therefore, the degree of uniformity in applying the 1958 New York Convention in any country, including the Republic of Moldova, can be considered a barometer of the effectiveness of international commercial arbitration. Thirty-one years after the adoption in 1994 of the first Law on arbitral proceedings in the Republic of Moldova, as an independent state, we can observe a gradual increase in the complexity of cases examined by national courts, indicating that international arbitration is playing a more prominent role in the commercial relations of parties with residency or interests in the Republic of Moldova.

The evolution of jurisprudence reflects a series of stages – from interpretative confusions and procedural errors to more nuanced solutions recently, consistent with international standards. General statistics indicate a high rate of admission of requests for recognition and enforcement, estimated at approximately 80% of requests being granted (Lazăr, 2018).

However, the history of judicial practice also reveals moments of uncertainty and initial divergences, marked by a blatant circumvention of the New York Convention's provisions. A landmark precedent in this regard is the decision of the Supreme Court of Justice of September 14, 2011, in case no. 2r-429/11, in the dispute with "*Merchant Outpost Company*". This case exemplified significant deficiencies in how recognition and enforcement requests were handled by trial and appellate courts, as well as how limited knowledge of the institution of international commercial arbitration was exploited in bad faith. The seized court admitted major violations in the application of the Convention's provisions and national legislation, demonstrating the precariousness of the judicial system and a public policy danger, as noted in the informative note and the final decision of the Supreme Court of Justice (Cojocaru and Lazăr, 2018, p. 179). This case generated the need for interventions in the civil procedure law, but through the explanatory decisions of the Supreme Court of Justice, aimed at guiding and providing comprehensive standards to the body of magistrates regarding the recognition and enforcement of foreign arbitral awards.

The analysis of recent decisions by the Chişinău Court of Appeal, the competent court for hearing requests for recognition and enforcement of foreign arbitral awards, and, in some cases, by the Supreme Court of Justice, illustrates a predominantly favorable approach to recognizing arbitral awards. However, in more complex cases, or those involving the state and its public authorities, we can conclude that the degree of erroneous and, at times, biased interpretations is much higher.

In certain cases, a non-conforming application of specific arbitration rules can be observed, situations in which the state or public authority is advantaged. In the case of *SRL "Badprim" v. Government of the Russian Federation*, the claimant, a commercial company headquartered in the Republic of Moldova, sought recognition and enforcement of an SCC arbitral tribunal award from Stockholm, pursuant to the Rules of the International Court of Arbitration of the Paris Chamber of Commerce and Industry, upheld by the Svea Court of Appeal in Sweden. In July 2016, the Chişinău Court of Appeal rejected the request on the grounds that "neither the Chişinău Court of Appeal nor any other court in the Republic of Moldova is competent" (Lazăr, 2018). The court explained that such an arbitral award obliging a foreign state to pay the indicated sums does not fall within its jurisdictional competence. In an appeal order in the same case, the Supreme Court of Justice held that "no court in the Republic of Moldova is competent to resolve such requests, otherwise the judicial act would blatantly affect the sovereignty of the Russian Federation, also violating the principle of territoriality of the act of justice." These treatments raise comments, as the ability of states and public legal entities to conclude an arbitration agreement, and thus be a party to arbitral disputes, is widely recognized. The participation of the state and public institutions in arbitration and their capacity to conclude arbitration agreements, referred to as "subjective arbitrability," is enshrined both by Article II para. (1) of the 1961 Geneva European Convention, ratified by the Republic of Moldova in 1997, the Washington Convention on the settlement of investment disputes between states and nationals of other states of March 18, 1965, as well as by national legislation and comparative jurisprudence. Through the famous decision *Galakis v. Trésorerie publique* (1966), the French Court of Cassation found that the prohibition of a state from appearing in arbitration is not applicable in the case of an international contract, thereby establishing a new rule of international public policy, which has become a principle applied uniformly in both ordinary law jurisprudence and arbitral practice (Cojocaru and Lazăr, 2018, p. 114).

The public policy refusal ground remains one of the most problematic limitations, its application not being consistent with international standards (ICCA, 2025) and the uniform practice analyzed in the explanatory Decision of the Supreme Court of Justice Plenum, as amended in April 2016 (SCJ, 2016). We can observe a clear deviation from the definition and interpretation of the concept

of public policy in these cases. When applying the public policy criterion for refusing recognition and enforcement of foreign arbitral awards, the court must refer to the concept of international public policy or private international law public policy. For the ground stipulated in Article V para. (2) lit. b) of the New York Convention to be upheld, the forum must find whether the infringements on public policy occur because of the recognition and enforcement of the foreign arbitral award and are not presumed from the essence of the foreign arbitral award. These violations and contraventions of the forum's public policy must be "evident, effective, and concrete" (Madden and Knoebel, 2022). In doctrine, most authors give the concept of public policy a restrictive interpretation, although there are also opinions favoring an extensive application of this ground (Lazăr, 2018).

Finally, we can conclude that, in result of the Plenum Decision of the Supreme Court of Justice of the Republic of Moldova "Regarding the practice of application by the courts of the legislation concerning the recognition and enforcement of foreign judicial and arbitral awards" no. 9 of December 9, 2013, with substantial amendments from April 25, 2016, the alignment with uniform standards regarding the recognition and enforcement of foreign arbitral awards in the Republic of Moldova has improved.

In the case of "Stork International GmbH (Germany) v. Agrofloris-Nord SRL" (SCJ, 2023), the Supreme Court of Justice rejected the debtor's appeal and confirmed the appellate court's decision regarding the recognition of the international arbitral award, reaffirming the principle of autonomy of the arbitral procedure. The Court emphasized that it lacked jurisdiction to rule on the merits of the dispute and that the existence of a valid arbitration agreement and proper notification of the parties were sufficient to admit the enforcement request. This solution is in full compliance with international jurisprudence and the spirit of the New York Convention. Similarly, in the case of "M. Gres v. W." (2022), the Supreme Court of Justice correctly confirmed the decisions of the lower courts, explicitly mentioning the fundamental principles of arbitration – especially the binding nature of the award and the impossibility of examining its merits (Court of Appeal Chișinău, 2022c). Thus, it was reiterated that national courts cannot substitute the authority of the arbitral tribunal in interpreting the agreement and resolving the dispute.

1.5. Interpretation of grounds for refusal of recognition and enforcement of foreign arbitral awards in the jurisprudence of the Republic of Moldova

The application of the grounds for refusal of recognition and enforcement of foreign arbitral awards, provided by Article V of the New York Convention and transposed into the Civil Procedure Code of the Republic of Moldova, is an area where courts must exercise caution, respecting the exhaustive nature of these grounds. In the practice of the Republic of Moldova, Moldovan courts have

variably interpreted these grounds, with oscillating tendencies between a restrictive approach, in the spirit of the Convention, and a more formalistic one, which can lead to the rejection of the enforcement request:

- **Lack of a valid arbitration agreement (Art. V(1)(a))**

A primary ground invoked by Moldovan courts for refusing enforcement is the absence or nullity of the arbitration agreement. In the case *Just Us SRL (Romania) v. Air Moldova* (2022), the Moldovan Supreme Court of Justice rejected the request for recognition and enforcement of an arbitral award rendered by the International Commercial Arbitration Court of Romania, citing the non-existence of a valid arbitration agreement (Court of Appeal Chişinău, 2022a).

The extensive interpretation of Article V(1)(a) ignored the rule of autonomy of the arbitration clause from the main contract (principle of severability) and contravened the restrictive approach promoted internationally.

- **Lack of proper notification (Art. V(1)(b))**

Article V(1)(b) of the New York Convention allows for the refusal of recognition and enforcement if the party against whom the award is invoked was not properly notified. In the case *SRL "Energoalians" v. SRL "Feren-M"* (2008) the Court of Appeal of the Republic of Moldova reasoned that the defendant was not legally summoned, "a fact that prevented the commercial company from the Republic of Moldova from defending its rights and expressing its opinion on the dispute."

Seized with an appeal, the Supreme Court of Justice overruled the Court of Appeal's decision as unfounded because the defendant had not provided evidence of improper summoning (Cojocaru and Lazăr, 2018, pp. 177-178).

These precedents indicate that the courts did not apply the international standard for assessing notification – based on criteria of efficiency and real possibility of participation – and treated this ground as an absolute formal error, affecting the predictability of practice.

- **Incapacity or lack of jurisdiction of the tribunal (Art. V(1)(c) NYC)**

Article V(1)(c) provides for the possibility of refusal if the tribunal exceeded the scope of the arbitration agreement. In the case *Just Us SRL v. Air Moldova* (Court of Appeal Chişinău, 2022a), the Court of Appeal invoked the alleged lack of jurisdiction of the tribunal, although there was no detailed analysis of its jurisdiction in relation to the arbitration clause. The court substituted its own analysis for that performed by the arbitral tribunal, violating the *kompetenz-kompetenz* principle. In contrast, in *Optimo Distribution SRL v. OT Solution Ltd* (UK) (2024), the Chisinau District Court correctly applied this principle, emphasizing that objections regarding jurisdiction should have been raised before the arbitral tribunal, and the courts do not have authority to re-examine this issue at the recognition stage (Court of Chisinau District, 2025).

- **Violation of public policy (Art. V(2)(b) NYC)**

The most sensitive and controversial ground for refusal remains public policy. In the jurisprudence of the Supreme Court of Justice, this ground is often invoked extensively, which contradicts its exceptional nature. In the case *Bio-Labs (Pvt) Ltd v. Dita EstFarm SRL* (Court of Appeal Chişinău, 2022b), the Court of Appeal refused enforcement of the award on the grounds that enforcement would allow the creditor to obtain an unjustified benefit and referred to the value of an administrative act violated during the delivery of goods subject to the contract. This analysis amounted to a review of the merits and indicates a broad interpretation of the public policy ground, inconsistent with generally accepted practice principles.

- **Merits of the dispute inadmissibly analyzed**

Although not expressly provided as a ground for refusal, review on the merits constitutes a violation of the principle of finality of arbitral awards. In several cases, the Supreme Court of Justice exceeded the limits of its role as a recognition court. The cases *Bio-Labs (Pvt) Ltd v. Dita EstFarm SRL* (Court of Appeal Chişinău, 2022b) are the most eloquent, where the court analyzed the validity of the claim, contrary to the rules on separation of powers.

The analysis of Moldovan jurisprudence regarding the refusal of recognition and enforcement of foreign arbitral awards reveals a non-uniform and often extensive application of the grounds for refusal provided by the New York Convention.

4. HARMONIZATION OF JURISPRUDENCE AND THE ROLE OF COURTS IN THE RECOGNITION AND ENFORCEMENT OF INTERNATIONAL ARBITRAL AWARDS

1.6. Doctrinal considerations and foundations of jurisprudential harmonization in international commercial arbitration

The harmonization of jurisprudence concerning the recognition and enforcement of international arbitral awards reflects a profound doctrinal and practical evolution in contemporary arbitration law.

The harmonization of jurisprudence, both at the level of state courts and arbitral tribunals, represents a necessary premise for ensuring legal certainty in the process of recognizing and enforcing international arbitral awards. Non-uniform application of the 1958 New York Convention can significantly affect the effectiveness of arbitration. The *in favorem arbitrandum* principle emphasizes the orientation towards maximum efficiency and effectiveness of the arbitration act, and legal certainty is a fundamental desideratum in this equation.

As Professor Gary Born emphasizes, "predictability is a fundamental ingredient of the rule of law, and the consistency of jurisprudence in international arbitration is essential for attracting foreign capital" (Born, 2021, p. 113).

Professor Gaillard stresses that international arbitration law functions as an autonomous system, with its own rules, principles, and jurisprudence. He advocates for the development of an "epistemic community" of practitioners and judges who apply the rules in a coherent and predictable manner. Harmonization is, in Emmanuel Gaillard's view, "the key to strengthening confidence in the international arbitral system" and guarantees that arbitral awards will not be refused enforcement for arbitrary or inconsistent reasons across different jurisdictions (Gaillard, 2010, pp. 18–21). Albert Van den Berg consistently advocated for a uniform and restrictive interpretation of Article V of the Convention, warning of the risk of "renationalization" of arbitration if courts expansively interpret concepts such as "public policy." In his classic article "The New York Convention of 1958: Towards a Uniform Judicial Interpretation," he pleads for the creation of convergent jurisprudence using comparative doctrine and jurisprudential collections (Van Den Berg, 1987, pp.155-202).

Authors Julian Lew, Loukas Mistelis, and Stefan Kröll – in *Comparative International Commercial Arbitration* (Lew *et al.*, 2003) – draw attention to the need for coherence in applying recognition and enforcement principles, emphasizing that harmonization contributes to reducing forum shopping and uncertainty. Similarly, Professor Jan Paulsson remarked that "persuasive precedent" functions as an informal mechanism for harmonization and stability, influencing the resolution of international disputes through constant references to decisions considered representative (Paulsson, pp. 89-101).

Doctrine highlights that, despite progress made through uniform law instruments such as the UNCITRAL Model Law and the 1958 New York Convention, national courts continue to face difficulties in their uniform interpretation and application, which can affect predictability and efficiency in the recognition and enforcement of foreign arbitral awards (Arp, 2020, p. 2). Harmonization is facilitated by the systematic use of similar norms and principles within arbitral tribunals and by promoting a common institutional framework (Garnett, 2000). This trend is supported by the philosophy of international arbitration, where party autonomy and the transnational nature of the legal regime prevail, and previous decisions of tribunals or foreign courts function as persuasive benchmarks, even in the absence of a strict rule of precedent (Béguin, 2009).

In this logic, legal certainty in the field of recognition and enforcement of arbitral awards is strengthened by the interaction between legislation, jurisprudence (Bělohávek, 2013), and *soft law* instruments, all converging towards an increasingly uniform interpretation of relevant international standards (Dasser, 2021). Thus, in the absence of a formal system of precedent, the persuasive authority of foreign judgments functions as a functional substitute for the *stare decisis* rule in international arbitration. In support of the idea that the persuasive authority of foreign arbitral or judicial awards can function as a

functional substitute for the *stare decisis* rule in international arbitration, Professor Kaufmann-Kohler notes that arbitrators often resort to precedents not out of obligation, but to ensure the coherence and predictability of the system. She argues that "precedent in arbitration is not binding, but it is persuasive and critical to the development of a coherent legal framework" (Kaufmann-Kohler, 2007, p. 366).

1.7. International best practices and the contribution of global institutions and initiatives to the harmonization of jurisprudence in the recognition and enforcement of arbitral awards

The harmonization of judicial and arbitral practice is an essential element for consolidating the international credibility of arbitration and for creating a predictable standard regarding the recognition and enforcement of arbitral awards. At the international level, this process is supported by established arbitral institutions, as well as by intergovernmental organizations and multilateral professional initiatives that propose instruments, recommendations, and models of good practice. International arbitration centers such as the ICC (International Chamber of Commerce), LCIA (London Court of International Arbitration), SCC (Stockholm Chamber of Commerce), HKIAC (Hong Kong International Arbitration Centre), or VIAC (Vienna International Arbitral Centre) play a fundamental role in shaping coherent and predictable practice by developing modern procedural rules, publishing decisions (in anonymized form), and compiling thematic collections of jurisprudence.

For example, the ICC International Court of Arbitration in Paris regularly publishes selections of arbitral awards and reports on the reasons for arbitral decisions, thus contributing to an indirect form of precedent or soft law. Through the Guides and Explanatory Notes issued, the ICC actively contributes to the convergence of arbitral procedures and the formation of harmonized practice regarding the application of the New York Convention. It is noteworthy that the ICC's practice of encouraging arbitral tribunals to refer, when appropriate, to existing jurisprudence, thereby increasing the consistency of reasoning and encouraging an ecosystem of decisions with guiding value, even in the absence of a formal rule of precedent (ICC, 2021).

LCIA and HKIAC are also active in the field of transparency and decision coherence, providing statistical reports and summaries that allow for the analysis of trends in accepting or rejecting recognition and enforcement requests. VIAC has distinguished itself by integrating a European approach, adapted to EU law, which has facilitated the acceptance of its awards in European jurisdictions.

Another essential pillar of harmonization is the activity of UNCITRAL (United Nations Commission on International Trade Law), which has developed two fundamental instruments: the 1958 New York Convention and the UNCITRAL Model Law on International Commercial Arbitration (1985, with amendments in 2006). These provide not only uniform rules but also guidance for

interpretation. The implementation guides and interpretive reports published by UNCITRAL offer national courts and legislators a coherent interpretive compass, essential for harmonization.

The International Council for Commercial Arbitration (ICCA) represents one of the most important initiatives for promoting global harmonization. Through publications such as the *ICCA Yearbook Commercial Arbitration* or *ICCA Guides to the Interpretation of the New York Convention*, the organization provides analytical and comparative tools that directly contribute to reducing disparities in interpreting grounds for refusing recognition and enforcement. The *New York Convention Guide*, an interactive platform that provides access to global jurisprudence on recognition and enforcement, thematically classified and comparable across jurisdictions (UNCITRAL, 2016). This initiative provides courts with a direct and credible source of inspiration to base their decisions in a harmonized manner.

The harmonization of jurisprudence regarding the recognition and enforcement of arbitral awards is not the result of imposed regulation, but of a collective effort to build an international standard based on doctrinal convergence, institutional practice, and inter-jurisdictional cooperation. In this context, the idea is increasingly clear that coherent and predictable justice in international arbitration depends on the continuous interaction between comparative jurisprudence, soft law instruments, and the willingness of courts to leverage global best practices.

1.8. Recommendations for the Republic of Moldova for consolidating jurisprudential uniformity and the effectiveness of recognition and enforcement of foreign arbitral awards

The Republic of Moldova, although possessing a legislative framework favorable to international arbitration, faces significant limitations in its coherent and effective application. The arbitration culture is still underdeveloped, and judicial practice is fragmented, which affects the predictability of solutions and, implicitly, legal certainty.

The Republic of Moldova is a party to the main international treaties on the recognition and enforcement of arbitral awards, including the New York Convention since 1998, the European Convention on International Commercial Arbitration since 1994, and the ICSID Convention since 1994.

Domestically, Law No. 24 of February 22, 2008, on International Commercial Arbitration is based on the UNCITRAL Model Law on International Commercial Arbitration 2006 revised edition, which offers an inherent degree of legislative compatibility with states possessing advanced arbitration systems.

This legislative framework creates prerequisites for normative uniformization with established jurisdictions. However, the major difficulty lies

in transposing these standards into judicial practice and the functioning of arbitral institutions.

In terms of both judicial and arbitral jurisprudence concerning the recognition and enforcement of foreign arbitral awards, the volume of such cases in the Republic of Moldova is relatively low. This reality affects the level of familiarity and in-depth knowledge of magistrates and legal professionals regarding international standards for the effectiveness of arbitral awards. In the absence of consolidated practice and a significant number of consistently analyzed cases, judicial interpretations can remain fragmented, which generates risks in the correct application of the 1958 New York Convention on the Recognition and Enforcement of Foreign Arbitral Awards.

The International Commercial Arbitration Court (ICAC) at the Chamber of Commerce and Industry of the Republic of Moldova annually hears approximately 7 international commercial cases, while domestic arbitration cases are 10 times more numerous. The judicial practice of the courts of appeal, which have jurisdiction over applications for recognition and enforcement of foreign arbitral awards, is also equally limited.

In 2021, over 22 arbitral institutions were registered in the Republic of Moldova, but only one or two of them show constant activity and connections with international partners, European Bank for Reconstruction and Development and International Development Law Organization (EBRD and IDLO, 2021) – particularly the ICAC at the CCI of Moldova and the Chisinau International Court of Commercial Arbitration by the Moldovan American Chamber of Commerce in Moldova. The remaining institutions either are not effectively active or do not adhere to minimum transparency standards, such as publishing awards, maintaining an accessible register of arbitrators, or making procedural rules available. This situation contributes to a weak perception of the efficiency and credibility of arbitration in the Republic of Moldova.

At the same time, judicial practice regarding the recognition and enforcement of foreign arbitral awards can generally be characterized as "pro-enforcement," especially in the last decade. Approximately 80% of recognition and enforcement applications are granted by national courts, indicating a favorable disposition towards the application of the New York Convention. However, in more complex cases, particularly those involving notions of public policy, foreign applicable law, or procedural equivalence, errors in interpretation and application of international standards occur.

A significant turning point for the uniformization of practice was the adoption of Explanatory Decision No. 9 of the Plenum of the Supreme Court of Justice of December 9, 2013, amended by Decision No. 2 of April 25, 2016 (SCJ, 2016). This decision provides an official interpretation aimed at ensuring the correct and uniform application of procedural rules in cases concerning the recognition and enforcement of foreign arbitral awards. The document transcribes

a series of New York Convention standards, interpreted in accordance with the ICCA Guide (ICCA, 2025), bringing clarity to the application of grounds for refusal and promoting a restrictive approach to them.

In particular, the Plenum of the SCJ reaffirms the courts' obligation to refrain from any re-examination of the merits of the arbitral award and recommends a restrictive interpretation of the public policy ground for refusal, in line with international jurisprudence and arbitration doctrine (SCJ, 2016). Although the explanatory decisions of the Plenum of the Supreme Court of Justice are not strictly binding, they exert a consolidated interpretive authority, frequently followed by lower courts to ensure uniform judicial practice.

As highlighted in specialized literature, an efficient and coherent system for the recognition and enforcement of arbitral awards directly contributes to strengthening investor confidence in the domestic legal order and to the integration of the state into the global circuit of international commercial affairs (Al-Busaidy, 2013).

In this context, it is recommended to elaborate and publish analyzed jurisprudential compendia, focused on international commercial arbitration cases, especially concerning recognition and enforcement. These should include not only relevant decisions but also doctrinal commentaries, references to international guides, such as ICCA, UNCITRAL, CIArb, and comparative jurisprudence from established jurisdictions.

This network of compendia, guides, and doctrinal syntheses creates a common pool of knowledge and benchmarks that can contribute to reducing the risk of divergent or arbitrary treatments, supporting the consolidation of coherent global arbitral law. At the same time, it is opportune to elaborate a transparent national register of functional arbitral centers, with an annual presentation of statistics on resolved cases, adherence to international standards, and involvement in regional and international cooperation networks. Institutional consolidation of the most active arbitral centers, such as the ICAC, should be encouraged by providing a favorable regulatory framework and supporting their participation in international standardization initiatives.

The continuous training of magistrates should include modules dedicated to the application of the New York Convention, the study of foreign jurisprudence, and the analysis of complex cases with foreign elements. Useful models can be drawn from Swiss jurisprudence, where the Federal Tribunal promotes a pro-enforcement interpretation, strictly limiting the application of the public policy exception, as well as from French and American practice, where courts avoid reviewing the merits and uphold the autonomy of the arbitral tribunal. Furthermore, the jurisprudence of the European Court of Human Rights emphasizes the importance of respecting the right to a fair trial, guaranteed by Article 6 of the Convention, even in arbitral proceedings, obliging states to ensure

that the recognition and enforcement of arbitral awards do not contravene fundamental guarantees.

The consolidation of jurisprudential uniformity in the Republic of Moldova cannot be achieved in the absence of a coherent national strategy, accompanied by international partnerships, legislative initiatives, and a firm commitment from the courts.

5. CONCLUSION

The Republic of Moldova advances on a pro-enforcement trajectory regarding the recognition and enforcement of foreign arbitral awards, yet judicial practice remains fragmented. Despite a solid legislative basis and the general orientation of courts toward enforcement, key challenges persist – stemming from inconsistent application of the New York Convention, insufficient understanding of arbitration principles, and limited exposure to comparative jurisprudence.

To ensure legal certainty and reinforce Moldova’s international credibility, jurisprudential uniformization must become a structured national priority. This requires coordinated measures, including: (i) continuous training of judges and legal professionals in arbitration standards and best practices; (ii) elaboration and dissemination of jurisprudential guides and compendia aligned with ICCA, UNCITRAL, and comparative doctrine; (iii) institutional strengthening of active arbitral centers, with transparent procedures and international cooperation; and (iv) active participation in global harmonization platforms.

Uniform, coherent jurisprudence is not merely a formal ideal but a prerequisite for legal predictability, investment attractiveness, and compliance with Moldova’s European commitments. In this context, consolidating judicial practice, fostering professional competence, and anchoring Moldova in the global arbitral dialogue are essential steps toward a credible and effective pro-arbitration legal system.

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IS AI A BETTER DRIVER? A SPECIAL LOOK ON WAYMO ACCIDENT HISTORY WITH THE REGULATORY AND POTENTIAL LIABILITY FRAMEWORKS FOR DRIVERLESS CARS IN MIND

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Abstract

The locus of liability has begun to settle on the manufacturers and designers of autonomous vehicles. It is unsurprising, as driverless cars completely unattended by a human driver are now legally allowed on the road in many states. When a human driver is no longer at the wheel to make mistakes, the fault may rest with the programmers of the vehicle's software. AVs like those used by Cruise or Waymo (Google's robotaxi service) can make any mistake that the humans drivers do, but the robotaxi companies argue, they do so at far smaller rates than humans drove vehicles. AVs are even immune from fatigue, intoxication and the number one cause of traffic accidents: distracted driving. But regardless of their safety compared to human drivers, autonomous vehicles pose a unique issue for someone injured by one. If there is no driver, who is liable? And to what extent is liability affected by the lack of a human driver?

Keywords: *driverless cars; accident; regulatory framework; liability framework.*

JEL Classifications: K40.

1. WAYMO'S SAFETY MILESTONE AFTER 50 MILLION AUTONOMOUS MILES

Waymo's autonomous driving system has surpassed an important milestone, having accumulated over 50 million miles in fully autonomous operation. According to a recent report from Ars Technica, these vehicles demonstrate a notably strong safety record, with crash rates significantly lower than those of human drivers (Lee, 2025). This achievement represents a critical benchmark for the long-term viability and public acceptance of self-driving technology.

A significant discovery indicates that over 44 million autonomous miles, Waymo estimates human drivers would have been involved in approximately 190 injury-causing collisions, a markedly higher rate compared to incidents involving Waymo vehicles. Moreover, insurance-claim data reveals that property damage

claims for Waymo vehicles are 88% lower than those for conventional human-driven vehicles (Di Lillo, 2024).

Peer-reviewed research provides robust support for Waymo's safety assertions: an analysis encompassing 56.7 million "rider-only" miles demonstrated a notable decrease in crash rates across multiple categories (Kusano, *et al.*, 2025). Intersection-related crashes, recognized as high-risk, were reduced by 96% for incidents involving any injury and by 91% for those requiring airbag deployment. Other crash types, including collisions with pedestrians, cyclists, motorcycles, or those leading to secondary accidents, also experienced statistically significant declines. Importantly, no crash category reported higher rates for Waymo vehicles relative to human drivers, indicating comprehensive safety improvements.

These results represent a significant advancement in the capabilities of autonomous vehicles. Waymo's performance demonstrates consistent improvements in safety relative to human drivers, even in complex environments such as intersections; Comprehensive validation utilizing both real-world data (including insurance claims) and rigorous statistical analysis; Emphasis on operational design, as Waymo generally restricts autonomous operation to mapped urban areas and favorable conditions. Notably, within these parameters, Waymo consistently surpasses human driver performance, indicating substantial progress towards safer, scalable deployment (Kropka, 2023).

Nonetheless, researchers and policymakers advocate for continued caution. Despite the promising nature of Waymo's results, "edge cases", rare or unpredictable events, remain critical challenges, especially in highly complex or extreme scenarios. Waymo has achieved over 50 million autonomous miles with significantly lower crash rates compared to human drivers, representing a pivotal development in the advancement of autonomous vehicle safety. The consistency observed across various crash types, coupled with rigorous analysis, provides substantial evidence that autonomous vehicles can outperform human drivers in numerous real-world scenarios. Looking ahead, the primary challenge for both industry stakeholders and regulators will be facilitating the integration of autonomous technology into increasingly diverse environments and effectively managing rare but critical edge cases. While Waymo's accomplishment demonstrates considerable promise, addressing these remaining challenges will be essential for fully realizing the long-term potential of autonomous vehicles.

To prepare for the future, this article will try to explain the emergence, development and legal implications of autonomous vehicles in the direction of clarifying the stage of knowledge and the prospects that unfold before us.

2. EMERGENCE AND DEVELOPMENT OF SELF-DRIVING CAR LEGISLATION WORLDWIDE

Autonomous vehicles (AVs), also referred to as self-driving cars, have progressed from conceptual ideas to active areas of technological development and legal consideration. Governments internationally are formulating regulatory frameworks intended to manage innovation alongside issues related to public safety and ethical standards. Initial trials of self-driving technology identified both possible benefits, such as decreasing human error in accidents and improving mobility for individuals unable to drive, as well as challenges involving liability, data governance, and public acceptance. Consequently, the legal context for AVs has changed over the past decade, evolving from local policies to broader national strategies. We will examine the emergence and advancement of self-driving car legislation across different regions. It includes a historical review of early regulatory efforts, assesses current legislative approaches in key regions (including the United States, Europe – with a focus on Germany and the UK – Asia’s leaders like China and Japan, and early adopters such as the UAE), considers central legal, ethical, and technical issues, and outlines potential future regulatory developments.

The initial regulatory approaches to self-driving vehicles were characterized by caution and inconsistency, mirroring the experimental phase of technology during the early 2010s. In the United States, regulation was primarily initiated at the state level. Notably, Nevada became the first jurisdiction globally to permit autonomous vehicles on public roads in 2011 (NCSL, 2023).

This significant development, which established a licensing and testing framework for autonomous vehicles (AVs), was soon followed by Florida's 2012 legislation that affirmed its intent to promote the safe advancement and evaluation of AVs, explicitly stating that such testing was not prohibited under existing law (Norton Rose Fulbright, 2016). In subsequent years, numerous states enacted their own statutes or executive orders regarding AVs. By the mid-2010s, many U.S. states had adopted laws pertaining to AV testing or operation, each with varying requirements and definitions. Typically, these initial state laws mandated the presence of a human safety driver, required specific vehicle identification or permits, and addressed preliminary insurance and liability considerations on a trial basis.

This combination of state actions addressed the lack of binding federal regulations: at the federal level, the U.S. Department of Transportation and National Highway Traffic Safety Administration (NHTSA) provided non-binding guidance instead of formal regulations. In 2013, NHTSA released a preliminary policy statement outlining levels of vehicle automation and recommending that states restrict full self-driving operation to testing phases. In 2016, the Obama Administration introduced the first Federal Automated Vehicles Policy, indicating an interest in creating safety assessment standards; however, comprehensive

federal legislation had not been enacted (Norton Rose Fulbright, 2016). As a result, initial U.S. regulatory activity consisted mostly of state-level measures and federal guidelines that supported testing with a human driver as a fallback.

International regulations faced challenges with autonomous vehicles due to the 1968 Vienna Convention, which required a driver to control the vehicle. In March 2016, the UN amended the Convention to permit automated driving systems if they can be overridden by a human or meet UN standards. This change enabled countries to update their laws for driverless technology, and some nations had already started pilot programs under strict controls before the amendment (UNECE, 2016).

In Europe, individual nations began updating national laws and guidelines by the mid-2010s. For example, Germany adopted a proactive stance. The German government released a national strategy on automated driving in 2015, and in June 2017 it amended the German Road Traffic Act to legally permit drivers to cede control to highly or fully automated systems under certain conditions (Gesley, 2021). The 2017 amendment, one of the first of its kind, permitted Level 3 automated driving features on public roads, provided that a human driver could intervene and remained ultimately responsible. In the same year, Germany established an Ethics Commission to examine the moral considerations associated with autonomous vehicle decision-making, demonstrating an early legislative awareness of ethical concerns. For example, legislation aimed to ensure that unavoidable accident scenarios did not involve discrimination based on personal characteristics of potential victims (Gesley, 2021).

The United Kingdom adopted an early approach involving guidance rather than legislative changes. In 2015, the UK government issued a Code of Practice for testing automated vehicles (“The Pathway to Driverless Cars”), which permitted trials on public roads without additional legislation, provided that a safety driver was present and requirements such as roadworthiness and insurance were met (UK Dept. for Transport, 2015). This approach allowed initial pilot projects for automated vehicles in UK cities while postponing the resolution of more complex legal issues. In 2018, the UK enacted the Automated and Electric Vehicles Act 2018, which primarily addressed insurance for automated vehicles by requiring insurers to cover incidents involving a vehicle operating in automated mode, treating the vehicle as the driver for insurance purposes. During this time, other countries such as France, Sweden, and Singapore also granted special permissions for pilot testing, typically through regulatory sandboxes or exemptions within existing traffic laws.

Within the Asia-Pacific region, Japan established itself as a regulatory leader in autonomous vehicle (AV) policy during the late 2010s. Confronted with demographic challenges such as an aging population and driver shortages, Japan identified AV technology as a viable mobility solution. The government consequently prioritized the creation of a legal framework to enable higher levels

of automation in both personal and public transportation. By 2019, amendments to Japan's Road Traffic Act facilitated the limited deployment of Level 3 autonomous vehicles on highways. In 2020, Japan became the first country to officially permit Level 3 self-driving cars – under specified conditions – for production vehicles, leading to Honda's introduction of a Level 3-capable sedan, the Legend, on Japanese roads in 2021. This progressive approach continued in April 2023 with another significant legislative development: a revision to the Road Traffic Act permitting Level 4 autonomous driving on public roads under defined circumstances (ITA, 2023). Initially this Level 4 permission is limited to defined areas and use-cases such as unmanned autonomous shuttle services in sparsely populated towns, reflecting a cautious roll-out. Nevertheless, Japan's legal amendments in 2023 explicitly enable fully self-driving vehicles (without a human driver onboard) in designated zones, making it one of the first countries to legalize Level 4 operation (Japan Road Traffic Act, 2023). These early Japanese regulations also impose requirements such as remote monitoring and emergency override systems for unmanned vehicles, illustrating how early legislation tied technical safeguards to permissions.

China in the 2010s approached autonomous vehicle regulation through government directives and city-led pilot regulations rather than immediate national legislation. The Chinese government identified autonomous and connected vehicles as a strategic emerging industry and issued high-level guidance (e.g. the “Made in China 2025” plan and subsequent innovation strategies). By 2017–2018, China's Ministry of Industry and Information Technology (MIIT) and Ministry of Public Security jointly released national guidelines for intelligent connected vehicle road testing, which set basic conditions for cities to authorize trials (such as requiring a qualified safety driver and test permits). Major cities including Beijing, Shanghai, and Shenzhen established dedicated test zones and licensing schemes for companies like Baidu, Pony.ai, and others. For example, Shanghai opened up an expansive Intelligent Vehicle test area and issued some of the first batch of licenses for unmanned vehicle testing on certain roads. By 2020, over a dozen Chinese cities had published local rules to manage AV pilot projects. These early rules were often promulgated as municipal orders or interim measures, focusing on safety driver qualifications, vehicle equipment requirements, data reporting, and gradual expansion from testing to passenger-carrying pilot service. A notable development in China's early regulatory timeline is the creation of national pilot demonstration zones: by 2023 China had 17 national-level Intelligent Connected Vehicle (ICV) test zones with over 3,200 km of roads designated for AV testing, and more than 700 test licenses issued to companies (Dentons, 2025). This indicates that even without a single blanket law on AVs, China's early approach combined central policy support with local regulatory innovation to facilitate large-scale testing.

Other regions also saw initial steps during the 2010s. In the Middle East, the United Arab Emirates (especially the Emirate of Dubai) declared ambitious goals for AV integration (targeting 25% of trips to be autonomous by 2030) and began issuing regulations for testing. Dubai in 2017 and 2019 released guidelines for AV trials, and Executive Council Resolution No. 3 of 2019 set out safety requirements for testing autonomous cars on Dubai's roads – always including mandatory police supervision during tests and the presence of a human safety driver (Sadek, 2021). By 2020, Dubai had established a process for companies to apply to the Roads and Transport Authority (RTA) for AV testing permits and had partnered with industry (notably an agreement with the U.S. company Cruise to deploy autonomous taxis) to accelerate adoption (Sadek, 2021). Similarly, Singapore issued its first AV test permits in 2015 and passed an amendment to its Road Traffic Act in 2017 to allow the transport minister to exempt autonomous vehicle trials from certain rules, thereby legalizing on-road pilots. Australia and Canada also launched consultations and trial regulations around 2016–2018 at state/provincial levels. These early global efforts shared a common thread: they were mostly focused on enabling testing and research, often through temporary measures, and universally required a human supervisor (either inside the vehicle or remotely) during any automated driving trials.

In summary, the development of self-driving car legislation evolved incrementally. Early regulatory strategies worldwide were marked by prudence and experimentation, employing special permits, executive orders, and targeted legal adjustments to facilitate the testing of autonomous vehicles on public roads. Between approximately 2010 and 2016, the focus was placed on data collection and demonstrating safety through controlled trials, rather than establishing comprehensive legal frameworks for consumer deployment. However, by the late 2010s, insights from numerous pilot programs, alongside emerging concerns regarding safety, liability, and standardization, prompted the transition toward more robust and comprehensive legislative measures in subsequent phases.

3. THE PRESENT GLOBAL STATE OF AUTONOMOUS VEHICLE LEGISLATION

As of 2025, the regulatory landscape for autonomous vehicles is markedly more robust and structured than a decade prior. Many countries and regions have progressed from tentative pilots to formal laws or regulations governing the deployment of self-driving cars. However, approaches still vary widely, reflecting different legal systems, traffic conditions, and policy priorities.

In the United States, the regulatory framework for autonomous vehicles is characterized by a constellation of state statutes, underpinned by federal oversight. As of 2025, there is no comprehensive national legislation directly addressing the operation of autonomous vehicles; federal law has yet to establish an overarching Autonomous Vehicle Act. Federal initiatives have instead centered on modifying

vehicle safety standards and issuing voluntary guidelines. Legislative efforts in Congress, such as the SELF DRIVE Act and AV START Act (circa 2017–2018), did not advance due to ongoing debates concerning safety protocols and liability frameworks. In this legislative vacuum, the U.S. Department of Transportation (DOT) and the National Highway Traffic Safety Administration (NHTSA) have introduced incremental reforms. Notably, in 2022, NHTSA revised select Federal Motor Vehicle Safety Standards to permit vehicles lacking traditional controls – such as steering wheels or pedals – thus facilitating the deployment of fully driverless vehicles that need not comply with requirements designed for human-operated vehicles (Reuters, 2022). Additionally, NHTSA has exercised its authority to grant exemptions for limited deployments of experimental vehicles without conventional features, exemplified by approvals granted to GM’s Cruise and Nuro for small fleets of autonomous shuttles. Federal agencies have also published successive guidance documents – AV Policy 2.0: A Vision for Safety (2017), AV 3.0 (2018), and AV 4.0 (2020) – which articulate best practices and cross-modal integration strategies. While these policy statements lack binding force, they convey federal expectations on critical matters such as safety assessment, cybersecurity, and data management. For instance, DOT guidance recommends manufacturers submit a voluntary safety self-assessment addressing twelve key safety domains, including object recognition and fallback performance, and reaffirms the applicability of existing federal safety standards and state traffic laws absent AV-specific federal legislation. The prevailing federal approach remains permissive and industry-oriented, enabling autonomous vehicle testing and deployment within existing regulatory structures, supplemented by case-specific exemptions and reactive enforcement measures when necessary. This absence of uniform federal regulation has shifted significant responsibility to individual states, resulting in operational uncertainties for interstate vehicle deployment, but has concurrently afforded the industry considerable latitude to innovate within receptive legal environments.

State legislation in the U.S. is the primary source of rules for self-driving car operations. As of 2025, most states have addressed autonomous vehicles in some form – either through statutes or gubernatorial executive orders. The scope of these state laws varies. Many states now explicitly authorize fully driverless operation (i.e. a vehicle with no human onboard) under certain conditions. For example, California – which hosts extensive AV testing – established a detailed regulatory process through its Department of Motor Vehicles: companies must obtain a testing permit (with a safety driver) and, separately, a permit for driverless testing and another for deployment for commercial service. California’s rules mandate annual public reports of any disengagements (incidents where the human driver had to take over) and any crashes, providing a level of transparency. In contrast, states like Arizona took a very business-friendly approach: via executive order and legislation, Arizona allowed driverless testing and operations with

relatively fewer procedural hurdles, which attracted companies like Waymo to launch early robotaxi services in Phoenix. States such as Florida and Texas have passed laws explicitly allowing autonomous vehicles to operate without a human driver or even without a human occupant, as long as certain insurance and safety requirements are met. For instance, Florida's 2019 law removed the requirement that a licensed driver be present in the vehicle, making it legal for a car to drive itself with no person inside on Florida roads (Farah and Farah, 2023). By 2022–2023, new states continued to join the trend: the National Conference of State Legislatures notes that 29 states have enacted legislation related to AVs (as of early 2023), and several others have active executive orders (NCSL, 2023). Common elements in state laws include: definitions of “automated driving system” and levels of driving automation (often referencing the SAE Level 0–5 taxonomy), requirements for an AV to comply with traffic laws and safely stop if it fails, mandatory insurance or surety bonds, and designation of the automated driving system as the “driver” for purposes of traffic law when it is engaged. Liability rules are beginning to be addressed as well: some states (e.g. Illinois, Tennessee) clarify that the original manufacturer is not liable for after-market automated driving systems installed by third parties, whereas others assert product liability theories can apply to software failures. There is also growing attention to trucking: states like Texas have authorized autonomous trucks to operate on highways without a human, spurring pilot projects in freight transport.

The U.S. has a complex but generally permissive legal landscape for autonomous vehicles, allowing companies to test and operate ride-hailing AVs under various state regulations. While efforts are underway to coordinate rules, crossing state lines can mean navigating differing laws. The U.S. leads in real-world AV deployment due to supportive policies in some states, with fully autonomous robotaxis operating in cities like San Francisco and Phoenix as of 2025.

Germany has established itself as a pioneer in autonomous vehicle legislation within Europe, while working in tandem with evolving European Union regulations. German law not only permits advanced levels of vehicle automation but also frames specific requirements for their safe operation, influenced by ethical considerations and technical standards. Meanwhile, the EU has been developing a harmonized framework to ensure uniform safety across member states, particularly through type-approval regulations and United Nations Economic Commission for Europe (UNECE) standards. Germany's 2017 amendment to the Road Traffic Act, mentioned earlier, was an initial step that allowed Level 3 automated driving features (highly automated, but with a human fallback). Building on that, Germany enacted a groundbreaking Autonomous Driving Act in July 2021, which made it the first country to broadly legalize Level 4 autonomous vehicles in defined public traffic areas. Under this law, vehicles with “autonomous driving capabilities” (SAE Level 4) are permitted on public

roads nationwide, without a human driver on board, so long as they operate within an approved defined operating area (Gesley, 2021). These operating areas are specific zones or routes approved by local authorities – for example, a city might approve an autonomous shuttle service on a particular bus route or a logistics company might get approval for driverless forklifts on set paths. A critical aspect of the German approach is the requirement of a technical supervisor: even when no human is in the vehicle, a remote human operator must be designated who can monitor the vehicle and intervene or deactivate it if necessary (Gesley, 2021). The law also imposed robust safety and cybersecurity requirements. Vehicles must have an “accident-avoidance system” that prioritizes protection of human life and never makes choices based on personal attributes like age or gender – a direct incorporation of the Ethics Commission’s guidelines into law (Gesley, 2021). Additionally, a form of “black box” data recorder is mandated: the vehicle must log detailed operational data (e.g. sensor inputs, control actions, incidents) to aid in accident investigations and continuous safety evaluation. Another element is compulsory insurance covering the autonomous operation and the technical supervisor’s liability (Gesley, 2021). Taken together, Germany’s 2021 law provides one of the most comprehensive legal frameworks for AVs in the world, covering definitions, technical standards, oversight mechanisms, and liability. It has enabled pilot deployments such as driverless shuttle buses (“people movers”) on certain city routes and autonomous parking systems in Stuttgart’s airport garage – all under strict regulatory approval and supervision.

As an EU member, national regulations on vehicles must align with EU rules, especially regarding vehicle safety certification. The EU’s approach has centered on updating type-approval regulations and endorsing international (UNECE) standards that facilitate automated driving. A major development was the revised EU General Safety Regulation (EU) 2019/2144, which took effect in July 2022. This regulation not only made a suite of advanced driver-assistance systems mandatory in new cars (such as intelligent speed assistance, lane-keeping, event data recorders, and driver monitoring), but also explicitly created a legal framework to approve “fully automated vehicles” in the EU (European Commission, 2019).

Pursuant to this, the European Commission in 2022 adopted technical implementing rules for Level 4 vehicles – the first such regional regulations globally. These rules allow for EU type-approval of fully driverless vehicles (like robotaxis or automated shuttles) in limited numbers (initially under a small-series type approval scheme). They set stringent requirements for safety validation, including comprehensive test procedures, cybersecurity measures, software update compliance, data recording of incidents, and oversight of manufacturers’ safety management practices. In essence, an automaker or operator can now seek approval to sell or deploy a Level 4 vehicle across EU countries, provided it meets these new standards – a significant step toward scaling AV deployment beyond

isolated pilots. For Level 3 automation (where the car drives itself under certain conditions, but a human might need to take over upon request), the EU has aligned with UNECE regulations, specifically UNECE Regulation No. 157 on Automated Lane Keeping Systems. UNECE R157 was initially limited to low-speed (up to 60 km/h) traffic jam scenarios but was updated in 2022 to allow operation up to 130 km/h with more stringent safety requirements (Mercedes-Benz notably used this to offer a Level 3 “Drive Pilot” system in Germany). The EU automatically incorporates such UNECE regs, enabling vehicles with approved ALKS systems to be sold across member states single-market-economy.ec.europa.eu. Thus, a German or French consumer can buy a car with a certified Level 3 system and legally use it on highways because the underlying international regulation has been agreed and adopted.

Following its departure from the EU, the United Kingdom has enacted a comprehensive law governing autonomous vehicles. Initially, the UK issued limited reforms like the 2015 Code of Practice for AV testing and the 2018 Automated & Electric Vehicles Act focused on insurance and definitions. To create a broader regulatory framework, the government commissioned a review (2018–2021) by the Law Commissions, resulting in a January 2022 report that recommended an entirely new system to address automation across vehicle approval, legal responsibilities, and insurance.

The Law Commissions proposed a legal distinction between “driver assistance” and “self-driving” features, holding that once a vehicle is classed as self-driving (requiring no human monitoring), responsibility shifts from the human user to new entities like manufacturers or operators. They defined roles such as the “User-in-Charge” – a person present to take over when prompted – and “No-User-in-Charge” vehicles, which are fully autonomous. An “Authorized Self-Driving Entity,” typically the manufacturer or software provider, would be legally accountable for the vehicle’s actions during automated operation, with safety assured both at approval and through ongoing monitoring. These proposals have been enacted in the Automated Vehicles Act 2024.

The Automated Vehicles Act 2024, which received Royal Assent on 20 May 2024, establishes the core of the UK’s AV legal framework (Gupta, 2023). Under this Act, it is lawful for an “authorized automated vehicle” to drive itself on public roads in Great Britain without a human driver in control – a radical departure from previous law, which always assumed a human driver. To achieve authorization, a vehicle must pass a specified self-driving test that evaluates whether it can drive autonomously, safely, and legally in each operational design domain. In essence, the vehicle must demonstrate that it is at least as safe as a competent human driver in that environment and complies with traffic rules to an acceptable degree. The Act empowers the Secretary of State for Transport to set safety performance criteria (a “Statement of Safety Principles”) that guide this assessment.

The UK Act formalizes the roles of User-in-Charge (UiC) and No-User-in-Charge (NUiC) features. If a vehicle's autonomous feature requires a fallback user (UiC), that person is not criminally liable for the vehicle's motions while automated but must take over when alerted (akin to Level 3 scenarios). If the feature is NUiC, the vehicle can operate with no person on board or no active driver at all (Yaros et al., 2024mayerbrown.commayerbrown.com). The Act creates the concept of an Authorized Self-Driving Entity (ASDE) – typically the company that puts the vehicle on the market – which is responsible for the vehicle's behavior in self-driving mode and can be held liable for failures (UK Government, 2025gov.ukgov.uk). For vehicles with no user in charge, a licensed NUiC Operator must oversee the journey (perhaps remotely), handling non-driving duties like maintenance and incident response (UK Government, 2025gov.uk). These operators and entities will be subject to regulatory approval and ongoing requirements, ensuring they have the necessary integrity, financial stability, and monitoring capabilities.

In terms of liability and insurance, the UK's approach continues to ensure that victims are covered by insurance regardless of whether a human or an automated system was driving. The 2018 Act's insurance provisions remain, but now the manufacturer/operator accountability is strengthened: if a crash occurs due to the automated driving system, the insurer can in turn recover costs from the ASDE if the vehicle was defective or misrepresented safety. The Act also includes provisions to prevent misleading marketing of vehicles as “self-driving” before they are truly authorized as such – addressing concerns that overzealous marketing could lead to unsafe use of driver-assist systems by consumers.

China's regulatory framework for self-driving vehicles involves government oversight, the development of pilot zones, and the introduction of national-level guidelines. Instead of enacting a single law through the national legislature, China has implemented administrative regulations and policies that allow for local trials, which may later be expanded. As technology develops, these measures are evolving into more standardized regulations and laws.

In recent years, China has selected key cities for AV testing and deployment. Beijing launched its first comprehensive AV test zone in 2018, progressing to fully driverless tests in select suburbs by 2022 with operators like Baidu's Apollo Go. Shanghai issued 2021 regulations enabling not just testing but early commercial pilot services in Pudong, and in 2023 passed rules requiring permits for robotaxis and freight vehicles, legally allowing driverless passenger transport in specific areas. Shenzhen enacted a 2022 law defining automation levels and permitting L4 vehicles on public roads under license, assigning liability to the vehicle owner or operator in fully autonomous mode. These local laws position automated driving systems as new legal subjects.

Since 2020, China's central ministries have developed regulations for intelligent connected vehicles (ICVs). The Ministry of Public Security issued road

testing guidelines, while the State Council's roadmap targets large-scale autonomous car production by 2035 and a regulatory system by 2025. By 2023, over 30 industry standards addressed issues like vehicle cybersecurity and communication protocols, guiding manufacturers and local governments on safety. At the end of 2021, the Ministry of Industry and Information Technology released draft rules for smart car data security and software updates, requiring automakers and AV operators to safeguard user privacy and national security, especially in response to concerns over mapping data. By linking data regulations to autonomous vehicle deployment, China maintains oversight of data flows and aims to prevent misuse as vehicles become more autonomous.

China has rapidly expanded autonomous vehicle (AV) services, with pilot driverless robotaxi operations in at least seven cities by 2023, including Beijing, Shenzhen, Wuhan, and Chongqing (Dentons, 2024). For instance, Baidu and Pony.ai were the first to receive permits for paid, fully driverless robotaxis in Beijing, while autonomous buses are also running in cities like Guangzhou and Suzhou. Major tech companies, such as JD.com and Meituan, have introduced driverless delivery carts for last-mile logistics (Dentons, 2024). These initiatives rely on local approvals supported by national policies. A draft law to unify AV regulation was under review in 2022 to clarify testing, liability, and market entry rules. In early 2023, the government released new policies encouraging commercialization and streamlined approvals for AVs. By mid-2023, Chinese AV test vehicles had driven tens of millions of kilometers. China's approach remains "centrally coordinated, locally implemented," accelerating AV development under strong regulatory oversight and minimal public resistance.

Japan's current autonomous vehicle legislation builds upon the early initiatives described previously, placing the country among the leaders in legalizing higher levels of vehicle autonomy. Japanese regulators have focused on incremental expansion of permitted automation levels, tied to specific use cases like highway driving and low-speed community transport, all under a strict safety regime.

A fundamental aspect of Japan's regulatory strategy is the explicit incorporation of SAE automation levels into legal frameworks. In 2019, amendments to the Road Traffic Act and Road Transport Vehicle Act introduced definitions for "automated driving equipment" and formally legalized Level 3 conditional automation on expressways. As a result, Level 3 (conditional automation) became operational on Japanese highways in 2020, following the enactment of these legislative changes. Under this structure, drivers are permitted to allow vehicles to operate autonomously in specific situations – such as highway traffic congestion – without the obligation to monitor the driving environment during those periods. However, drivers must remain prepared to resume control upon system request.

Japan achieved a global milestone in 2021 by granting the first government certification of a Level 3 automated system for consumer vehicles: the Honda Legend equipped with “Traffic Jam Pilot,” an automated driving system designed for congested highway traffic, received type-approval for commercial sale with this functionality. Regulatory requirements stipulate that all Level 3 vehicles be equipped with data recording devices to document usage of automated mode and any control handover prompts. Additionally, operation is confined to clearly defined scenarios, such as specified speeds and designated road segments. Drivers utilizing Level 3 systems must comply with established usage regulations. For example, while activities such as sleeping or vacating the driver's seat are prohibited, tasks like watching a video are permitted when the system is actively controlling the vehicle – activities ordinarily forbidden during manual driving. This comprehensive regulatory approach has positioned Japan as the first nation to legally enable drivers to disengage from active driving responsibilities within restricted settings, underpinned by clear legal protections.

Japan legalized Level 4 autonomous vehicles in specific settings with an April 2023 Road Traffic Act revision, allowing driverless shuttles on fixed rural routes under strict safety rules and special permissions. The first approval went to an autonomous shuttle in Eihei-ji, Fukui Prefecture, which operates without human drivers or attendants. These vehicles must comply with MLIT’s high safety standards, including system redundancy and remote monitoring, and their use is limited to controlled, fixed-route services – private cars aren’t yet permitted Level 4 autonomy. Vehicle certification laws, such as the Road Transport Vehicle Act, have been updated to allow advanced driving features, aligning with UNECE regulations. Japan has also established technical guidelines for AV safety and security through METI. To promote public acceptance, Japan supports large-scale AV trials, like the “Road to the L4” project, conducting demonstrations in over 40 locations and aiming for 50 by 2025. These efforts, supported by special government permissions and targeted infrastructure adaptations, are part of a broader strategy to integrate autonomous vehicles into society.

The United Arab Emirates (UAE) has taken steps to develop regulations for autonomous vehicles (AVs), aiming to advance technological capabilities and enhance transportation services. While the UAE's road traffic laws are primarily federal, individual emirates like Dubai have led local regulatory efforts for AV deployment. Abu Dhabi and other emirates are also conducting trials, supported by federal standards initiatives. Dubai’s regulatory framework includes the Autonomous Transportation Strategy announced in 2016, which set a target for 25% of trips to be made using self-driving modes by 2030. The government introduced several regulations to support this objective. Executive Council Resolution No. 3 of 2019 established requirements for AV testing in Dubai, including collaboration with police and the implementation of specific safety protocols (Sadek, 2021). This was followed by Administrative Decree No. 501 of

2020 by the RTA, which specifies application procedures for companies interested in conducting AV tests (Sadek, 2021). Entities seeking to test AVs must submit technical documentation, provide proof of insurance, and have each test vehicle inspected and approved by RTA officials. A human safety driver at least 25 years old with a valid UAE driver's license is required to be present during all tests (Sadek, 2021). For operational use beyond testing, Dubai implemented Law No. 9 of 2023, which regulates the operation of autonomous vehicles within the emirate. This legislation establishes legal grounds for the commercial deployment of AVs, setting out procedures for certification of vehicles and operators by the RTA (The National News, 2023). The law authorizes the RTA to define technical standards, issue operator licenses, and determine operating zones and conditions. Autonomous vehicles must be registered and display a special plate or marking. Regarding liability, if a vehicle is operating autonomously, responsibility for traffic violations or accidents lies with the permitted operator. Operators are required to maintain adequate insurance and may need to equip vehicles with data recorders, as outlined in subsequent RTA resolutions. Through Law 9/2023, Dubai is among the first jurisdictions in the Middle East to enact specific legislation for self-driving vehicle operations. As of late 2023, a limited pilot project involving Cruise autonomous taxis (without human drivers) was underway in Dubai's Jumeirah area, with future plans for expansion.

In Canada, the regulation of autonomous vehicles primarily falls within provincial jurisdiction. For instance, Ontario has implemented an AV testing program since 2016, utilizing a pilot permit system, and expanded its framework in 2019 to enable driverless testing – without a human operator in the vehicle, subject to stringent requirements. At the federal level, guidance for safe AV testing was issued in 2022, with ongoing efforts to modernize motor vehicle standards to align with UNECE regulations (Canada, Transport Canada AV Guidelines, 2021). Canada's regulatory model closely parallels that of the United States, seeking to foster provincial innovation while maintaining robust federal safety oversight.

Several Australian states have conducted automated shuttle bus trials in cities such as Perth and Adelaide. The National Transport Commission has established guidelines, and in 2020 proposed a national law to support the commercial deployment of automated vehicles. Australia is developing an Automated Vehicle Safety Law, which would establish a dedicated AV regulator and approval process, with implementation anticipated by 2026.

Singapore has introduced various autonomous vehicle (AV) initiatives over recent years. The Autonomous Vehicles Act 2022 consolidates existing regulations and introduces a licensing framework for AV operators, enabling driverless buses and robo-taxis to operate within designated areas. This legislation covers operator responsibilities, passenger safety requirements, and penalties for misuse of AVs.

South Korea enhanced its legal framework through the Autonomous Vehicle Act 2020, which established designated zones for testing and introduced a certification system for vehicles at Level 3 autonomy and above. In 2022, the government initiated a commercial self-driving taxi pilot in Seoul's Sangam district under a regulatory sandbox. Additionally, Korea continues to make substantial investments in smart road infrastructure, with legislation supporting the deployment of vehicle-to-everything (V2X) communication as a core component of autonomous vehicle integration.

Israel has emerged as a center for autonomous vehicle technology and enacted the Autonomous Vehicles (Trial) Law in 2019 to permit extensive public road testing. The government is currently considering additional legislation to enable commercialization, driven in part by innovative companies such as Mobileye (an Intel subsidiary), which are advancing autonomous ride-hailing pilots in Tel Aviv.

While each nation tailors its legal framework to suit local circumstances, a prevailing pattern emerges: an incremental approach to deployment, beginning with pilot testing, proceeding to restricted use, and eventually expanding as confidence in the technology grows, and adaptive legislation, which typically starts with provisional or experimental regulatory measures before transitioning to permanent statutes once the technology is sufficiently advanced. Additionally, international cooperation is becoming more prominent, exemplified by organizations such as UNECE's Working Party 29 on vehicle standards and Working Party 1 on road traffic rules. These forums facilitate harmonization of definitions and safety standards, even though specific legal frameworks may vary between jurisdictions.

4. LEGAL, ETHICAL, AND TECHNICAL ISSUES

Legislation regarding autonomous vehicles has advanced, but regulators and stakeholders continue to encounter several challenges. These include legal uncertainties, ethical considerations in machine decision-making, and technical issues related to safety and reliability.

Assigning responsibility in the event of an autonomous vehicle (AV) crash poses complex legal questions. Traditional traffic laws attribute accidents primarily to human driver negligence or, in some cases, mechanical failure by manufacturers. However, AVs complicate this framework, as the "driver" may be an algorithm. Regulatory responses vary internationally: for example, under the UK's 2018 legislation and Singapore's recent framework, insurers are initially liable when a self-driving vehicle is involved in an incident; insurers can later seek recourse from manufacturers or software providers if technological faults are identified. This approach aims to ensure timely compensation for victims but does not conclusively resolve questions about fault allocation between human users and vehicle makers. In Germany, for Level 3 automation, the law maintains the human

driver's liability, requiring intervention when prompted, whereas Level 4 shifts responsibility to the operator or vehicle keeper, mandating insurance coverage for autonomous operation.

In the United States, where there is no overarching federal law, courts and state statutes address liability, including product liability claims against AV companies concerning system failures. These cases examine whether an AV is "defective" or whether incidents resulted from unavoidable scenarios, with legal standards on what constitutes sufficient safety still under discussion, specifically, whether AVs should perform at the level of a reasonable human driver or achieve the highest possible technological safety. Liability apportionment is another point of consideration, especially for vehicles requiring human supervision (Level 2/3), where accidents may result from either user inattention or system design. Some jurisdictions, such as New York, require that drivers maintain hands on the wheel during partial automation, upholding the legal premise of human control. Insurance models are adapting accordingly, with new policies for AV fleets being developed and expanded mandatory coverage requirements introduced in countries like the UK and Germany, including protection against events such as hacking. Regulators are working to update insurance frameworks to remain effective and equitable in the context of AV adoption, possibly necessitating data sharing from vehicles to facilitate accident investigations (Kubica, 2022).

The regulation of autonomous vehicles (AVs) represents one of the most complex and multifaceted legal challenges of contemporary mobility governance. This essay examines the evolving global legislative landscape surrounding AV deployment, highlighting key legal, ethical, and policy issues. A central difficulty is definitional inconsistency across jurisdictions. Terms such as "autonomous," "self-driving," and "automated driving system" are not uniformly defined, and reliance on SAE levels (0–5) often leads to misinterpretation. Misleading marketing of partially automated systems as "self-driving" has already prompted legislative countermeasures, such as the United Kingdom's restrictions on the use of autonomy-related claims. Harmonization remains essential, particularly in cross-border contexts like the European Union, where mutual recognition of vehicle approvals and driving permits is under development but not yet resolved.

Another major area of concern is data governance. AVs generate and process vast amounts of sensor, location, and environmental data, raising significant privacy challenges under strict regimes such as the EU's General Data Protection Regulation (GDPR). Laws in countries such as Germany and the UAE attempt to balance road safety with personal data protection by limiting collection and regulating law enforcement access. Closely linked is cybersecurity, as AVs constitute connected digital platforms vulnerable to malicious attacks. Regulatory frameworks such as UNECE Regulations R155 and R156 now mandate cybersecurity management systems and secure software update protocols, shifting vehicle compliance from a one-time approval model to continuous oversight.

Liability for cyber incidents remains unresolved, particularly regarding whether manufacturers or third-party actors bear responsibility (NCSL, 2020).

An important topic is the integration of AVs into existing traffic systems. Mixed traffic conditions expose tensions between AVs' rule-abiding behavior and human drivers' less predictable conduct, with incidents of "bullying" AVs already observed. Legislators are adapting rules for platooning, right-of-way, and vehicle-to-infrastructure (V2I) communications, while cities explore new planning measures to accommodate robotaxi fleets. Enforcement of AV laws introduces novel challenges, as police and regulators must interact with vehicles lacking drivers. Some jurisdictions mandate remote disablement functions, though these create security risks. The UK's forthcoming "in-use regulator" represents a pioneering model of continuous safety assurance, including audits, testing, and the ability to revoke approvals.

Safety standards and testing methods remain unsettled. While traditional vehicle regulation assessed passive crashworthiness, AV approval requires evaluating AI driving competence through scenario testing, simulations, and frameworks such as ISO 26262, ISO 21448, and the EU's NATM. Defining acceptable levels of risk – whether AVs must merely match or exceed human safety performance – remains debated. Additional complexities arise from continuous software updates, which may alter vehicle functionality post-sale, requiring new regulatory oversight mechanisms.

Finally, the ethical and societal dimensions raise the questions of crash decision-making, social equity, accessibility, and employment displacement highlight the broader impacts of AV adoption. Bias in detection algorithms, privacy implications, and misleading consumer communication further complicate policymaking. Ethics commissions in countries such as Germany and France have influenced legal frameworks, yet global consensus is lacking. Public trust emerges as a decisive factor in AV adoption, shaped by transparent regulation, clear liability rules, and safeguards against misinformation.

Overall, the AV regulation requires unprecedented legal innovation, blending traditional type approval with continuous oversight, integrating data protection with cybersecurity, and embedding ethical considerations into technical standards. Achieving harmonization across jurisdictions while preserving public trust will be crucial for the safe and equitable global deployment of autonomous vehicles.

5. CONCLUSION

This article examines the global evolution of self-driving car legislation, tracing the trajectory from early experimental initiatives in the 2010s to the sophisticated frameworks now taking shape in major jurisdictions. It highlights how pioneering regions such as Nevada, Germany, and Japan established initial precedents, from authorizing on-road testing to formally recognizing Level 4 automation. Subsequent developments, including amendments to the Vienna

Convention and the UK's 2024 regulatory framework, underscore an emerging international consensus while revealing persistent differences in national approaches. The United States has pursued a decentralized, innovation-led model, Europe has emphasized centralized safety certification, and Asian countries display contrasting strategies, with Japan progressing gradually and China advancing through rapid pilot programs. The UAE and other emerging markets are also accelerating reforms to attract investment and modernize transport systems.

Key challenges addressed by legislation include liability, safety validation, cybersecurity, and data protection. Jurisdictions are exploring diverse liability models ranging from manufacturer responsibility to hybrid insurance schemes, while technical standards are evolving beyond traditional safety benchmarks to include AI-driven testing and continuous oversight. Ethical considerations remain central, particularly regarding fairness, equity, and the prioritization of human life in unavoidable crash scenarios. At the same time, public trust and transparent governance are recognized as prerequisites for widespread deployment.

Looking ahead, the article anticipates a decade of adaptive policy development and regulatory harmonization, shaped by technological progress, international cooperation, and societal values. Innovative governance tools, such as citizen panels, ethics boards, and sandboxing provisions, may enhance responsiveness and legitimacy. The scope of regulation is also expected to expand to autonomous trucks, drones, and other vehicles, requiring either unified or harmonized legal frameworks for integrated mobility systems. Ultimately, successful legislation will balance innovation with accountability, enabling safe, equitable, and future-ready transport ecosystems.

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TAX DISPUTE RESOLUTION MECHANISM IN THE EUROPEAN UNION OR MUTUAL AGREEMENT PROCEDURE TO AVOID DOUBLE TAXATION?

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Abstract

This paper aims to clarify how the provisions of Council Directive (EU) 2017/1852 on tax dispute resolution mechanisms in the European Union should be understood and applied. This directive is supplemented by the provisions of its Implementing Regulation (EU) 2019/652 of the Commission, adopted on April 24, 2019, which establishes the standard operating rules for the advisory commission or the alternative dispute resolution commission.

On August 22, 2019, the Romanian Government adopted Ordinance No. 19/2019, amending and supplementing the Tax Procedure Code, which was later consolidated by the adoption of Law No. 127/2021. Both legislative acts are reflected in Title IX of the Tax Procedure Code: "Resolution of Tax Disputes Arising from the Interpretation and Application of Agreements and Conventions Providing for the Avoidance/Elimination of Double Taxation," Chapter II, which regulates a mutual agreement procedure to avoid/eliminate double taxation. This legislative framework ensures that Romania has fully transposed the aforementioned European regulations into its national legal system. Understanding and navigating this complex procedure, which can only be initiated by the affected party but involves negotiations carried out exclusively between the national tax authorities of the Member States, may offer valuable insights for both the European and national legislators. Strengthening this procedure would enhance its effectiveness as a legal instrument for resolving tax disputes and addressing circumstances that could be highly detrimental to European taxpayers.

Keywords: *avoidance of double taxation; tax disputes; contentious procedure; mutual agreement procedure; national tax authorities of the Member States.*

JEL Classification: K34; K41.

1. INTRODUCTION

The financial and fiscal activity of modern states faces various situations or circumstances that are extremely difficult to resolve, as they are extremely difficult to identify and delineate. One of these situations refers to the multiple taxation of a taxpayer (Dumiter and Jimon, 2016), a situation that must always be

viewed in parallel with non-compliant practices found at the opposite extreme, when the taxpayer manages to avoid the jurisdiction of the national tax laws of multiple states.

As a general practice, the avoidance of double taxation is achieved through agreements between two (or more) states, through which the parties establish general rules and methods that will be equally applied for the proper taxation-by only one state-of the assets and income of taxpayers conducting activities with cross-border elements (Dumiter and Jimon, 2017).

These rules must have a general character, as a variety of taxes or social contributions can be subject to either double taxation or, conversely, to non-taxation by any state. This includes corporate income tax for companies operating in multiple countries, dividend tax, as well as VAT or excise duties-mentioning only the most important taxes that may be owed by legal entities-or income tax and social contributions in the case of individual taxpayers (Costaş and Tofan, 2023).

At the level of the European Union, a suitable solution for these situations could be fiscal harmonization (Tofan, 2019), but this is still perceived as a limitation of the fiscal sovereignty of member states. In these circumstances, specific instruments such as bilateral double taxation avoidance agreements are still used, although they have proven to be of limited effectiveness and somewhat cumbersome or inflexible. Therefore, the European Union has intervened through a European directive to provide member states with a common legislative framework, so that they can subsequently regulate procedures for resolving cross-border tax disputes.

Within this framework, on August 22, 2019, the Government of Romania adopted Ordinance No. 19/2019 for the amendment and completion of the Fiscal Procedure Code, which was later consolidated by the adoption of Law No. 127/2021. Both legal acts are reflected in the content of Title IX "Settlement of tax disputes arising from the interpretation and application of agreements and conventions for the avoidance/elimination of double taxation", Chapter II of the Fiscal Procedure Code, which regulates an amicable procedure for the avoidance/elimination of double taxation. In this way, Romania ensured the transposition into national legislation of Council Directive (EU) No. 1852/2017 on tax dispute resolution mechanisms in the European Union, which was required to be implemented by June 30, 2019. The European legal act states in Article 23 that it entered into force on the twentieth day following its publication in the Official Journal of the European Union and applies to any complaint submitted from July 1, 2019, regarding disputes related to income or capital earned in a financial year starting on or after January 1, 2018, but leaves member states free to extend these provisions to earlier financial years. Romania limited the scope of application of these provisions to income or capital earned as of January 1, 2018, and added the condition that the National Agency for Fiscal Administration and

the competent authorities of the concerned member states must agree on this matter.

It is important to mention that the provisions of Council Directive (EU) No. 1852/2017 are supplemented by the provisions of its Implementing Regulation (EU) No. 652/2019 of the Commission of April 24, 2019, establishing the standard rules of operation for the advisory commission or the alternative dispute resolution commission.

To obtain the most relevant conclusions, we consider it useful to compare the approaches of the two regulations, namely the European and the national ones. Thus, according to the title of Council Directive No. 1852/2017, it establishes mechanisms for resolving tax disputes in the European Union, while the Romanian Fiscal Procedure Code refers to an amicable procedure for avoiding/eliminating double taxation. This is not merely an analysis of the titles of the two legal acts, but an attempt to determine the legal nature of this procedure so that any subsequent analysis can be carried out based on this reality.

2. PRESENTATION OF THE PROCEDURE

The procedure under analysis here represents a logical and chronological sequence of acts and operations which, in the end, should lead to the fairest possible resolution for the taxpayer who considers themselves wronged by the fact that their assets or income have been subject to multiple taxation under the fiscal regulations of several EU Member States.

2.1. Initiation of the procedure. The complaint – the act of notification to the competent tax authorities

According to Article 283³ of the Fiscal Procedure Code, a person affected by a tax assessment decision that results in a situation of double or multiple taxation may submit a complaint to the National Agency for Fiscal Administration (ANAF) regarding this situation. According to Romanian legislation, this is considered a “dispute” whose resolution falls under the responsibility of this Romanian authority.

First, attention is drawn to the term “dispute”. It is the term used by the Romanian legislator to implement Council Directive (EU) No. 1852/2017 on tax dispute resolution mechanisms in the European Union. As can be seen, the European document uses the expression “mechanism for resolving tax disputes.” The object of the dispute concerns the determination of the applicable law in specific tax-relevant situations, in order to eliminate unjust cases of multiple taxation of the same tax base. The “dispute” arises between the national tax administrations of two or more Member States, but the entity responsible for initiating the “dispute resolution mechanism” is the “affected person.”

It must be noted that the person in question must be a tax resident in Romania, meaning they are subject to Romanian tax law and are liable to fiscal obligations

arising under Romanian law. If this condition is not met, the person does not have standing to be involved in resolving such a “dispute.”

A second very important aspect refers to the fact that initiating this procedure also implies that any previously initiated amicable procedure is legally terminated (i.e., by the effect of the law, under Article 283¹, paragraph (2) of the Fiscal Procedure Code).

The complaint must be submitted within 3 years from the date the tax assessment decision is communicated, a decision which results or will result in a dispute (i.e., double taxation), regardless of whether the affected person has used available administrative or judicial remedies under applicable laws – meaning, regardless of whether they accessed the regular administrative-tax litigation procedures. This complaint must be submitted simultaneously (and containing the same information) to each competent authority in each Member State involved in the dispute (i.e., the case of double or multiple taxation), within the same timeframe. Naturally, the complainant must also indicate in the complaint all the Member States involved in the situation.

As stipulated, this appears to be a forfeiture deadline-failure to observe it extinguishes the complainant’s right to submit a complaint under this procedure and regarding this subject. Of course, this is valid from the perspective of the Romanian tax authority. If another Member State’s national tax law provides otherwise and is more favorable, we believe the procedure may still be initiated beyond this period, by notifying the competent tax authority of the Member State whose legislation allows it. In such cases, if the procedure is validly initiated in that state, ANAF cannot refuse participation in the procedure, which is regulated by a European directive that Romania has adopted.

According to the provisions of Article 283², paragraph (6) of the Fiscal Procedure Code, the complaint filed by the affected person must include detailed information about the taxpayer, the taxable matter under analysis, the tax periods in question, and especially the legal provisions on which the situation is based. Additionally, the complaint must be accompanied by thorough and relevant data, information, and documents that support the claim of double taxation.

Analyzing these provisions leads to two observations. On one hand, this procedure does not interfere with ordinary litigation procedures initiated by the affected party. On the other hand, the legislator emphasizes that the party must cease any similar amicable procedures already underway. Although a previous article states that “the submission of a complaint terminates any other amicable or dispute resolution procedure conducted under other legal instruments such as double taxation agreements or conventions to which Romania is a party,” the Romanian legislator also requires a written declaration from the affected party to this effect. However, we consider that the phrase “terminates” could also be interpreted to mean “suspends” such procedures, not necessarily “ends” them-if this is allowed under the relevant procedures-so that after a final solution is

reached under the current procedure, the affected party might still pursue the other amicable procedures already initiated or those whose deadlines and procedural steps can still be met. Of course, all such procedures must be established by agreements or conventions for the avoidance of double taxation to which Romania is a party.

On the other hand, an affected person who wishes to withdraw a complaint must simultaneously send a written withdrawal notice to each competent authority of the concerned Member States. This notification immediately terminates all procedures carried out under the regulations being analyzed. At the same time, if ANAF receives such a notification, it must promptly inform the other competent authorities of the Member States involved about the termination of the procedures. Therefore, the affected person may withdraw their complaint before a mutual agreement is reached or before a final decision is issued by the competent authorities involved.

If, for any reason, the dispute ceases to exist, all procedures are closed, and ANAF must promptly inform the affected person of the factual and legal reasons for the termination of the procedures.

2.2. Decision of the competent authority regarding the complaint

According to Article 283⁴ of the Fiscal Procedure Code, within 180 days from the receipt of the complaint-or within 180 days from the receipt of any additional information and documents requested from the complainant, if that date is later-ANAF must decide whether to:

- accept the complaint and initiate the mutual agreement procedure provided under Article 283⁵ of the Fiscal Procedure Code;
- accept the complaint and resolve the disputed matter unilaterally, without involving the other competent authorities;
- reject the complaint.

Naturally, ANAF is required to promptly notify both the affected person and the competent authorities of the Member States involved about the decision taken.

If ANAF decides to resolve the disputed matter unilaterally, the mutual agreement procedure in question is terminated.

However, if ANAF fails to make a decision regarding the complaint within the aforementioned 180-day period, the complaint is considered accepted, and the procedure is deemed to have been initiated.

ANAF may reject the complaint in the following situations:

- if the complaint does not contain the necessary information and documentation as previously outlined;
- if the affected person fails to provide additional information and documents requested by ANAF, in its role as the competent authority for conducting the mutual agreement procedure;
- if no dispute actually exists;

- if the complaint was not submitted within the 3-year deadline, which, as previously mentioned, is considered a statute of limitation.

Of course, in the case where ANAF rejects the complaint, the notification sent to the affected person must include both the factual and legal reasons on which the rejection decision is based.

In turn, if the complaint is rejected, the affected person may proceed as follows:

- if the complaint is rejected by all the competent authorities involved, the affected person may contest ANAF's rejection decision, by way of derogation from the provisions of Article 7 of Law no. 554/2004 on administrative litigation, directly before the competent court, within 30 days of receiving the notification;
- if the complaint is rejected by at least one, but not all of the competent authorities involved, the affected person may submit a request to ANAF to establish an Advisory Commission.

If the complaint is rejected by all the competent authorities involved, the affected person who exercises their right to such a legal remedy may not request that the dispute be resolved by the Advisory Commission if:

- the decision rejecting the complaint is still subject to judicial appeal under applicable legal provisions;
- the decision rejecting the complaint may still be appealed in accordance with the legal remedies available in the other Member States involved;
- the rejection decision has been upheld through judicial review, and the ruling of the competent court or other relevant judicial authority in any of the Member States involved can no longer be overturned.

In the case where a legal remedy has been exercised, the decision of the relevant court or other relevant judicial authority is taken into account.

2.3. The actual mutual agreement procedure

We refer to the “actual mutual agreement procedure” as the process that takes place when ANAF accepts the complaint submitted by a person affected by a case of double or multiple taxation.

Thus, according to Article 283⁵ of the Fiscal Procedure Code, if ANAF and the other competent authorities of the concerned Member States accept the complaint, the national tax authority is responsible for making all necessary efforts to resolve the disputed matter through the mutual agreement procedure within a period of 2 years. This period begins from the date of the latest notification of acceptance of the complaint by one of the competent authorities of the Member States involved.

This period may be extended only in duly justified cases, by up to one additional year, at the request of ANAF or any of the other competent authorities involved. The request must be addressed to all the other authorities participating

in the procedure. If the extension is accepted by all national tax authorities involved, ANAF must notify the affected person who submitted the complaint.

However, if ANAF reaches an agreement with the competent authorities of the concerned Member States on how to resolve the dispute within the 2-year period, it shall issue a decision to conclude the mutual agreement procedure, which shall be immediately communicated to the affected person. This decision is formalized through an order issued by the President of ANAF.

The decision becomes binding and enforceable, provided the affected person accepts it and waives the right to pursue any other remedies, whether administrative or judicial. If other remedies are already in progress, the decision becomes binding and enforceable only after the affected person presents proof to ANAF that appropriate steps have been taken to terminate such actions. These proofs must be submitted within 60 days from the date the decision was communicated to the affected person.

The decision reached through the mutual agreement procedure is implemented immediately, regardless of any statute of limitations provided by applicable legal norms.

Finally, it is possible that ANAF and the competent authorities of the concerned Member States do not reach an agreement on how to resolve the dispute – neither within the initial 2-year term nor during the one-year extension. In such cases, ANAF shall notify the affected person, stating the factual and legal reasons why no agreement was reached.

2.4. Procedure for dispute resolution by the advisory commission

A new step that can be taken to amicably resolve a dispute concerning the double taxation of a person involves the establishment of an advisory commission. Thus, according to Article 283⁶ of the Fiscal Procedure Code, if the affected person submits a request to ANAF and to the other competent authorities of the Member States involved, these authorities will proceed with the establishment of an advisory commission in one of the following scenarios:

- if the complaint submitted by the affected person is rejected by at least one of the competent authorities of the Member States involved, but not by all;
- if ANAF together with the other competent authorities of the Member States involved have accepted the complaint filed by the affected person, but have not reached an agreement on the amicable resolution of the dispute within 2 years (possibly extended by another year, as previously mentioned).

In the first scenario, the affected person may submit a request for the establishment of the advisory commission if no judicial remedy can be exercised against the decision to reject the complaint, or if no such remedy is ongoing, or if

the person has formally waived their right to such remedy. The request must include a written declaration to that effect.

The affected person must submit the written request to establish the advisory commission within a maximum of 50 days from the date of:

- receiving notification that the complaint was rejected by at least one national tax authority involved in the case;
- receiving notification that the complaint was accepted, but no agreement was reached on its resolution;
- issuance of the decision of rejection by the administrative court.

The advisory commission must be established within no more than 120 days from receipt of the request, and the president of the advisory commission must notify the affected person without delay.

According to Article 283⁷ of the Fiscal Procedure Code, if the advisory commission is not established within this timeframe, the affected person may submit a request for its establishment (within 30 days) to a competent court or to any other national body authorized to make appointments from the Member States involved.

Thus, if ANAF has not appointed at least one independent person and their alternate to the advisory commission, the affected person may submit a request to the national body authorized to make appointments, in order to carry out the necessary appointments from a list of independent persons who may later be authorized to participate in such advisory commissions.

In Romania, the national body authorized to make such appointments is the Ministry of Finance. Therefore, if neither ANAF nor the other competent authorities of the Member States involved have appointed at least one independent person and their alternate to the advisory commission, the affected person may submit a request to the Ministry of Finance, as well as to the competent courts or national appointment bodies from the other Member States, to appoint two independent persons from the official list established under Council Directive (EU) 2017/1852 on tax dispute resolution mechanisms in the European Union.

If the affected person's complaint is rejected by at least one national authority, the advisory commission adopts a decision to accept or reject the complaint within 180 days from its establishment, and notifies its decision to the competent authorities within 30 days of adoption.

If the advisory commission accepts the complaint, at the request of ANAF or any of the other competent authorities of the Member States involved, the actual amicable procedure is initiated. The competent authority requesting the initiation of the amicable procedure must notify the advisory commission, the other competent authorities of the Member States involved, and the affected person. The 2-year term (possibly extended by another year) for the amicable resolution of the affected person's complaint starts from the date of notification of the advisory commission's decision to accept the complaint.

However, if neither ANAF nor the other competent authorities involved request the initiation of the amicable procedure within 60 days of the advisory commission's notification of its acceptance decision, the advisory commission issues an opinion on how to resolve the dispute. In this case, the 180-day term provided under Article 283¹⁴ paragraph (1) starts from the expiry of the 60-day period.

If the advisory commission issues a decision to reject the complaint, the procedures for amicable resolution of the dispute come to an end.

Finally, if ANAF together with the other competent authorities of the Member States involved have accepted the complaint filed by the affected person but have not reached an agreement on the amicable resolution of the dispute, the advisory commission issues an opinion on the resolution of the matter.

Regarding the creation of the list of independent persons in each state, according to Article 283⁹ of the Fiscal Procedure Code, it is based on nominations made by the Member States. In Romania, ANAF is responsible for nominating, for a 4-year term, at least 3 persons with proven economic or legal expertise, demonstrated by a high level of professional qualifications and experience in the field, who do not fall under any of the disqualifying situations provided in Directive (EU) 2017/1852, and against whom objections may be raised due to potential conflicts affecting objectivity. Failure to meet these objectivity requirements during the term results in removal from the list of independent persons.

ANAF notifies the European Commission of the names of the nominated independent persons. It also provides the Commission with complete and up-to-date information regarding their professional and academic background, their expertise and experience, as well as any potential conflicts of interest. ANAF may indicate which of the nominated persons may serve as president. Additionally, ANAF promptly informs the European Commission of any changes to the list. If ANAF has valid reasons to object to the inclusion of an independent person on the list due to lack of independence, it informs the European Commission, providing adequate supporting evidence. The Member State that nominated the person is also informed via the European Commission.

If ANAF is informed by the European Commission of objections and evidence regarding the lack of independence of a nominated person, it must take appropriate measures within 180 days from notification to assess the objections and decide whether to retain or remove the person from the list. ANAF then informs the European Commission of its decision.

The independent persons listed may select a president by drawing lots, and any of them may be designated in this role.

Regarding the composition of the advisory commission, according to Article 283⁸ of the Fiscal Procedure Code, it consists of:

- a) president;

- b) one representative from each competent authority of the Member States involved. If the authorities agree, the number of representatives may increase to two per competent authority;
- c) one independent person appointed by each competent authority from the Member States involved from the list mentioned in Article 283⁹.

If the competent authorities agree, the number of appointed independent persons may increase to two per competent authority.

The rules on appointing independent persons are set by mutual agreement between the competent authorities of the Member States involved. After appointing the independent persons, each must also have an alternate, in case any member is unable to perform their duties. If no appointment rules are agreed upon, the appointments are made by drawing lots.

ANAF or any competent authority from a Member State involved may object to the appointment of any independent person to the advisory commission, unless the person was appointed by a competent court or national appointment body of the Member States involved. Objections may be raised based on pre-agreed reasons or on the following:

- the person is or has been within the last 3 years a member of or acting on behalf of a tax authority of any of the Member States involved;
- the person has or had a significant shareholding or voting right in any of the affected persons or was, within the past 5 years, employed by or served as a consultant to them;
- the person does not provide sufficient assurance of objectivity for resolving the dispute(s);
- the person is or has been, within the last 3 years, employed by a tax consultancy or otherwise professionally engaged in tax advisory services.

ANAF or any competent authority of a Member State involved may request that an independent person or their alternate disclose any interest, relationship, or other circumstance that may affect their independence or impartiality, or that may reasonably give the appearance of bias in the proceedings.

As a general rule, for a period of 12 months from the date the advisory commission issues its decision, an independent person who was part of that commission should not find themselves in any situation that would have justified an objection by ANAF or another competent authority if such situation had existed at the time of their appointment.

The representatives of each competent authority and the appointed independent persons elect a president from the list. Unless agreed otherwise, the president must be a judge.

2.5. Procedure carried out by the alternative dispute resolution commission

If A.N.A.F. together with the other competent authorities of the member states concerned have accepted the complaint filed by the affected person but have

not reached an agreement on the amicable settlement of the disputed issue, they may agree, according to art. 283¹⁰ of the Fiscal Procedure Code, to establish:

- a) either an advisory commission;
- b) or an alternative dispute resolution commission, hereinafter referred to as the alternative dispute resolution commission, instead of an advisory commission, which shall issue an opinion regarding the manner of resolving the disputed issue according to art. 283¹⁴;
- c) or, exceptionally, an alternative dispute resolution commission in the form of a committee with a permanent nature, hereinafter referred to as the permanent committee.

As a result, the alternative dispute resolution commissions may apply, as the case may be, any dispute resolution procedure to resolve the disputed issue with binding effect. As an alternative to the type of dispute resolution procedure applied by the advisory commission, namely the independent opinion procedure, any other type of dispute resolution procedure, including the final offer arbitration procedure, may be agreed upon by the competent authorities of the member states concerned and applied by the alternative dispute resolution commission.

2.6. Opinion of the advisory commission or the alternative dispute resolution commission

The activity of the advisory commissions and the alternative commissions results in an opinion which represents a professional and impartial point of view on the fiscal issue in dispute.

According to art. 283¹⁴ of the Fiscal Procedure Code, the opinion must be notified to the competent authorities of the member states concerned within 180 days from the date it was established. If the advisory commission or the alternative dispute resolution commission considers that, given the nature of the disputed issue, more than 180 days are necessary to issue an opinion, this period may be extended by an additional 90 days. The advisory commission or the alternative dispute resolution commission shall inform the competent authorities of the member states concerned and the affected persons about the extension.

This opinion must be based on the provisions of the applicable agreements or conventions, as well as any applicable legal norms in force.

The opinion is issued by the simple majority vote of the members of the advisory commission or the alternative commission, as applicable. If a majority cannot be reached, the president's vote is decisive for the final opinion. The president communicates the opinion of the advisory commission or the alternative dispute resolution commission to the competent authorities.

2.7. Final decision

The entire procedure described above is regulated by the European normative act and transposed into our national legislation by the Romanian legislator in order to provide national authorities with strong arguments on which to base their final decision.

According to art. 283¹⁵ of the Fiscal Procedure Code, within 180 days from the notification of the opinion of the advisory commission or the alternative dispute resolution commission, A.N.A.F. together with the competent authorities of the member states concerned shall proceed as follows:

- a) agree on the manner of resolving the disputed issue and issue a final decision respecting the opinion of the advisory commission or the alternative dispute resolution commission;
- b) agree on the manner of resolving the disputed issue and issue a final decision without respecting the opinion of the advisory commission or the alternative dispute resolution commission;
- c) do not agree on the manner of resolving the disputed issue and issue a final decision respecting the opinion of the advisory commission or the alternative dispute resolution commission.

If the affected person is a tax resident in Romania, A.N.A.F. shall immediately notify the affected person of the final decision regarding the disputed issue. In the absence of such notification within 30 days from the date of the decision, the affected person may address the competent court to obtain the decision.

The final decision is binding for the member states concerned and does not constitute a precedent. The final decision is implemented on the condition that the affected person accepts it and waives the right to exercise any national appeal within 60 days from the date of notification of the decision. As a result, A.N.A.F. will implement the final decision by adjusting taxation, regardless of the limitation periods provided by the applicable legal norms.

If the final decision is not implemented by A.N.A.F., the affected person may submit a complaint to the Bucharest Court of Appeal to request enforcement of the final decision.

By exception to the above rule, the final decision is not implemented by A.N.A.F. if the Bucharest Court of Appeal rules that, according to the applicable legal norms regarding appeals and applying the legal criteria presented in this work, there was a lack of independence of the independent persons appointed by A.N.A.F. to the advisory commission.

2.8. Interaction with national procedures and derogations

Since this procedure is a transposition of a European directive, the Romanian legislator has identified and established a series of rules to harmonize it with the existing national fiscal procedural provisions.

Thus, according to art. 283¹⁶ of the Fiscal Procedure Code, the affected person may resort to amicable settlement procedures for interactions of tax laws of the member states, even if the tax assessment decision generating the disputed issue has become final within the national appeal systems. Submitting the disputed issue for resolution by applying the amicable procedure or the dispute resolution procedure does not prevent the initiation or continuation, in Romania, of judicial procedures or procedures related to administrative and criminal sanctions concerning the same aspects.

Also, affected persons may use the appeals available to them under the applicable legal norms. However, when the affected person has initiated procedures to introduce such an appeal, the deadlines mentioned in art. 283⁴ para. (1) of the Fiscal Procedure Code, and art. 283⁵ para. (1) and (2) begin to run from the date on which a decision issued within those procedures becomes final or on which those procedures have been definitively concluded in another way or suspended.

If a final decision regarding a disputed issue was issued by the competent court in Romania before the competent authorities of the member states concerned reached an agreement under the amicable procedure, A.N.A.F. notifies the final court decision to the other competent authorities of the member states concerned, and that procedure is closed from the date of that notification.

The dispute resolution procedure is terminated if the final court decision was issued at any time after an affected person made such a request, but before the advisory commission or alternative dispute resolution commission issued its opinion to the competent authorities of the member states concerned, in which case A.N.A.F. informs the other competent authorities of the member states concerned and the advisory or alternative commission about the effect of this court decision.

Last but not least, according to the law, A.N.A.F. may refuse access to the dispute resolution procedure in the following cases:

- when sanctions have been applied in Romania related to the adjusted income or capital for tax evasion offenses, including related offenses. If judicial or administrative procedures which may lead to such sanctions are ongoing simultaneously with any amicable procedures covered by this analysis, A.N.A.F. may suspend these procedures from the date of complaint acceptance until the final result of those procedures;
- when the disputed issue does not concern double taxation. In such case, A.N.A.F. informs the affected person and the competent authorities of the member states concerned without delay.

3. CONCLUSIONS

Analyzing the amicable procedure for resolving disputes regarding multiple taxation of a taxpayer within the Union territory, we draw a series of final

observations which we consider relevant and useful to correctly determine the legal nature of these procedures for solving fiscal disputes.

Council Directive (EU) No. 1852/2017 establishes mechanisms for resolving tax disputes within the European Union, while the (Romanian) Fiscal Procedure Code refers to an amicable procedure for avoiding/eliminating double/multiple taxation.

Although considered an “amicable” procedure, its results become binding for the national tax authorities involved. Only the affected party has the option to accept or reject the outcome of the procedure. Therefore, no appeal procedure against the final decision is required, as the affected party may simply refuse to implement the decision.

The “amicable” nature derives only from the fact that the final solution is decisively influenced by the opinion (advice) of a committee composed of experts in the fiscal field who are previously nominated on a public list of such experts and who, for these reasons, enjoy a presumption of independence and objectivity in the cases submitted to their analysis.

National tax authorities can be “forced” to participate in these procedures, even if one of them rejects the request filed by the affected party.

Moreover, national tax authorities can be “forced” to implement the final decision.

Last but not least, initiating this procedure and issuing a final decision does not prevent other contentious or different procedures before national judicial authorities.

In conclusion, we consider that we are dealing with a *sui generis* procedure for resolving conflicts through negotiation and arbitration that may arise between the tax legislations of Member States.

We emphasize that negotiation takes place between the national tax authorities, while arbitration is performed by a committee of independent experts proposed by the national authorities. We also mention that this procedure is initiated by the taxpayer affected by a double or multiple taxation situation, but the taxpayer remains effectively uninvolved in the conduct of this procedure. Thus, although this procedure concerns the taxpayer to the highest degree since they are (or consider themselves) harmed by bearing multiple tax burdens simultaneously on the same taxable base and for the same time period, they cannot influence the course of this procedure in any way. The person who considers themselves harmed can only initiate this procedure with the consent of the national tax authorities, but the latter bear no responsibility for the attitude they display during the procedure. By “attitude,” we mean both the manner in which the tax authority performs the procedural acts incumbent upon it according to the provisions of the European directive and national tax legislation, as well as its “willingness” to resolve the request as favorably as possible for the taxpayer truly affected by multiple taxation.

Therefore, we consider that this procedure is not an administrative jurisdiction, even though the final decision is binding for the national tax authorities involved. We believe this for two reasons.

Firstly, the national tax authority is not liable for the non-performance or defective performance of procedural acts incumbent upon it, and consequently, not liable for damages suffered by the affected party due to this non-compliant conduct of the tax authority. However, we consider that the general rules on liability might apply in this matter, namely Articles 573 and following of the Administrative Code regarding patrimonial administrative liability.

Secondly, the fact that the final decision is not binding on the affected party means there is no open path to ordinary jurisdictional procedures. It is natural that the affected party should not be obliged to accept the result of a procedure in which they do not participate, but they also cannot access a jurisdictional procedure where they could have an active role.

Thus, since the affected party (i.e., the taxpayer/payer) can only initiate this procedure and refuse the final decision, having no involvement in the negotiation between the national tax authorities of the Member States, we consider that this procedure is not a typical form of arbitration.

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AI-DRIVEN SOCIAL ENGINEERING IN BUSINESS ENVIRONMENTS: A REVIEW OF CURRENT RESEARCH

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Abstract

Social Engineering (SE) continues to be a major threat in many sectors as well as Business, by manipulating human behaviour to breach organizational defences. With the integration of Artificial Intelligence (AI) techniques and principles, these attacks have become more targeted, scalable, and difficult to detect – especially for the business domain. This manuscript builds a literature review which highlights the major findings from representative peer-reviewed articles published within 2020 and 2025, retrieved from the Web of Science (WoS) and Scopus databases. The research examines how AI technologies, including Machine Learning, Natural Language Processing, and Deepfake technology, are being leveraged to enhance phishing, impersonation, and behavioural profiling techniques. Preliminary findings indicate a significant rise in the use of AI-driven tools for spear-phishing and executive impersonation within corporate contexts, where the Small and Medium-Sized Enterprises (SMEs) are mostly affected. Additionally, the study highlights a growing gap between the sophistication of attacks and current defensive measures. These insights underscore the need for adaptive, AI-aware security frameworks tailored to evolving SE threats.

Keywords: *artificial intelligence; social engineering; business cybersecurity; phishing attacks; deepfake technology.*

JEL Classification: M15; G19; H75.

1. INTRODUCTION

The digital transformation of business environments has brought unprecedented opportunities for efficiency and growth, but it has also expanded the attack surface for malicious actors. Organizations of all sizes are increasingly reliant on interconnected systems and data, making them vulnerable to a wide range of cyber threats. Among these threats, social engineering remains a

significant concern, exploiting human psychology to manipulate individuals into divulging confidential information or performing actions that compromise security.

Social engineering, in the context of cybersecurity, refers to the psychological manipulation of people to perform actions or divulge confidential information. It is a technique that relies heavily on human interaction and involves deceiving people by exploiting human weaknesses, such as trust, helpfulness, and lack of awareness. Attackers may use various methods, including but not limited to, phishing, pretexting, baiting, and tailgating. Unlike traditional hacking, which relies on technical skills to breach systems, social engineering focuses on exploiting human behavior to gain access to information or systems (Okdem and Okdem, 2024; Nobles, 2024).

1.1. Background on social engineering in business environments

Social engineering attacks are not a new phenomenon, but their prevalence and sophistication have increased in recent years. These attacks, which often involve phishing, pretexting, baiting, and other manipulative tactics, target the weakest link in the security chain: human behavior (Nobles, 2024; Okdem and Okdem, 2024). In business environments, the consequences of successful social engineering can be particularly devastating, leading to financial losses, data breaches, reputational damage, and disruption of operations. The rise of remote work and the increasing reliance on digital communication channels have further exacerbated these vulnerabilities, creating new opportunities for attackers to exploit (Hijji and Alam, 2021; Abdulla *et al.*, 2023).

The landscape of social engineering is constantly evolving, with attackers employing increasingly sophisticated techniques to deceive their victims. Attackers are continuously finding new ways to exploit human vulnerabilities in an increasingly digital world.

1.2. The role of AI in social engineering

AI is playing a dual role in the realm of social engineering. On the one hand, AI is being weaponized by malicious actors to enhance the effectiveness and scale of their attacks (Elsadig, 2024; Nobles, 2024; Toapanta *et al.*, 2024). AI can be used to craft more convincing phishing emails, automate the generation of persuasive deepfake content, and analyze victim behavior to tailor attacks for maximum impact. Large language models (LLMs) like ChatGPT can generate human-like text for phishing and business email compromise attacks and can be used to create fake profiles and automate the grooming of victims (Gupta *et al.*, 2023).

Conversely, AI also offers promising avenues for improving cybersecurity defenses and mitigating the risk of social engineering attacks. Machine learning algorithms can analyze vast amounts of data to detect patterns indicative of social

engineering attempts, such as anomalous email activity, suspicious communication patterns, and deceptive language (Alsufyani and Alzahrani, 2021). AI-powered tools can also be used to enhance security awareness training, personalize interventions, and provide real-time support to employees in identifying and responding to potential threats (Shahzadi *et al.*, 2025).

1.3. Scope of the review

This paper aims to provide a comprehensive review of the current research on AI-driven social engineering in business environments. The review will examine how AI is being used to both enhance social engineering attacks and develop more effective defense mechanisms. It will focus on studies that investigate the intersection of AI, social engineering, and cybersecurity within the context of business organizations.

2. METHODOLOGY

This section outlines the methodology used to conduct this review, detailing the search strategy, study selection process, and data extraction and synthesis methods employed.

The paper explores the following four hypotheses.

H1: AI-driven solutions offer enhanced capabilities in proactively detecting and mitigating diverse cyber threats, including social engineering.

H2: AI plays a dual role in social engineering attacks, both by enhancing the sophistication of attacks and offering potential avenues for improved detection and prevention.

H3: The application of AI in cybersecurity varies across different domains, with the financial sector and tourism/hospitality facing unique challenges and requiring tailored AI-based solutions.

H4: Emerging AI techniques, including intention recognition and machine learning, show promise in addressing specific cybersecurity challenges such as password attacks and improving overall security awareness.

2.1. Search strategy

A systematic search of relevant literature was conducted using the Scopus and WoS databases. These databases were chosen for their comprehensive coverage of peer-reviewed research in the fields of computer science, cybersecurity, and business. The following search query was used:

"TITLE-ABS-KEY ("Artificial Intelligence" AND "Social Engineering" AND ("Cybersecurity" OR "Business")) AND PUBYEAR > 2019 AND PUBYEAR < 2026"

This query was designed to identify studies published between 2020 and 2025 that investigated the role of AI in social engineering within a business context.

2.2. Study selection

The study selection process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The study selection process is illustrated in the PRISMA flow diagram (see Figure 1), which details the number of studies identified, included, and excluded at each stage.

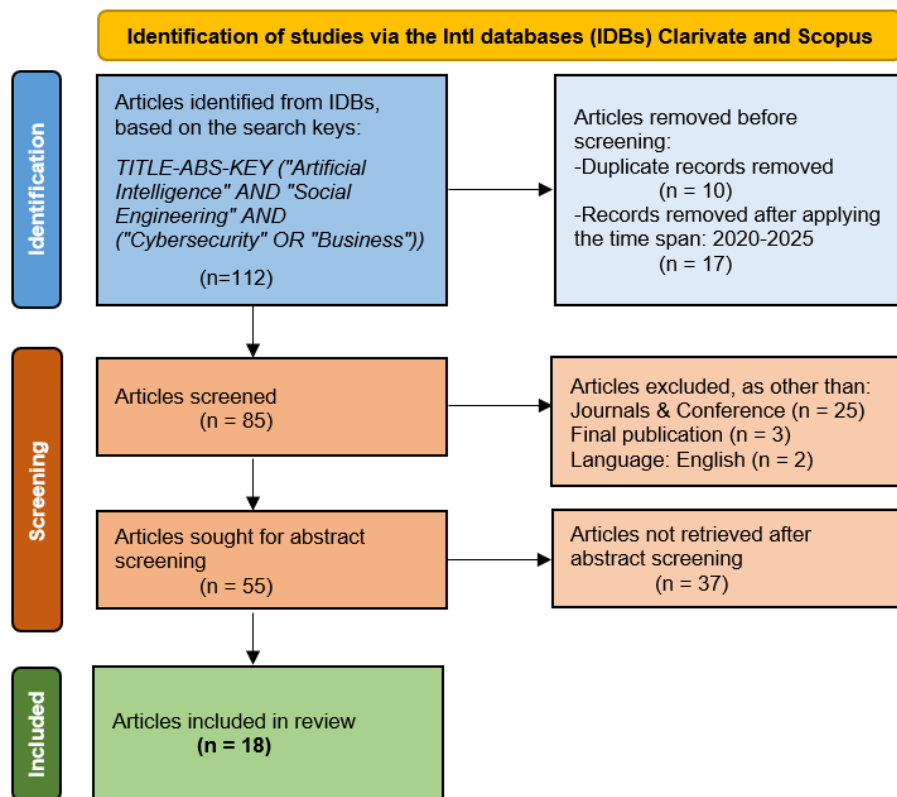


Figure 1. Article selection procedure

The inclusion criteria were studies published in peer-reviewed journals or conference proceedings, written in English, and that explicitly address the use of AI in Social engineering within business environments. After applying the inclusion criteria, 112 articles remained. Exclusion criteria were articles not published in peer-reviewed journals or conference proceedings (e.g., books, book chapters, reports), studies not written in English, and that do not focus on the intersection of AI, social engineering, and business, and duplicate studies. The remaining 55 articles were read and 37 were removed as they did not fit the scope

of the review. The final number of articles included in the study is 18 and the papers were read in full and analyzed in comparison with the hypothesis.

2.3. Data extraction and synthesis

The extracted data were then synthesized using a thematic analysis approach and based on the formulated Hypotheses. This involved identifying recurring themes and patterns in the literature related to the use of AI in social engineering within business environments. The themes were then organized into four categories:

- The Dual Role of AI in Cybersecurity
- AI-Driven Solutions for Proactive Threat Detection and Mitigation
- Applications and Challenges of AI in Cybersecurity
- Emerging AI Techniques for Specific Cybersecurity Challenges and Awareness

3. RESULTS

This review organizes the selected 18 articles based on thematic connections to the proposed research hypotheses. Each section will highlight the original contributions of the papers in relation to the overarching theme.

3.1. The dual role of AI in cybersecurity: enhancing attacks and defences

Hypothesis 2 (H2) posits that AI plays a dual role in social engineering attacks, both by enhancing the sophistication of attacks and offering potential avenues for improved detection and prevention. Several articles in this review directly address this duality, exploring how AI is used by both attackers and defenders.

The weaponization of AI in cybersecurity is a significant concern, as malicious actors exploit AI and Machine Learning (ML) models (Nobles, 2024). Nobles' systematic review examines academic studies on AI weaponization and AI-driven cyberattacks, concluding that more research is necessary on weaponizing AI for offensive cybersecurity applications. Key observations from this study include: (a) a connection between AI weaponization and countermeasures, (b) AI's role in enhancing cybersecurity defences, (c) AI weaponization offering mitigation strategies, and (d) AI-driven attacks exploiting vulnerabilities, enabling automation, facilitating data poisoning, improving social engineering, and augmenting evasion (Nobles, 2024). This highlights AI's capability to make attacks more sophisticated by enabling automation, scalability, and improved social engineering tactics.

Generative AI (GenAI) models like ChatGPT have been identified as powerful tools that can be used for both offensive and defensive cybersecurity tasks, including social engineering (Gupta *et al.*, 2023; Charfeddine *et al.*, 2024). Gupta *et al.* (2023) explore the limitations, challenges, potential risks, and

opportunities of GenAI in cybersecurity and privacy. They demonstrate how vulnerabilities in models like ChatGPT can be exploited for malicious purposes (e.g., jailbreaks, reverse psychology, prompt injection attacks) and how cyber offenders can use GenAI tools to develop social engineering attacks, phishing attacks, automated hacking, and malware. Conversely, the paper also examines defensive uses of GenAI, such as cyber defence automation, threat intelligence, secure code generation, attack identification, and malware detection (Gupta *et al.*, 2023).

Similarly, Charfeddine *et al.* (2024) investigate ChatGPT's security risks and benefits, covering harmful attacker uses such as malicious prompt injection, testing brute force attacks, and preparing ransomware attacks. The authors also address proactive defensive activities, highlighting ChatGPT's significance in security operations and threat intelligence, categorized according to the National Institute of Standards and Technology (NIST) cybersecurity framework. They propose secure enterprise practices and mitigations, emphasizing clear usage standards, protection of personally identifiable information, and adversarial attack prevention (Charfeddine *et al.*, 2024). Elsadig (2024) also provides a thorough investigation and discussion of how ChatGPT can significantly support hackers in committing various attacks, concluding that ChatGPT has significantly supported hacking behaviors and can be exploited to spread malicious activities. This necessitates continuous development and enforcement of appropriate standards and for policymakers and developers to work together to prevent negative effects (Elsadig, 2024).

The work by Toapanta *et al.* (2024) provides a practical approach to AI-driven vishing (voice phishing) attacks. They demonstrate how current AI tools, including ChatGPT and three AI-enabled applications for voice synthesis, can be used to create synthetic voices similar or identical to a person to be impersonated, making vishing attacks more straightforward and precise. Their results from deploying vishing attacks in an academic environment demonstrate the effectiveness of these AI-driven attacks and the maturity level of the employed AI tools, underscoring how AI enhances the sophistication of social engineering attacks (Toapanta *et al.*, 2024).

These studies collectively support H2 by illustrating that while AI offers innovative ways to augment attacks (making them more sophisticated, automated, and personalized), it concurrently provides new mechanisms for defence, threat intelligence, and improved security measures. Golda *et al.* (2024) further contributes by offering a comprehensive survey on privacy and security concerns in Generative AI, discussing GAI architectures, model types, applications, and recent advancements, while also highlighting current security strategies and proposing sustainable solutions involving various stakeholders.

3.2. AI-driven solutions for proactive threat detection and mitigation

Hypothesis 1 (H1) suggests that AI-driven solutions offer enhanced capabilities in proactively detecting and mitigating diverse cyber threats, including social engineering. The reviewed literature provides substantial evidence supporting this.

Okdem and Okdem (2024) explore the potential of artificial intelligence as an emerging tool to enhance cybersecurity, focusing particularly on its preventative capabilities against prevalent threats like phishing, social engineering, ransomware, and malware. While acknowledging AI's recent integration into cybersecurity, they offer a comprehensive review of current AI applications and present a case study on securing communication in resource-constrained Internet of Things (IoT) networks using AI, illustrating a specific AI application in a cybersecurity context (Okdem and Okdem, 2024).

Zhang *et al.* (2025) specifically addresses the cybersecurity needs of small and midsize enterprises (SMEs) by benchmarking and evaluating Large Language Models (LLMs) in phishing detection. Their comprehensive analysis, using high-quality email datasets of human and AI-generated phishing and legitimate emails, demonstrated that the open-source Llama-3-8b-instruct model outperformed other alternatives. It achieved the highest accuracy and F1-score and offered a cost-effective and flexible solution for SMEs, emphasizing ease of implementation without additional training or fine-tuning. The proposed prompt template also enables LLMs to provide explanations and suggestions, assisting users in making informed decisions (Zhang *et al.*, 2025). This highlights LLMs' potential for robust phishing detection, a key aspect of mitigating social engineering.

Alsufyani and Alzahrani (2021) propose using natural language processing (NLP) along with machine learning techniques for text phishing detection. They started with a dataset of 6,224 emails (phishing and legitimate) and used NLP for data preparation before extracting features with the Word2Vec algorithm. They trained four models using k-nearest neighbors (KNN), Multinomial Naive Bayes (MNB), Decision Tree, and AdaBoost algorithms to classify text messages. Three of their models (KNN, Decision Tree, and AdaBoost) obtained considerable values in performance, demonstrating the practical application of ML in identifying text-based phishing attacks, even with unbalanced datasets (Alsufyani and Alzahrani, 2021).

Abualhija *et al.* (2023) propose a novel approach to detecting and preventing social engineering attacks by combining multiple security systems and utilizing the concept of Honeypots with artificial intelligence. Their study aims to merge AI and honeypots with an intrusion prevention system (IPS) to detect social engineering attacks, threaten the attacker, and restrict their session. This signifies a technological solution focused on making users more secure by providing an automated prevention mechanism against manipulation tactics (Abualhija *et al.*, 2023).

These papers illustrate the diverse ways AI, through machine learning, NLP, LLMs, and novel system designs like AI-enhanced honeypots, can enhance the proactive detection and mitigation of cyber threats, particularly social engineering attacks such as phishing.

3.3. Domain-specific applications and challenges of AI in cybersecurity

Hypothesis 3 (H3) states that the application of AI in cybersecurity varies across different domains, with sectors like finance and tourism/hospitality facing unique challenges and requiring tailored AI-based solutions. The reviewed articles provide insights into these domain-specific considerations.

The financial sector is a prime target for cyber threats, necessitating specialized AI-driven defenses. Ali *et al.* (2024) provides a comprehensive review of cybersecurity issues and mitigation measures in FinTech. They examine pressing cybersecurity issues such as privacy concerns, data breaches, malware attacks, hacking, insider threats, identity theft, and social engineering attacks that confront FinTech firms. In response, they evaluate various mitigation strategies, including technological solutions like artificial intelligence and machine learning, big data analytics, and blockchain technologies, alongside regulatory compliance and robust cybersecurity cultures. Their work emphasizes the need for a collaborative strategy to address the growing cyber threat landscape in FinTech (Ali *et al.*, 2024).

Nicholls *et al.* (2021) conduct a comprehensive survey of deep learning approaches to tackle the evolving financial crime landscape, introducing the term "financial cybercrime" which combines financial crime, hacking, and social engineering. They highlight those cybercriminals are using a combination of hacking and social engineering techniques that bypass current security measures in financial institutions. The survey discusses different fraud methods, relevant systems and algorithms (including graph-based techniques and neural network models), their drawbacks, and the unique constraints in applying AI, such as the demand for transparency, fairness, and privacy. This underscores the specialized AI approaches needed to identify illicit transactions while minimizing disruption to genuine customers in the financial domain (Nicholls *et al.*, 2021).

Shahzadi *et al.* (2025) explore personalized and gamification-based cybersecurity risks within financial institutions. Their systematic literature review examines the use of personalized, gamification-based strategies, potentially enhanced by AI, to mitigate cyber threats in the financial domain. The paper assesses the evolving landscape of cyber threats specific to the financial industry, including traditional attacks, APTs, and threats in gaming platforms linked to financial services. They propose AI-driven measures for prevention and detection, emphasizing regular security assessments, user training, and system monitoring. This research points to tailored AI-enhanced gamification to reinforce cybersecurity protocols in finance (Shahzadi *et al.*, 2025).

The tourism and hospitality sector also presents unique cybersecurity challenges. Del Mar Alonso-Almeida and Giglio (2024) compare literature reviews on cybersecurity issues in mature business and management fields with the embryonic tourism and hospitality area. By using the general study as a benchmark, they map current trends and identify gaps specific to tourism and hospitality. Their findings suggest topic clusters for future research in this sector, including (1) machine learning, artificial intelligence, blockchain, big data; (2) fraud and reputation; (3) phishing and social engineering; and (4) human security and user education (del Mar Alonso-Almeida and Giglio, 2024). This indicates a growing need for AI-based solutions tailored to the specific operational models and customer data vulnerabilities inherent in tourism and hospitality.

These articles support H3 by demonstrating that different sectors, particularly finance and potentially tourism/hospitality, face distinct cybersecurity threats and operational constraints, thus requiring the development and application of specialized AI-based security solutions.

3.4. Emerging AI techniques for specific cybersecurity challenges and awareness

Hypothesis 4 (H4) suggests that emerging AI techniques, including intention recognition and machine learning, show promise in addressing specific cybersecurity challenges such as password attacks and improving overall security awareness.

Kassa *et al.* (2024) delve into intention recognition within digital forensics and cybercrime in their systematic literature review. Intention recognition, a subfield of AI, aims to identify agents' intentions based on their actions. The authors categorize research into logic-based, classical machine learning-based, and deep learning-based modelling approaches. They note that intention recognition is now addressing critical challenges across various subdomains, including social engineering attacks. While deep learning is dominant, its lack of transparency is a challenge for digital forensics, leading the authors to advocate for hybrid solutions that blend explainability, reasonableness, efficiency, and accuracy. Their work also proposes a taxonomy for intention recognition, highlighting its promise for predicting and understanding cybercriminal actions (Kassa *et al.*, 2024). This directly aligns with H4 by showing how an emerging AI technique can address complex cyber threats like social engineering by understanding attacker intent.

Taşçı *et al.* (2021) focus on detecting specific password attack types (brute force, dictionary, and social engineering) using a Cowrie Honeypot and machine learning. Logs obtained from these attacks were used to train various machine learning algorithms (Naive Bayes, Decision tree, Random Forest, SVM) to classify subsequent similar attacks. Their research determined that these attacks could be identified with high success rates. The authors emphasize that

determining the type of password attack is critical for implementing appropriate countermeasures. This study shows the promise of machine learning in addressing specific challenges like password attacks by classifying attack types, thus enabling more targeted defences (Taşçı *et al.*, 2021).

The importance of security awareness is highlighted by Abdulla *et al.* (2021), who analyzed social engineering awareness among students and lecturers at the University of Sulaimani. While their study primarily uses a quantitative approach (questionnaires) to gauge awareness, it notes that social engineering attacks use methods like pretexting with Artificial Intelligence or phishing, exploiting human error. The findings show a lack of knowledge of cybersecurity and that participants are inexperienced with network security systems, emphasizing the significance of SE training. Although this paper doesn't directly propose an AI solution for awareness, it underscores the need for improved awareness (Abdulla *et al.*, 2023), a domain where AI-driven training and simulation tools (as suggested by the abstract of the main review) could play a role, aligning with the latter part of H4.

Hijji and Alam (2021), in their multivocal literature review on social engineering-based cyber-attacks during the COVID-19 pandemic, identify open challenges and prospective solutions, including the use of latest technologies such as artificial intelligence, blockchain, and big data analytics. While their primary focus is on the types of SE attacks (phishing, scamming, vishing) and platforms used, the call for AI as a prospective solution to these challenges supports the idea that AI techniques can address these specific issues and potentially enhance security awareness regarding them (Hijji and Alam, 2021).

These papers support H4 by demonstrating the application and potential of specific AI techniques like intention recognition and machine learning algorithms in tackling detailed cybersecurity challenges such as password attacks and by pointing towards the need for better security awareness where AI could be leveraged.

4. CONCLUSIONS

This review of current research between 2020 and 2025 confirms the transformative and dual-edged impact of Artificial Intelligence on social engineering in business environments. The literature substantiates that AI significantly enhances the capabilities of attackers, making social engineering tactics more sophisticated, scalable, and harder to detect, particularly through the use of Generative AI for crafting convincing phishing, vishing, and malware attacks (H2). Tools like ChatGPT are noted for both their potential misuse in creating advanced attacks and their utility in bolstering defences.

Concurrently, AI-driven solutions, including machine learning, NLP, and Large Language Models, offer powerful new avenues for proactively detecting and mitigating these advanced threats (H1). Innovations such as AI-enhanced

honeypots and specialized LLMs for phishing detection provide crucial tools, especially for SMEs that are often heavily targeted.

The application of AI in cybersecurity is not uniform across sectors; domains such as FinTech and tourism/hospitality face unique challenges and require tailored AI-based strategies to combat specific threats like financial cybercrime and protect sensitive customer data (H3). Furthermore, emerging AI techniques like intention recognition and focused machine learning applications demonstrate significant promise in addressing specific vulnerabilities, such as password attacks, and offer potential for improving overall security awareness and understanding attacker motivations (H4).

Overall, the results point out that there is a fast evolving threat landscape where AI-driven social engineering is increasingly prevalent. This underscores an urgent need for businesses to adopt adaptive, AI-aware security frameworks and foster continuous research to bridge the growing gap between the sophistication of AI-powered attacks and current defensive capabilities.

5. LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This review has several limitations as depicted below. As the search was limited to the Scopus and Clarivate databases, the results may not capture all relevant studies. Further, the review focused solely on studies published in English, potentially excluding valuable research published in other languages. Moreover, the review is limited to the timespan of 2020-2025. Future research paths could tackle these limitations by expanding the search to include additional databases, considering non-English publications, and covering a broader time frame. Additionally, future research could explore the ethical implications of using AI in social engineering, both for attack and defence, in more detail. It should also investigate the effectiveness of different AI techniques in mitigating specific types of social engineering attacks.

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THE IMPACT OF EU SUSTAINABILITY REGULATIONS ON THE FINANCIAL PERFORMANCE OF EUROPEAN OIL AND GAS COMPANIES

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Abstract

Financial performance (FP) is a subjective yet pivotal measure of how effectively a firm can use its assets from primary business activities to generate revenues and thus maximize value, a core aim within the economic system. FP acts not only as a key indicator of a firm's overall financial health but also as an important criterion for assessing how well a business can adapt to market changes, enhance operational methods, and face potential challenges. This study seeks to understand how sustainability initiatives affect financial performance and whether they facilitate or obstruct the pursuit of value maximization in the corporate sector.

This study aims to explore the impact of Directive 2014/95/EU, which for the first time in Europe mandates the disclosure of non-financial information, on the financial performance of European oil and gas companies listed on Euronext. Employing retrospective analysis and utilizing secondary data sources such as annual reports, the research analyzes how sustainability regulations influence profitability indicators like return on assets (ROA), return on equity (ROE), and return on invested capital (ROIC). The financial data covering five years before and seven years after the directive's implementation is subjected to Wilcoxon Signed-Rank Test analysis using the SPSS software. The purpose of this test is to determine if there are statistically significant differences in financial performance between the periods before and after the implementation of the directive.

Results of the Wilcoxon Signed-Rank Test, applied to multi-year averages over a five-year pre and seven-year post directive period, indicate that the values of these indicators did not change significantly between the two timeframes for oil and gas companies. In this context, the non-financial reporting requirements introduced by the directive did not have a statistically significant impact on the profitability of the analyzed companies.

The limitations of the study include the selection of financial indicators that remains an subjective choice and may not fully capture the broader effects of sustainability related regulations. Additionally, external economic and geopolitical factors affecting the oil and gas sector during the analyzed period were not controlled for and may have influenced financial performance independently of the directive.

Keywords: *financial performance; sustainability; non-financial reporting; regulation; oil and gas industry.*

JEL Classification: M41; M14; Q56; L71.

1. INTRODUCTION

Over the past few decades, expectations regarding corporate social and environmental responsibility have increased significantly within the European Union, driven by public pressures, the evolution of investor requirements and expectations, and the strengthening of the regulatory framework in the corporate sustainability field (European Commission, n.d.). In this context, corporate sustainability has evolved from a best-practice initiative into a formal requirement under European legislation, with a direct impact on business strategies and both financial and non-financial reporting processes. The growing importance of ESG (Environmental, Social, and Governance) criteria in investor decision-making has highlighted this trend making sustainability transparency a key factor in assessing corporate performance (Meynier *et al.*, 2023). The oil and gas industry, known for its significant environmental impact and high exposure to regulatory risks, stands at the center of these pressures, frequently targeted both by emission reduction policies and by criticism concerning the actual transparency of its sustainability efforts (Ishwar and Frode, 2023).

In order to establish a regulatory framework that promotes systematic reporting of non-financial information, the European Union adopted Directive 2014/95/EU, amending Directive 2013/34/EU on financial reporting. This directive introduced, for the first time in Europe, the obligation for large public-interest entities with more than 500 employees to disclose information on their policies, risks, and performance in environmental, social, and governance matters (Envoria, 2022). Directive 2014/95/EU was designed not only to ensure greater transparency for investors, but also to integrate non-financial risks into the overall performance assessments of companies. In sectors with a significant environmental impact, such as oil and gas, the implementation of these requirements has led to substantial adjustments in reporting strategies and internal risk management systems, including the integration of ESG performance indicators into annual reports, the development of internal carbon emission monitoring systems, the implementation of clear climate risk management policies, and the establishment of sustainability committees at the board level (IPIECA, API, IOGP, 2020). At the same time, the literature also highlights potential negative effects of regulation, such as the intensification of compliance formalism, heavier administrative burdens, higher reporting costs, and, implicitly, a diversion from the actual goals of improving sustainability performance (Antonini and Gomez-Conde, 2024).

Considering these circumstances, through this study I aim to examine the impact of Directive 2014/95/EU on the financial performance of European oil and gas companies listed on one of the largest stock exchanges in continental Europe, Euronext. The main objective is to assess the changes in the level of return on assets (ROA), return on equity (ROE), and return on invested capital (ROIC), which are key indicators for evaluating the efficiency of economic resource

utilization. The statistical analysis will be conducted using the Wilcoxon Signed-Rank Test, a method appropriate for comparing the means of dependent samples when the normality assumption is not met (Pallant, 2020).

By focusing on a strategic sector positioned at the intersection of traditional economic performance and emerging sustainability requirements, and by employing a rigorous methodology adapted to the characteristics of the empirical data, the proposed study offers a meaningful contribution both to the literature and to contemporary managerial practices. The findings may provide a deeper understanding of how sustainability regulations influence resource utilization and profitability strategies within a sector exposed to the energy transition.

2. LITERATURE REVIEW

Corporate sustainability is conceptualized as the voluntary integration of social, environmental, and governance concerns into business activities and stakeholder interactions, with the aim of balancing short-term economic objectives with long-term sustainable development considerations (World Commission on Environment and Development, 1987). Over time, corporate sustainability has evolved from a set of ad hoc philanthropic initiatives into a strategic and fundamental dimension of modern corporate governance, becoming a key component in the assessment of long-term organizational risks and opportunities.

The emergence of ESG standards reflects a global trend toward the codification and formalization of non-financial criteria in the analysis of corporate performance. ESG indicators, structured around three fundamental dimensions, environmental protection, social responsibility, and corporate governance, were initially promoted by initiatives such as the Global Reporting Initiative (GRI) (Global Reporting Initiative, 2021) and the Principles for Responsible Investment (PRI) (United Nations, 2006), aiming to establish a unified reference framework for reporting and assessing extra-financial impact. The integration of ESG criteria into investment decision-making processes has accelerated under pressure from institutional investors, regulatory bodies, and public opinion, reflecting a growing recognition that ESG risks are inherently connected to traditional financial risks.

In a context marked by increasing demands for transparency and corporate accountability, non-financial reporting has become an essential tool for companies to legitimize their behavior toward stakeholders and to reduce the informational risks perceived by investors (Meynier *et al.*, 2023). Proper ESG disclosure not only facilitates access to capital and enhances corporate reputation, but also serves as a strategic differentiation mechanism in financial markets that are increasingly sensitive to sustainability issues. From the investors' perspective, non-financial information has become essential in the due diligence process, as it enables a comprehensive assessment not only of economic performance but also of an organization's exposure to environmental, social, and governance risks. This

information facilitates the anticipation of systemic risks and the identification of strategic opportunities, aspects considered critical in the context of the global transition to a sustainable economy (Bell, 2023).

Directive 2014/95/EU was adopted by the European Parliament and the Council of the European Union in October 2014, amending Directive 2013/34/EU concerning the disclosure of non-financial information and diversity information by certain large enterprises and groups. This was the first mandatory legislative framework at the European level for non-financial reporting, aimed at improving corporate transparency, social responsibility, and investor confidence in European financial markets (European Union, 2014). The reporting obligation introduced by the NFRD applies to public-interest entities that exceed the threshold of 500 employees and are either listed on a stock exchange or are credit institutions or insurance companies (Anderson, 2025). According to Article 19a, introduced by Directive 2014/95/EU into Directive 2013/34/EU, the affected companies must include in their management report or in a separate report information on the policies adopted, associated risks, and results achieved in the areas of environmental, social, and governance matters (European Union, 2014).

A defining element of the NFRD Directive is the principle of materiality, according to which organizations must report that information necessary to understand the development, performance, and financial position of the company, as well as the impact of its activities on the environment and society (Eccles *et al.*, 2012). This flexible approach has allowed reporting to be adapted to the specific characteristics of each organization; however, in the absence of clear and uniform standards, it has often led to heterogeneous reporting practices across companies and sectors. Successive assessments conducted by the European Commission have highlighted a number of structural limitations of the NFRD. Among the main issues identified are the lack of comparability between reports, the low level of detail in the information provided, the excessive use of vague formulations, and the difficulties investors face in assessing non-financial risks (Hao *et al.*, 2023).

In line with the objective of this study, which is to analyze the impact of sustainability regulations on the financial performance of companies from the oil and gas sector, Directive 2014/95/EU serves as the reference regulatory framework. The period under analysis, covering five years prior to and seven years following the implementation of the directive, is governed exclusively by the requirements established by the NFRD. Although the Corporate Sustainability Reporting Directive (CSRD) was adopted in December 2022, its applicability begins with the financial year 2024 (Edlinger, n.d.) which is why it does not influence the results of this research. Financial performance is a fundamental concept in economic and financial analysis; however, despite its wide usage, there is no single, universally accepted definition. In the literature, the term is approached from multiple perspectives, each emphasizing certain dimensions of a company's financial success. For some authors, financial performance refers to

an entity's ability to generate profits and maintain long-term financial stability through the efficient use of resources and the minimization of financial risks (Brealey *et al.*, 2019). This definition highlights the importance of profitability and financial sustainability over time. From a more applied perspective, certain authors argue that financial performance should be analyzed from the standpoint of the relationship between risk and return, depending on the specific objectives and context of each economic entity (Saputra, 2022). This approach emphasizes that financial performance indicators vary depending on industry, strategy, and external economic factors.

The European Union, through Directive 2013/34/EU on annual financial statements, defines financial performance as the result of an entity's economic activities, reflected in its financial position, profitability, and cash flows (European Union, 2013). This definition, used in financial reporting standards, focuses on the measurability of performance through specific financial indicators. Due to the complexity of the concept, financial performance is assessed using a variety of indicators, which are selected based on the objectives of the analysis and the characteristics of the entity being studied. Among the most commonly used indicators are return on equity (ROE), earnings before interest and taxes (EBIT), return on investment (ROI), etc. (Vimrova, 2015). One of the primary financial performance indicators is ROI (Return on Investment). Invented by Donaldson Brown, it was designed to provide a financial representation of the company. Brown also stated that ROI is a final and fundamental measure of industrial performance and represents the ultimate test of management efficiency in any business (Flesher and Previts, 2014). In the decades that followed, several other financial performance indicators were developed, largely inspired by ROI, such as ROE (Return on Equity) and RONA (Return on Net Assets).

Studies on the relationship between sustainability and financial performance have developed significantly in recent decades, strengthening their presence in major scientific journals and becoming one of the central topics in corporate finance and strategic management. Broadly speaking, research highlights the trend of identifying a positive correlation between sustainable practices and financial performance indicators, although there are also studies that find inconclusive results or suggest a neutral or even negative impact. One of the most cited studies is the meta-analysis conducted by Orlitzky, Schmidt, and Rynes, who examined over 50 previous studies and concluded that, on average, there is a positive correlation between corporate social responsibility and financial performance. Furthermore, the meta-analysis suggests that the positive effect is stronger in certain industries and for specific types of sustainability initiatives (Orlitzky *et al.*, 2003). Some authors have found that the improvement in economic performance (measured using ROA and ROE indicators) in the aquaculture industry is correlated with better resource management and sustainable practices (Llorente *et al.*, 2020). Others, through their research, highlight that companies included in the

Dow Jones Sustainability Index (DJSI) achieve superior financial performance compared to those in the industry, demonstrating that social and environmental responsibility contributes to a strategy that generates value. Although short-term liquidity is lower, long-term financial leverage is higher (DiSegni *et al.*, 2015).

A study conducted between 2014 and 2018 on a sample of firms highlighted a significant positive relationship between sustainability performance and financial performance. The total ESG score positively influenced financial performance, although the individual components (economic, environmental, and social) did not have a significant separate impact (Yilmaz, 2021). On the other hand, some studies do not identify a significant direct link that there are neutral or even negative effects, particularly in the short term. Methodological, sectoral, or contextual differences (regulations, economic climate, firm size) may explain these heterogeneous results (Landi *et al.*, 2022). Therefore, there is no consensus regarding the way to define the relationship between sustainability and financial performance.

The oil and gas sector is distinguished by an extremely high-risk profile regarding sustainability, both in terms of its direct environmental impact and its exposure to legislative and financial risks associated with the energy transition. Companies in this industry contribute significantly to global greenhouse gas emissions, and their activities involve risks such as water pollution, ecosystem degradation, and the intensive use of natural resources (Johnston *et al.*, 2020). In this context, non-financial reporting regulations, such as Directive 2014/95/EU, are not only a formal obligation but also an essential tool for reshaping the strategic positioning of these companies in a business environment where ESG criteria are becoming increasingly decisive for access to capital and for maintaining the social license to operate. The risk of greenwashing is particularly pronounced in the oil and gas industry, given the structural discrepancy between the publicly stated decarbonization goals and the reality of the fossil fuel-based business model (Aronczyk *et al.*, 2024). This dissonance creates acute reputational vulnerabilities and intensifies pressure from institutional investors, who are reconfiguring their portfolios based on the ESG scores and climate risks reported by companies.

Therefore, in the oil and gas industry, effective and credible non-financial reporting can no longer be treated as a superficial communication exercise, but has become a critical condition for maintaining relevance in global financial markets and for navigating the complexities of the transition to a low-carbon economy (Nelson, 2017).

3. RESEARCH METHODOLOGY

This research employs a quantitative, ex post facto approach, focusing on the retrospective analysis of financial data (Antorine *et al.*, 2024) to assess the impact of implementing Directive 2014/95/EU on non-financial reporting and its effect

on the financial performance of European companies in the oil and gas industry. The methodological foundation of the study is based on the premise that available historical data can reveal potential changes in corporate performance resulting from the introduction of new European regulations, without direct intervention by the researcher on the analyzed variables.

The target population consisted of oil and gas companies listed on the Euronext stock exchange, a choice justified by the international nature of this market, the standardization of financial and non-financial reporting for listed entities, and the extensive availability of historical data. The sample selection was made based on strict criteria, including only those companies that had been presenting complete financial reports since 2012, the chosen starting year for the pre-directive period. The exclusion of other companies on Euronext was due to the fact that Directive 2014/95/EU imposes reporting obligations solely on large enterprises with over 500 employees, meaning that many small and medium-sized enterprises were not subject to the regulation and did not publish relevant non-financial reports for the analyzed period. Thus, the final selection ensures sample homogeneity and minimizes the risk of selection bias. The resulting sample is presented in the table below (Table 1):

Table 1. Population of study

S/N	Name of company
1	Aker BP
2	Equinor
3	Havila Shipping
4	Interoil Expl Prod
5	Magnora
6	Nel
7	Panoro Energy
8	Prosafe
9	Solstad Offshore
10	Subsea 7
11	Tgs

Source: own processing based on public data available on Euronext

The observation period was divided into two distinct segments, in line with the implementation of the directive: the pre-directive period, covering the years 2012 to 2016, and the post-directive period, extending from 2017 to 2024. This

temporal delimitation addresses the need to capture the effects of the directive's effective implementation, given that reporting obligations became applicable starting with the 2017 financial year (Carmo and Ribeiro, 2022). Additionally, the inclusion of 2024 in the post-directive analysis reflects the intention to leverage the most recent available financial data, thus enhancing the temporal relevance of the conclusions drawn.

Data collection was based on the audited financial reports published by the companies included in the sample, using exclusively secondary, official, and verifiable sources. The indicators chosen for evaluating financial performance are Return on Assets (ROA), Return on Equity (ROE) and Return on Invested Capital (ROIC), with their selection grounded in their recognition in the literature as relevant measures of resource efficiency, profitability, and investment performance. For the statistical analysis, a preliminary normality test was conducted using the Kolmogorov-Smirnov and Shapiro-Wilk tests, with the results indicating significant deviations from a normal distribution. Consequently, the Wilcoxon Signed-Rank Test for paired samples, a non-parametric method appropriate given the deviation from the normality assumption, was used to compare financial performance between the two periods. The statistical analysis was performed using SPSS software, with a significance level set at 5% ($\alpha = 0.05$), and interpretations were based on the p-values obtained for each analyzed indicator.

4. RESEARCH RESULTS

To assess the impact of Directive 2014/95/EU on the financial performance of European companies in the oil and gas industry, the research was structured into three distinct methodological stages, each designed to ensure the accuracy and robustness of the results obtained.

In the first stage, for each company included in the sample, the annual averages of the financial indicators Return on Assets (ROA), Return on Equity (ROE), and Return on Invested Capital (ROIC) were calculated separately for the pre-directive period (2012–2016) and the post-directive period (2017–2024). The calculation of the averages for each indicator and each company aimed to minimize the influence of annual cyclical variations and eliminate the impact of isolated economic events on financial performance. This approach allowed for the stabilization of the analyzed values and facilitated a coherent comparison between the two periods, capturing general trends rather than accidental fluctuations.

In the second stage, normality testing of the data distribution was performed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. The purpose of this testing was to identify the nature of the financial indicators' distribution and to determine the appropriate statistical technique for analyzing differences.

Table 2. Normality test of ROA, ROE, ROIC for pre- and post-Directive periods

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
ROA_pre_mean	.242	11	.071	.734	11	.001
ROE_pre_mean	.254	11	.046	.853	11	.047
ROIC_pre_mean	.409	11	.000	.586	11	.000
ROA_post_mean	.288	11	.011	.811	11	.013
ROE_post_mean	.464	11	.000	.453	11	.000
ROIC_post_mean	.225	11	.124	.949	11	.636

Source: own processing based on public data from annual reports

If the p-value is greater than 0.05, there is insufficient statistical evidence to reject the null hypothesis, which states that the data are normally distributed. In other words, we accept that the data could be normally distributed, meaning that tests assuming normality can be used. If the p-value is 0.05 or lower, then we reject the null hypothesis, suggesting that the data are not normally distributed. This means that the data distribution significantly deviates from a normal distribution, and statistical methods that do not assume normality, such as non-parametric tests, are more appropriate. According to the results obtained, the majority of the variables analyzed did not meet the normality assumption. These findings necessitated the use of non-parametric statistical methods for the comparisons between periods, as the normality assumptions required for parametric tests were not met.

In the third stage, based on the results of the normality tests, the Wilcoxon Signed-Rank test for paired samples was applied. This non-parametric test was used to compare the pre- and post-directive means for each of the three financial indicators analyzed, considering that the data did not meet the necessary conditions for the use of parametric tests. The Wilcoxon test is recognized for its robustness in the absence of normality and for its ability to assess changes in the population's median between two time points for the same group of entities.

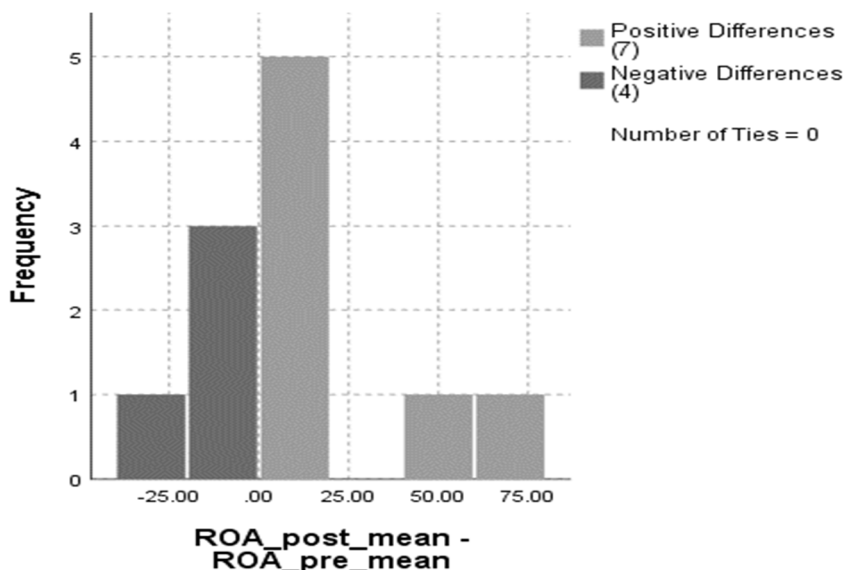
Table 3. Hypothesis test for ROA

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between ROA_pre_mean and ROA_post_mean equals 0.	Related-Samples Wilcoxon Signed Rank Test	.374	Retain the null hypothesis.

Source: own processing

The p-value is 0.374, which indicates that there is insufficient evidence to reject the null hypothesis. Therefore, there is no statistically significant difference

between the performance of assets before and after the implementation of the directive.



Source: own processing

Figure 1. Distribution of differences in ROA performance

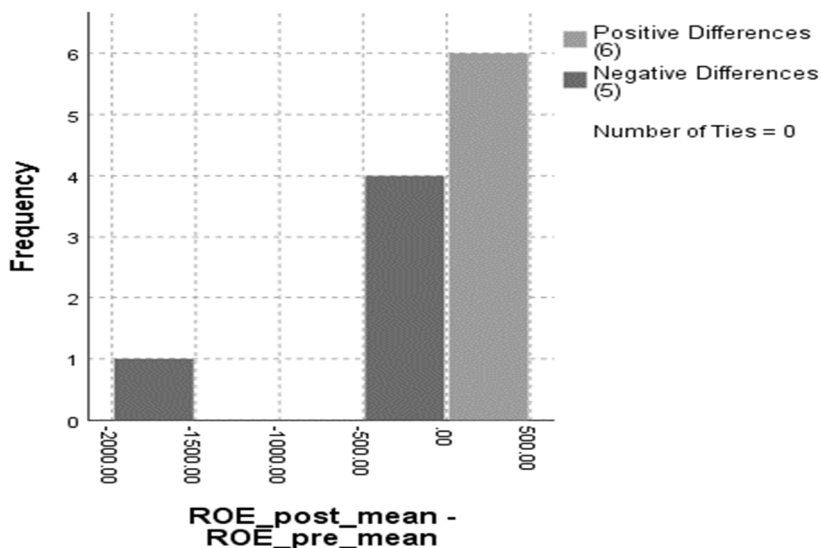
There were 7 positive and 4 negative differences, suggesting a slight individual improvement trend for most companies, but insufficient to generate a significant result at the sample level. These results show that, although there are certain individual variations in the ROA performance of the companies in the sample, they are not significant enough to indicate a widespread change caused by the implementation of the directive. Therefore, overall, there is no statistical evidence that the EU directive had a significant impact on the ROA of the companies analyzed.

Table 4. Hypothesis test for ROE

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between ROE_pre_mean and ROE_post_mean equals 0.	Related-Samples Wilcoxon Signed Rank Test	.594	Retain the null hypothesis.

Source: own processing

A p-value of 0.594 also indicates the absence of a statistically significant difference between the periods.



Source: own processing

Figure 2. Distribution of differences in ROE performance

The distribution of differences is relatively balanced, with 6 positive differences and 5 negative differences. Despite some individual changes in ROE for the companies in the sample, these are not consistently significant at the group level. The relatively balanced distribution of positive and negative differences suggests that there is no clear trend or uniform influence of the directive on the companies' return on equity performance.

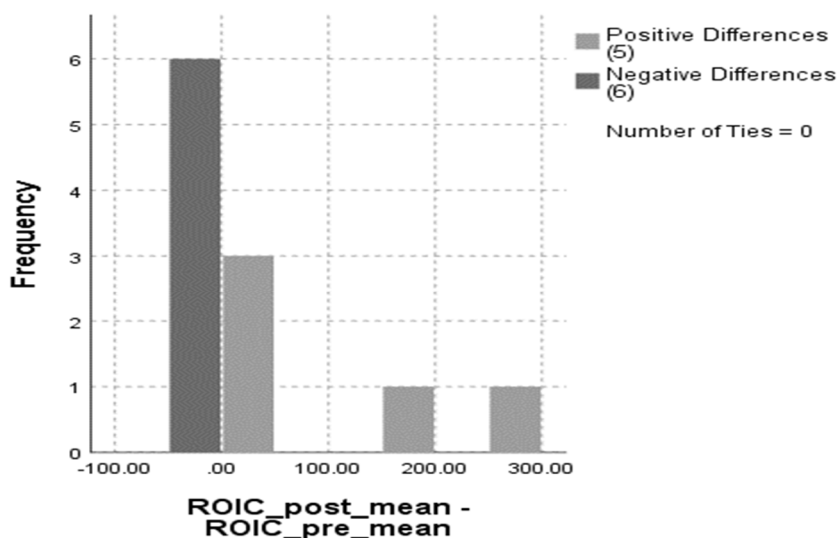
These findings indicate that, although some companies may have gained or lost as a result of the directive's implementation, the overall effect on ROE is not significant. This may suggest that other external or internal factors could have a greater impact on ROE than the implementation of the directive itself.

Table 5. Hypothesis test for ROI

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between ROIC_pre_mean and ROIC_post_mean equals 0.	Related-Samples Wilcoxon Signed Rank Test	.722	Retain the null hypothesis.

Source: own processing

The high p-value suggests that, overall, the implementation of the directive did not have a significant impact on the ROIC values of the companies examined. This may mean that, despite possible operational or strategic changes imposed by the directive, these did not significantly reflect in the return on invested capital across the entire sample of companies.



Source: own processing

Figure 3. Distribution of differences in ROIC performance

The nearly equal distribution between positive and negative differences shows that the effect of the directive on ROIC varied from company to company. Some experienced improvements, while others saw declines, but none of these effects were consistent or large enough to produce a statistically significant change at the group level.

Therefore, the analysis of means, normality tests, and the Wilcoxon test suggests that, while improvements in ROA and stabilizations in ROIC are observed after the implementation of Directive 2014/95/EU, these changes are not supported by statistically significant differences. Moreover, the high variability in financial performance between companies and the presence of extreme losses in the case of ROE suggest that the effects of the directive were heterogeneous and that adaptation to the new requirements varied significantly across organizations. Thus, the results indicate that Directive 2014/95/EU did not have a uniform and significant impact on the financial performance of companies in the oil and gas sector, at least in the short and medium term, and other external or internal variables may play a determining role in the dynamics of performance.

5. CONCLUSIONS

The impact of Directive 2014/95/EU on the financial performance of companies has been widely debated in the literature. Some studies suggest that the implementation of non-financial reporting can lead to greater transparency and, implicitly, an improvement in financial performance. For instance, research indicates that integrating sustainability information into corporate strategies can have positive effects on financial indicators such as return on assets and return on equity. However, other studies highlight that the effects of the directive may vary depending on the industry and the companies' ability to adapt to the new reporting requirements. In particular, in industries with a significant environmental impact, such as the oil and gas sector, companies may face challenges in effectively implementing non-financial reporting, which could negatively affect their financial performance.

The present study, focused on oil and gas companies listed on Euronext, aimed to assess the impact of Directive 2014/95/EU on financial performance, using a three-stage methodological approach. The results obtained indicate a slight improvement in ROA and stabilization of ROIC in the post-directive period, suggesting increased operational efficiency. However, ROE showed a significant deterioration, reflecting higher volatility and potential increased financial risks. Statistical tests did not reveal significant differences between the periods analyzed, suggesting that the impact of the directive on financial performance is not uniform and may be influenced by sector-specific factors and the companies' individual capacity to integrate non-financial reporting requirements. These findings highlight the complexity of the relationship between sustainability regulations and financial performance, emphasizing the need for tailored approaches and the strategic integration of non-financial reporting to maximize the potential benefits of the directive.

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GAMIFICATION MEETS AI: EXPLORING SYNERGISTIC TECHNOLOGIES FOR CYBERSECURITY EDUCATION IN BUSINESS SCHOOLS

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Abstract

The growing complexity of cybersecurity threats and countermeasures, combined with the low awareness on this topic, demands innovative approaches to education and training. Recent literature highlights the potential of gamification and artificial intelligence (AI) to enhance learner engagement and knowledge retention in the field of cybersecurity. This article offers a critical review of current applications of AI and gamification in cybersecurity education, with a focus on university-level teaching.

Building upon this theoretical foundation, the study explores students' and experts' perceptions of AI and gamification use, aiming to contribute to a better understanding of how emerging technologies can enhance motivation and engagement in cybersecurity education. The insights obtained through a mixed-methods approach may support the development of more engaging and relevant cybersecurity higher education practices.

Keywords: *gamification; cybersecurity; artificial intelligence; higher education; motivation.*

JEL Classification: I23; M15; D83.

1. INTRODUCTION

Last decade's technology evolution has impacted students' educational process, and their connection to the labour market. Due to the rise of artificial intelligence (AI), expectations have changed regarding the knowledge needed to remain adaptable in a dynamic economy and job market. Moreover, the continuous escalation of cybersecurity threats has made specialists in this field a critical asset in both public and private sectors (European Union Agency for Cybersecurity (ENISA), 2023), and created a steady demand for workforce in the sector (Tummala and Bottomley, 2024; Maennel and Maennel, 2024). The United

States already has a shortage of 265,000 security professionals in 2025 (Fourrage, 2025). CyberSeek shows that in 2024, only 83% of security jobs are filled in the United States (Dice Staff, 2024). According to a 2024 report by the World Economic Forum, the global cybersecurity industry needs 4 million specialists in order to fill the growing workforce gap (Meineke, 2024). Recent studies have shown that cybersecurity job growth is expected to reach 33% between 2023 and 2033 (Kelly, 2025).

According to IBM, information security is *the protection of important information from unauthorized access, use, disclosure, modification, or disruption*. This protection applies to all types of information assets, including digital files, paper documents, physical storage media, and verbal communications. Across the entire data lifecycle, information security (InfoSec) addresses infrastructure, software, testing, auditing, and archiving (Holdsworth and Kosinski, 2024).

Often, the term InfoSec (the abbreviation used for information security) is used interchangeably with CyberSec (the abbreviation used for cybersecurity). This is due to a simple confusion or a partial overlap of the two concepts. Information security is defined as guaranteeing and maintaining the confidentiality, integrity and availability of information (Taherdoost, 2022). Cybersecurity refers to *the protection of exclusively digital information systems* (Merriam-Webster, 2025).

The demand for qualified professionals in information security is linked to the level of awareness regarding the importance of information assets' protection. According to (Scholl, 2023), information security awareness should be regarded as an integral component of any organization, as it serves as a foundational requirement for effective information security management and for its operationalization. Creating awareness in any field is not an easy task, especially for higher-education students. Low motivation is a major factor in the limited engagement with security-related content, which is consistent with the general trend among students. To address this emerging issue, educational institutions are increasing their efforts to implement innovative teaching strategies to enhance student engagement and motivation.

One solution that has been studied extensively in recent years is gamification as a pedagogical instrument, aimed at making learning more engaging and fun. Gamification has proven particularly effective in higher education by combining theoretical concepts with real-life applications through immersive, scenario-based learning. Incorporating elements such as leaderboards, collaborative tasks and post-activity debriefings, gamified experiences foster student engagement and encourage active learning (Christopoulos and Mystakidis, 2023; Zourmpakis *et al.*, 2023).

The Cambridge Dictionary defines gamification as *the practice of transforming activities so that they resemble games, to make them more attractive*

and increase participant engagement (Cambridge Dictionary, 2025). Gamification refers, broadly speaking, to technological, economic, cultural and social developments, through which reality becomes more similar to a game, allowing for greater accumulation of skills, motivational benefits, creativity, involvement and, in general, happiness and constructive development (Hamari, 2019).

Recent meta-analysis studies show that gamification can significantly impact academic performance. Li *et al.* (2023) examined 41 studies in this field (with 5071 participants) and concluded that gamified instructional strategies can substantially enhance student learning outcomes in higher education. Another study focusing on the Kahoot! platform confirmed a moderately positive effect on academic performance, based on a meta-analysis of 43 empirical studies related to gamification (Özdemir, 2025).

In 2024, Zeng *et al.* (2024) conducted a meta-analysis on gamification in education, which investigated 22 experimental studies, carried out between 2008 and 2023. Using a random-effects model, the findings indicated that gamification had a moderately positive impact on student's academic achievement, providing valuable insights regarding the selection and utilization of the right game design elements.

Another obvious and relevant solution is the use of AI, which could contribute to increased engagement and motivation among students, if implemented correctly (Zourmpakis *et al.*, 2023; Lee *et al.*, 2024). Britannica defines AI as the ability of a digital computer to perform tasks commonly associated with intelligent beings (Copeland, 2025).

According to Robert Jenay, the higher education community is optimistic about the role of AI in teaching and learning: the survey they conducted shows that out of 730 respondents, 69% of them expect AI to be increasingly used for learning analytics, while 68% and 66% believe it will improve accessibility for students and faculty (Robert, 2024). Regarding motivation and engagement, AI has been shown to enable their enhancement, by offering personalized learning experiences, providing immediate feedback and fostering a supportive environment where learners feel more confident and less anxious (Batista *et al.*, 2024).

2. THE SYNERGETIC USE OF AI AND GAMIFICATION IN TEACHING AND LEARNING CYBERSECURITY

The *integration of AI in cybersecurity courses and trainings* represents an emerging approach, offering new possibilities for innovation in the educational system. Dwight (2023) proposes a scenario-based tabletop exercise (TTX) focused on cybercrime as an active learning method for students in the field of cybersecurity. The approach is based on the NIST Test, Training, and Exercise methodology and involves collaboration with industry professionals. It aims to

enhance students' practical skills while offering professionals an effective way to contribute to education, even with limited resources. The author also suggests the use of generative AI to assist in drafting the documentation required for TTX exercises. Given the increasing complexity of cybersecurity, Maennel and Maennel (2024) propose an integrated human-AI training model for exercises such as blue/red teaming, simulations, tabletop, and capture-the-flag. The model combines AI, learning analytics, and pedagogy to enhance cybersecurity education. It aims to teach learners how to collaborate with AI, detect misuse, and leverage AI tools, especially for analysing learning data. The authors show that multimodal analytics (e.g., facial recognition, eye-tracking) help transform raw data into insights on learning, retention, and behaviour, enabling personalized paths and real-time feedback. Won *et al.* (2024) present an innovative approach implemented during a summer camp intended to spark U.S.' high school students' interest in cybersecurity. The organizers used radio-controlled autonomous cars to integrate cybersecurity and AI concepts through hands-on activities and interactive projects. Students strengthen their technical skills and build confidence by training AI models for the cars or simulating cyberattacks. Pre- and post-camp surveys show a clear increase in students' interest and self-efficacy in computing, cybersecurity, and AI, encouraging early engagement with STEM careers.

Recent studies suggest that *combining AI and gamification* can enhance the quality of teaching and learning in higher education. The fusion of AI's adaptive capabilities with gamification's motivational mechanics can transform passive learning environments into interactive educational systems (Limonova *et al.*, 2023). Their study also highlights the time needed for teachers and professors to adapt to the new approaches, underlining the importance of continuous professional development, institutional support, and pedagogical training to ensure effective integration of AI and gamification into existing curriculum.

According to (Arteaga and Granados Guzmán, 2024), the combination of AI content with gamified narratives and storytelling can improve the overall experience of students. Escape rooms or quizzes integrated into platforms like Genially, Canva, Blooket and Quizizz, support personalized learning through instant feedback and positive competition, and offer engaging experiences that improve understanding and retention among students.

Besides already existing applications where gamification and AI can be integrated, researchers also explored the possibility of creating new and personalized platforms for students. Regarding this topic, Tan and Cheah, (2021) present an AI-enabled, gamified online learning application designed to enhance interactivity, personalize content, and maintain student engagement over time. They integrated AI algorithms and gamification elements into the app, the results indicating improvement in user satisfaction and engagement, but also in knowledge retention and learning effectiveness.

Zia and Noor (2024) argue that both gamification and AI can lead to improved educational outcomes, by making learning more interactive, customized and engaging for students. Their study highlights that AI's capabilities, combined with game elements, such as points, badges, leaderboards and challenges, can generate dynamic learning experiences.

An explicit use of AI in gamified learning systems is presented in the article "Developing a gamified AI-enabled online learning application to improve students' perception of university physics" (Tan and Cheah, 2021). The authors have implemented an AI mechanism that can analyse student behaviour and performance to adjust game mechanics, such as difficulty levels, rewards, and pacing. The results showed that most participants expressed willingness to use the tool, they believed that it could increase engagement among students, with 92% of them agreeing that it encouraged them to persist, even if they felt uncertain or stuck.

In 2023, Yang *et al.* (2023) conducted an experiment with 53 participants: 18 and 19 from two experimental groups and 16 from the control group. The experimental groups included students who interacted with an AI gamified model, while the control group was taught with traditional practices. The results show that the gamified AI model significantly improved students' learning outcomes, motivation, flow experience, problem-solving tendency, and reduced the cognitive load of learning, compared with the control group.

Beuran *et al.* (2023) discuss two AI-driven applications in cybersecurity education and training - a field that, compared to domains like threat detection or risk prediction, has received limited attention from an AI perspective. First, they introduce the AutoPentest-DRL framework, which employs Deep Reinforcement Learning to automate penetration testing, supporting the hands-on study of offensive security techniques. Second, the CyATP platform applies Natural Language Generation to create cybersecurity awareness content automatically, using sources such as Wikipedia and DBpedia. The platform integrates gamified learning tools, including quizzes and crossword puzzles, to engage non-technical users in foundational cybersecurity concepts.

As presented above, combining AI and gamification can create a powerful tool for increasing student engagement, enhancing motivation, and creating meaningful learning experiences. Still, the synergy between these two strategies has been documented in few literature articles and is still in its early stages of academic exploration.

To address that gap, our article proposes an investigation of both students' and professionals' perspectives on the implementation of AI and gamification (either separately or in combination) within university-level education and professional/organizational contexts, respectively.

3. RESEARCH DESIGN AND METHODOLOGY

For our study we used a mixed research approach, combining quantitative and qualitative techniques. For the quantitative component, we applied a Google Forms survey among students enrolled in information security courses at the Faculty of Economics and Business Administration, Alexandru Ioan Cuza University of Iași, Romania, and cybersecurity specialists. The Likert-scale items refer to the perceived utility of AI, gamification and combined elements introduced in teaching or learning techniques. We defined utility as the capacity to contribute to a better understanding of the content, the improvement of practical skills, increased student engagement, and the alignment of the course with current industry requirements. The scale used in the survey ranged from 1 to 5 (not at all useful, slightly useful, moderately useful, useful, very useful).

The items evaluated are:

- **For AI:** Study Unit: Introduction to AI; Study Unit: Fundamentals of Machine Learning (ML); Study Unit: Applications of AI and ML in Cybersecurity; Study Unit: Ethical and Social Implications of AI; Project: AI Solutions in Cybersecurity; AI Assistance in the Discussion of Cybersecurity Scenarios; Capture-the-Flag activities, defence simulations, blue/red team exercises in hybrid (human-AI) teams; Use of an educational chatbot to answer course content-related questions; Automated generation of test questions based on course materials; Automatic detection of AI-generated content in student projects – as identified in (Dwight 2023; Maennel and Maennel, 2024; Tummala and Bottomley, 2024).
- **For gamification:** Progress tracking elements (progress bar/circle, checklist, roadmap, timeline, etc.); Rewards (badges, trophies, medals, certificates, other benefits, etc.); Points; Avatars; Stories/Narratives/Scenarios; Leaderboards. These elements were chosen based on the literature review, taking into consideration the most known, used and trending ones;
- **For AI and gamification combined:** Use of applications/platforms that combine AI and gamification during teaching sessions; Automatic creation of personalized gamified activities for each student using AI; Adjustment of difficulty level, tasks, or rewards based on students' performance, automatically analysed by an AI system.

In the qualitative component of the study, an open question was meant to reveal the respondents' own perspective on the preferred AI/gamification/both elements to be used in their learning endeavour. By providing an answer to the question ("*Propose ways in which AI and gamification could be incorporated (separately and/or together) into course and seminar/laboratory activities for cybersecurity/information security subjects (university level)*"), participants were encouraged to reflect upon the innovative ways of teaching and learning. Their

responses offer insight into emerging trends, personal preferences regarding learning and teaching processes, and highlight potential implementation strategies.

The survey was addressed to: (1) undergraduate students who pursued information security courses and laboratories, and (2) specialists in the information security field.

- (1) The students were enrolled in one of two specializations within the Faculty of Economics and Business Administration at Alexandru Ioan Cuza University of Iași: Accounting and Management Information Systems (2nd year) and Economic Informatics (3rd year). Both specializations include courses in information security: Protection and Security of Information Systems (for the former) and Information Systems' Security (for the latter).
- (2) The specialists are professionals with information and cyber-security backgrounds, currently working in the private and/or academic sectors. They hold roles such as Software Solution Manager, Legal Advisor, Ethical Hacker, and Cybersecurity Consultant, with experience ranging from 1 to 20 years.

The survey was distributed to all students enrolled in the two previously mentioned specializations. The participation was voluntary, and the survey was made available via the institutional Microsoft Teams platform. It was also briefly introduced during the course sessions, with the goal of inviting them to respond. There was no restrictive selection criteria applied. The nature of the recruitment process (non-random and based on accessibility) classifies the sample as a convenience sample. Even though it is not statistically representative of a broader population, it offers relevant perspectives within the context of students studying information security in business-related programs at the undergraduate level. Regarding the information security specialists, they did not disclose their institutional affiliations.

We had a total of 149 students who responded to the survey, while only 4 specialists participated.

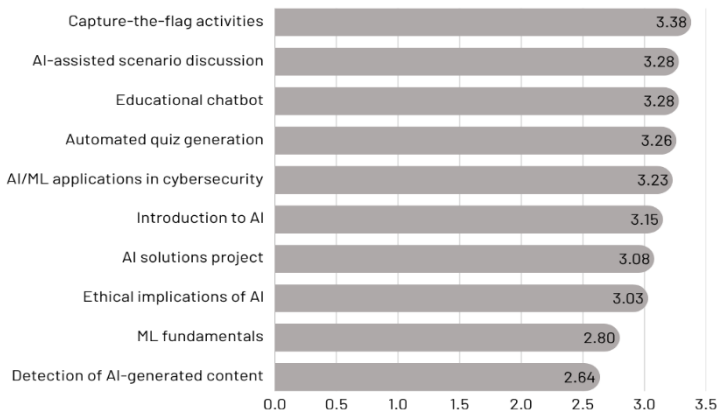
4. RESULTS AND DISCUSSION

This section presents the results of both quantitative and qualitative analyses, based on the responses gathered through surveys administered to students and specialists survey. For the quantitative part, we recoded the data from 0 to 4 for the purpose of statistical processing in Microsoft Excel. This technique did not affect the interpretation of the results.

To explore their preferences and perceptions, mean scores were calculated for each item, and open-ended responses were thematically analysed.

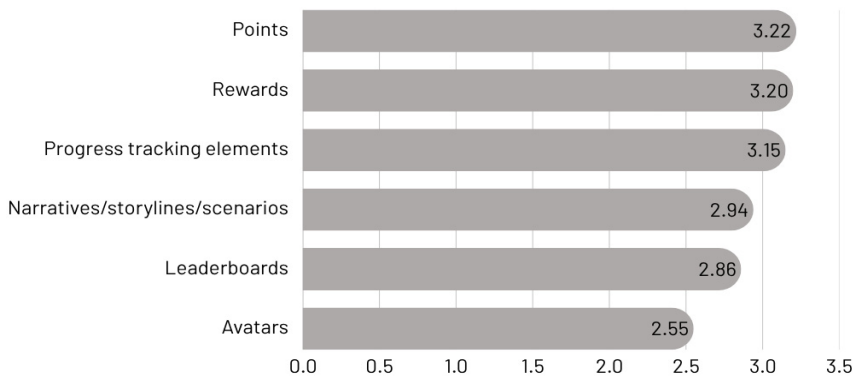
4.1. Quantitative analysis of survey results

The most appreciated AI-supported learning activity was the Capture-the-Flag exercise, with a mean score of 3.38, followed by AI-assisted scenarios and the use of educational chatbots, both scoring 3.28 (Figure 1). These results possibly suggest a strong preference for interactive and applied activities. Automated test generation (3.26), AI-supported cybersecurity activities (3.23), and general AI topics (3.15) were also positively received. In contrast, items such as machine learning fundamentals (2.80) and AI-generated content detection in student work (2.64) were rated lower, possibly due to perceived complexity or concerns over control and surveillance (Figure 1).



Source: own representation

Figure 1. Students' perceived utility of AI elements



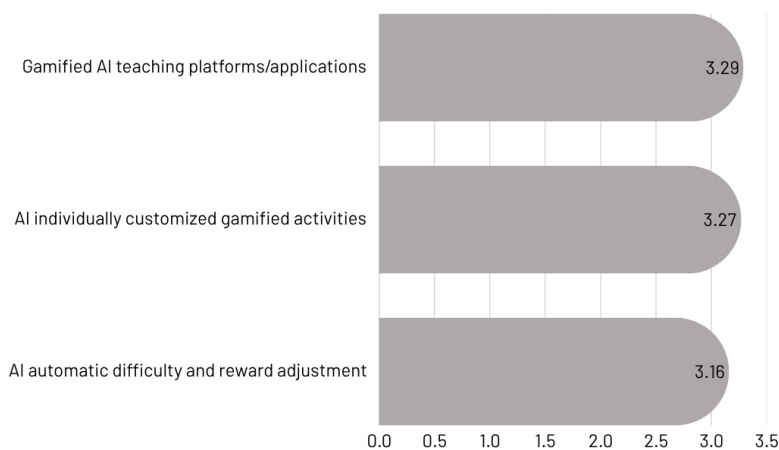
Source: own representation

Figure 2. Students' perceived utility of gamification elements

When evaluating classical gamification elements, students gave the highest scores to points (3.22), rewards (3.20 – e.g., badges, trophies, certificates), and progress tracking systems (3.15) (Figure 2). These findings reflect continued appreciation for traditional motivational mechanisms based on clear feedback and progress. Elements like avatars (2.55) and leaderboards (2.86) received the lowest ratings, suggesting that personalization and competitive ranking are less motivating in this context. Narrative elements such as storylines and scenarios were rated slightly above average (2.94), indicating a moderate interest in contextualized learning (Figure 2).

Students expressed particularly positive views toward the integration of AI into gamified educational platforms. Gamified AI-based teaching systems received the highest rating (3.29), followed by automatically personalized activities (3.27) and adaptive adjustments of difficulty and rewards (3.16) (Figure 3). This highlights a clear preference for systems that combine intelligent automation with motivational design, offering both personalization and engagement.

Overall, the results show a consistent pattern: students value educational tools that enhance interactivity, personalization, and adaptability. Traditional elements such as points and rewards remain relevant, while features perceived as symbolic or non-functional tend to be rated lower. These insights may support the development of future AI-enhanced gamification strategies tailored to learners' actual preferences.

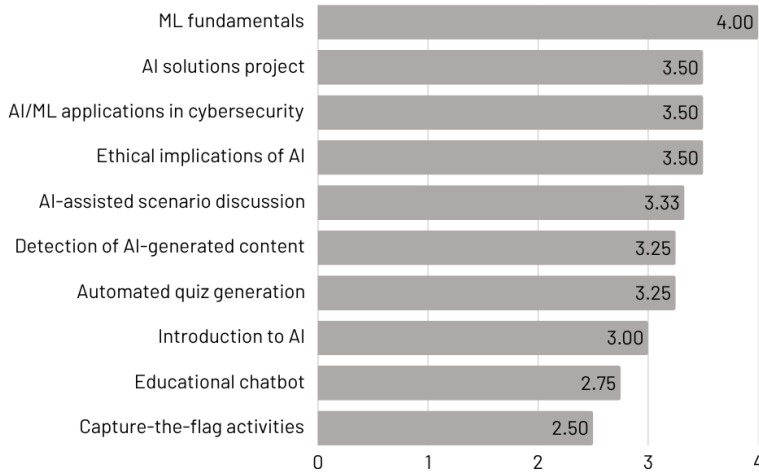


Source: own representation

Figure 3. Students' perceived utility of AI and gamification elements

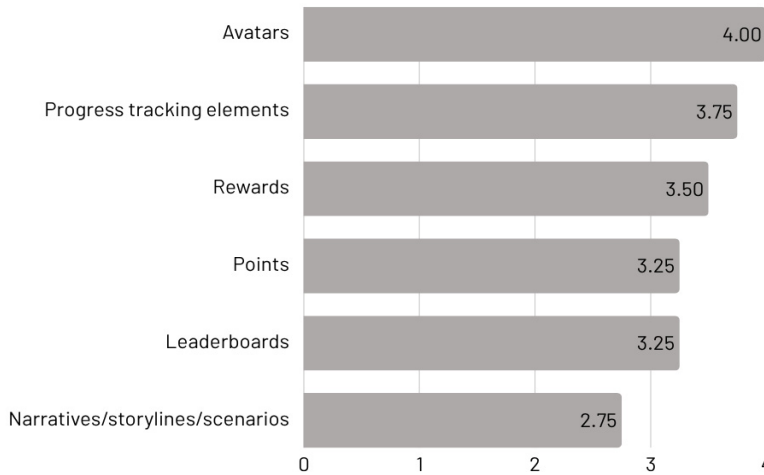
The responses provided by cybersecurity specialists offer an alternative perspective on the perceived utility of AI and gamification elements in education.

Like students, specialists evaluated each item on a scale from 0 to 4, and the results are represented using bar charts.



Source: own representation

Figure 4. Specialists' perceived utility of AI elements



Source: own representation

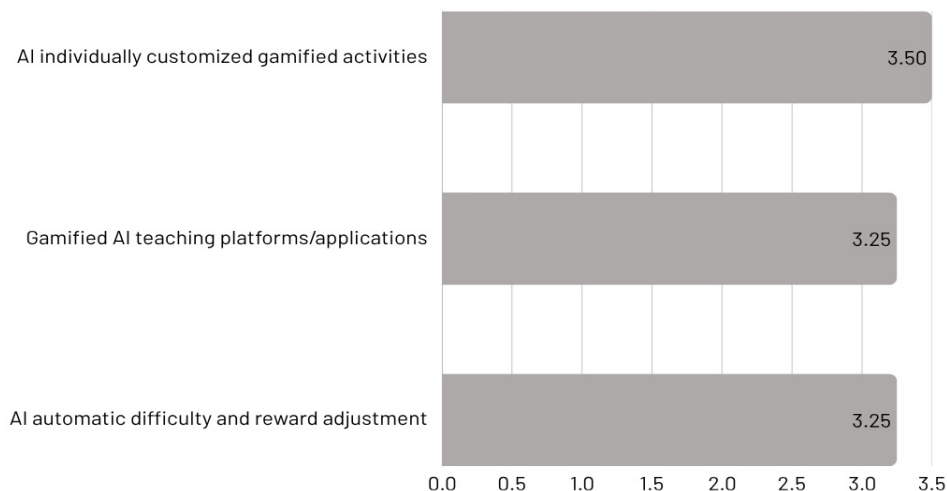
Figure 5. Specialists perceived utility of gamification elements

In terms of AI-related educational elements, the highest rating was given to machine learning fundamentals, which received a perfect score of 4.00 (Figure 4). AI solutions projects, ethical implications of AI, and AI/ML applications in

cybersecurity were also highly appreciated, each with an average score of 3.50. These results reflect a strong alignment with the specialists' technical background and their interest in ethical and applied aspects of AI. Other elements such as AI-assisted scenario discussions and automated content detection received moderate scores (Figure 4). Interestingly, Capture-the-Flag activities, which were rated highest by students, received the lowest rating among specialists (2.50), suggesting different priorities in evaluating practical applications.

When it comes to traditional gamification components, avatars received the highest score (4.00), followed by progress tracking elements (3.75), and rewards (3.50) (Figure 5). This indicates that specialists may value personalization and structured feedback systems more than students. Points and leaderboards were both rated at 3.25, while narratives and storylines received the lowest score (2.75), reinforcing a lower perceived relevance for narrative-driven learning among this group (Figure 5).

In terms of AI-supported gamification, specialists rated individually customized gamified activities highest (3.50), followed by AI-based teaching platforms and adaptive difficulty/reward systems, both at 3.25 (Figure 6). These results confirm that experts recognize the potential of AI to personalize and optimize the learning process through gamified elements, although their enthusiasm appears more tempered compared to student responses.



Source: own representation

Figure 6. Specialists perceived utility of AI and gamification elements

Overall, the results suggest that specialists place greater emphasis on foundational AI concepts, personalization, and structured feedback mechanisms.

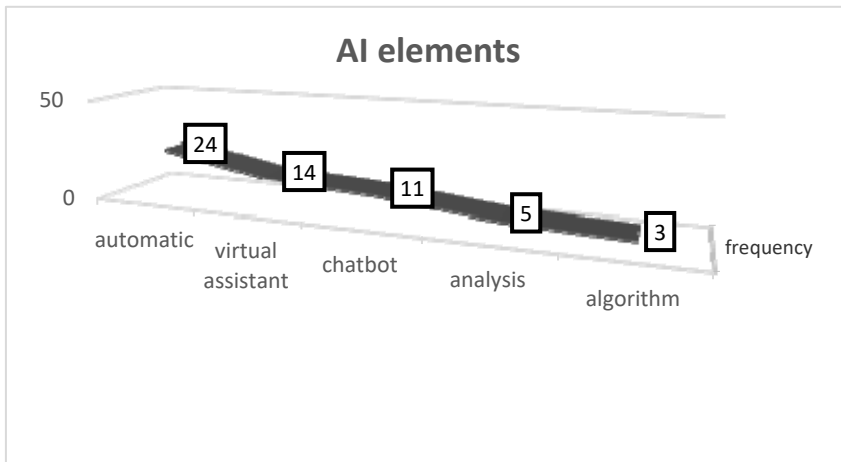
While they acknowledge the value of gamification and adaptive systems, their preferences are shaped by practical, technical, and ethical considerations rather than by interactivity or game-like experiences alone.

4.2. Key themes identified in qualitative responses

To gain a more detailed understanding of the thematic directions proposed by students, three charts were developed to synthesize the frequency of key terms extracted from open-ended responses. These terms were grouped into three categories: AI elements, gamification elements, and areas or activities within the field of information security where students would like to see these elements implemented, either separately or in combination.

The most frequently mentioned terms related to AI were “automatic/automation” (n = 24), “virtual assistant” (n = 14), and “chatbot” (n = 11) (Figure 7). This reflects a strong interest in interactive and automated tools that could support the learning process. Although the term “artificial intelligence” appeared 57 times in the responses, it was excluded from the chart due to its overly general usage, which would not contribute meaningfully to the analysis (Figure 7).

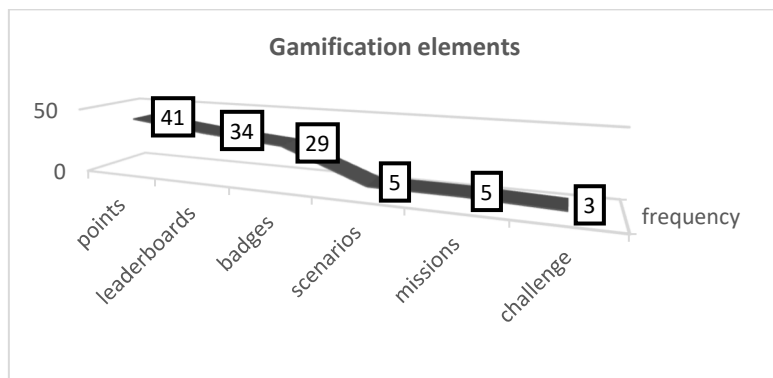
The emphasis on assistants and chatbots suggests a desire for continuous, on-demand support during the learning process. Moreover, the frequent reference to automation implies that students value efficiency and responsiveness in how content is delivered and personalized.



Source: own representation

Figure 7. Frequency of AI-related terms used by students

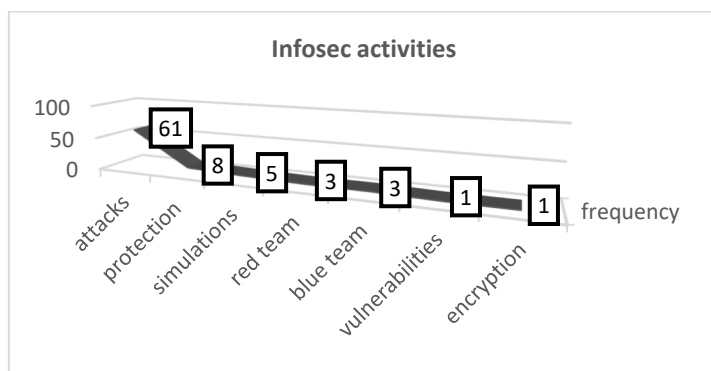
Gamification-related terms were dominated by familiar mechanics such as “points” (n = 41), “leaderboards” (n = 34), and “badges” (n = 29) (Figure 8). These terms suggest that students are used to reward and progress tracking systems and perceive them as helpful for maintaining engagement and motivation. Similar to the case of AI, the word “gamification” was mentioned frequently (n = 88) but was intentionally omitted from the visualization (Figure 8).



Source: own representation

Figure 8. Frequency of gamification-related terms used by students

In terms of security-focused activities, students showed a clear inclination toward practical scenarios. The term “attacks” was by far the most mentioned (n = 61), followed by “protection” (n = 8), “simulation” (n = 5), “red/blue team” (n = 6), and less frequently “vulnerabilities” and “encryption” (n = 1 each) (Figure 9). This suggests a desire to see both AI and gamified approaches applied to realistic, scenario-based cybersecurity education.



Source: own representation

Figure 9. Frequency of gamification-related terms used by students

In their open responses, students often linked gamification to mechanisms such as points, leaderboards, badges, missions, and scenarios. These tools were seen as means of tracking progress, staying motivated, and receiving rewards.

AI was frequently described as a valuable tool for personalized learning. Students mentioned the usefulness of chatbots and virtual assistants to answer questions at any time, underlining AI's potential to provide immediate feedback and ongoing support.

The combination of AI and gamification was one of the most referenced ideas in the responses. Approximately 100 out of 149 answers made simultaneous mention of both, indicating high interest and expectations regarding their integration into university-level cybersecurity education.

Overall, most responses reflect a desire for a more practice-oriented, interactive, and engaging learning process, enabled either by gamification, AI, or an integration of both.

Specialists have proposed a series of pedagogical innovations that combine AI with gamification strategies to enhance cybersecurity education at the university level. These proposals can be categorized into four primary thematic areas:

1. AI supported scenario development

Experts suggest leveraging AI, particularly large language models (LLMs), to assist instructors in designing complex, realistic cybersecurity scenarios. These include the generation of vulnerable code, the creation of adaptive challenges for laboratory exercises, and the development of competition-style environments tailored to student skill levels.

2. Gamified reward and motivation systems

Specialists advocate for the integration of gamification elements such as point-based systems and digital badges (e.g., "Ethical Hacker") to reinforce student motivation. These systems are intended to recognize progress and performance, fostering sustained engagement through virtual rewards and performance-based feedback mechanisms.

3. Interactive and role-based learning activities

A key proposal involves the use of interactive platforms (most notably Capture the Flag (CTF) environments) and the implementation of structured team-based games. In these activities, students assume defined roles such as attackers or defenders, simulating real-world cybersecurity operations in a collaborative learning context.

4. AI driven cyberattack simulations

Finally, specialists recommend using AI to simulate various types of cyber threats, including phishing attacks, malware propagation, and distributed denial-of-service (DDoS) scenarios. These simulations aim to expose students to realistic threat conditions and improve their ability to detect, analyse, and respond to cyber incidents.

5. LIMITATIONS

While the study provides valuable insights into the integration of AI and gamification in cybersecurity education, several limitations should be noted.

The number of specialist respondents was low, which narrows the range of expert perspectives represented in the analysis. Additionally, the study did not include empirical validation of the proposed methods, relying instead on participant feedback and perceived usefulness.

Among the surveyed students, the response rate was approximately 70%, indicating a satisfactory level of engagement but leaving room for potential response bias.

The design of the survey may have also influenced the nature of the qualitative data: since participants were first presented with Likert-scale questions rating the utility of specific AI and gamification elements, their subsequent open-ended responses may have reflected those predefined examples rather than introducing entirely original ideas. As a result, the creative scope of some responses may have been limited by the structure of the survey itself.

6. CONCLUSIONS

The findings of this study highlight a clear preference among students for educational technologies that combine adaptive, personalized support with motivational structures derived from gamification. Quantitative results show that both AI-enhanced tools and classical gamification elements are perceived as valuable, especially when they contribute directly to learning outcomes and engagement. While students showed strong enthusiasm for interactive elements like chatbots, simulations, and AI-assisted tasks, more symbolic features such as avatars or leaderboards were viewed as less effective.

In contrast, specialists emphasized foundational AI knowledge, structured feedback, and personalization, placing less importance on interactive or game-like experiences. This divergence may reflect their more practical and professional orientation, grounded in technical and ethical considerations.

The qualitative data reinforced these insights, revealing recurring references to automation, virtual assistance, and familiar gamification mechanisms. Students recognized the utility of these tools and expressed a desire for their integration into realistic cybersecurity training scenarios.

Overall, the results support the potential of integrating AI and gamification into higher education, especially in fields such as information security, where practice-oriented and dynamic learning environments are essential. Future implementations should focus on balancing personalized automation with engaging motivational elements, aligning technological innovation with pedagogical value.

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THE IMPACT OF AI TECHNOLOGIES ON DYNAMICS AND RESTRUCTURING OF COMPANIES

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Abstract

Artificial intelligence, as a tool for creating the functionality of the European Union market, has a major impact on the way societies, economies and organizations operate. Accelerated digitalization favors the implementation of artificial intelligence in the operational processes of companies. Through the capacity to process data and automate complex processes, artificial intelligence becomes a strategic tool that contributes to increasing efficiency, reducing costs and increasing the decision-making process at the company level.

The purpose of this study is to analyze how the technologies adopted by companies influence their productivity but also the consolidation and strategic repositioning of companies through involvement in mergers and security operations. The study takes into account for the period 2021-2024 companies with at least 250 employees from European Union member countries. The impact of adopting technologies in data analysis, marketing or sales, production and logistics process, spoken language conversion, object identification based on images, ICT security is analyzed.

Beyond the influence of these variables, there are reservations in adopting artificial intelligence motivated by too high costs, incompatibility with existing equipment, ethical considerations, data availability, lack of expertise and clarity of legal consequences.

Keywords: *artificial intelligence; digital technologies; mergers and acquisitions; European Union.*

JEL Classification: G34; O33.

1. INTRODUCTION

Accelerated technology development with the development of systems capable of performing tasks attributed to human intelligence has given Artificial Intelligence (AI) a transformative role in the business environment, acting as a catalyst for innovation, operational efficiency and competitive advantage. Analyzing complex data, identifying patterns or generating predictions provides added efficiency, accuracy and speed, essential elements for achieving business success.

Artificial intelligence is redefining growth and competitiveness strategies with a direct impact on merger and acquisition (M&A) decisions, from evaluating target companies to predicting the synergy obtained.

The purpose of the research is to explore how the use of artificial intelligence in different processes of companies in the European Union affects the production of mergers and acquisitions operations and conditions in the period 2021-2024. The set of variables reflects the level of integration of intelligent technologies in the organizational activities of companies with at least 250 employees and their capacity for innovation, emphasizing the use of AI for data analysis, written language; workflow automation, recognition of objects or people in images; use of AI in logistics, marketing and sales, production process and IT security.

However, many companies in the European Union are not adopting artificial intelligence for various reasons, which from one year to the next have led more and more companies to abandon AI technologies (Figure1). Despite the transformative potential of artificial intelligence, companies that do not adopt these technologies raise questions about the barriers and perceptions that are holding back digital transformation. The reasons for companies not adopting AI are perceived costs as too high, being considered inaccessible investments, lack of relevant internal expertise for the integration process, incompatibility with existing equipment or systems, problems with data quality and accessibility, their protection and confidentiality, along with ambiguities regarding the legal consequences of using AI.

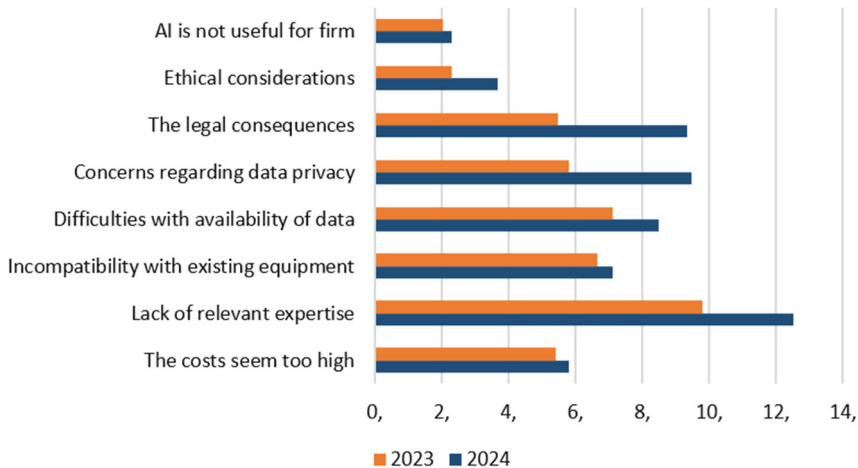


Figure 1. Reasons for non-adoption of AI by EU27 companies with at least 250 employees

These barriers can be reduced by government support for digitalization and training, providing subsidies to stimulate AI adoption, modernizing IT

infrastructure and including clear data protection standards. Bridging the gap between technology and perceived applicability by companies, as well as collaboration between the public, private and academic sectors, is essential to unlocking the full potential of AI.

The study contributes to economic literature by exploring an important current topic, less addressed in the evolution of mergers and acquisitions and more in the involvement of AI in the due diligence process.

As companies seek to gain competitive advantage, the integration of AI becomes a differentiating factor, which also influences the attractiveness of companies for M&A.

The study outlines a quantitative perspective on the impact of AI on the evolution of M&A transactions in European Union countries, which can be a support in making managerial and investment decisions for companies.

As a structure, the paper begins in the first section with the analysis of the specialized literature and the synthesis of the most relevant ideas. The second section develops the data and methodology used in the study, namely panel data for 18 European Union countries, analyzed between 2021-2024 using the Ordinary Least Square (OLS) method in the econometric software EViews. The third section highlights the research results and discussions, followed by conclusions, research limitations, and future research directions.

2. LITERATURE REVIEW

The literature on mergers and acquisitions has traditionally focused on financial and governance factors that determine transaction success.

Recent studies define mergers and acquisitions as those operations through which the assets of one company are transferred to another, with distribution of shares to the shareholders of the target company (Bilteanu and Stancu, 2024). Synergy occurs when the overall performance of the new company is superior to the separate individual performances. Chiriac *et al.* (2024) consider mergers and acquisitions a rapid reorganization strategy in order to acquire superior management to enter new markets, to acquire already trained employees, to share risks and to reduce the financial effort. In line with this perspective, the approach to mergers and acquisitions from the study conducted by Herghiligiu *et al.* (2024) is also found, which adds that mergers and acquisitions consolidate the financial position and determine the amplification of the company's value to correct the negative results obtained at a given time. Thus, the need for survival, protection, diversification of activity and increased sales appear as reasons for mergers and acquisitions. At the same time, Verma and Kumar (2024) argue that mergers and acquisitions are a normal phenomenon for developing countries and for large companies open to global trade for business expansion.

Opinions contrary to the above are found in the study by (Ilea *et al.*, 2024) who consider mergers as phenomena that create severe traumas leading to

behavioral and psychological problems of the staff, and to problems related to the adaptation of both the staff and the two companies. The complexity of transactions stems from the difficulties regarding the different perception of organizational culture and the takeover process, which limits the communication and sharing of valuable information for organizations. Similarly, Manole *et al.* (2024) consider that organizations undergo mergers and acquisitions that cause vulnerability and insecurity, threatening the identity of employees and their organizational belonging by changing organizational values and culture, while at the same time creating uncertainty related to achieving the company's well-being and performance.

Research in the field of artificial intelligence has gained momentum in recent times, with the increasing digitalization and technology adoption worldwide. Recent studies (Table 1) highlight that the integration of AI can transform business models by automating processes and increasing company efficiency.

Table 1. Synthesis of specialized literature on the impact of digitalization on M&A

Author	Year	Outcomes
Rien	2018	Managers should prepare organizations for the transition to AI by following Kotter's 8-step change model.
Gounopoulos <i>et al.</i>	2023	Companies that prioritize AI technologies tend to adopt more aggressive investment policies, driving mergers and acquisitions in a desire to build an empire.
Bedekar <i>et al.</i>	2024	By incorporating AI, the due diligence process becomes more efficient, more accurate and more strategic.
Cazzaro	2024	AI accelerates the closing of M&A transactions, facilitating the decision-making process regarding transaction structure and risk management.
Tokachichu, Kotha and Biyyala	2024	AI innovations reduce the difficulty of traditional mergers and acquisitions and create new sources of value. But investments in safety, cybersecurity and a professional workforce are needed.
Zhang <i>et al.</i>	2024	AI more precisely identifies successful synergistic combinations, considering important elements such as revenue growth rate, market capitalization/EBITDA ratio, and debt to equity.
Alghizzawi <i>et al.</i>	2025	AI highlights the importance of careful planning and strong leadership for post-merger integration to achieve real benefits from the M&A transaction.

As early as 2018, it was expected that the due diligence process in mergers and acquisitions would be fully or partially automated by 96% by 2028, as both manual and cognitive activities can be taken over by machines (Rien, 2018). The same process, due diligence, is significantly improved by artificial intelligence in

mergers and acquisitions deals by providing competitive advantage in a dynamic market. By incorporating AI, the process becomes more efficient, more accurate and more strategic, helping to assess financial health, compliance risks and strategic alignment. Thus, AI transforms due diligence into an essential tool for M&A success (Bedeckar *et al.*, 2024). Long processes can become more efficient throughout the life cycle of a transaction with the help of innovations (Kostas, 2022). AI accelerates M&A closings, facilitating decision-making on deal structure and risk management (Cazzaro, 2024). The AI-based process for M&A target selection and synergy prediction demonstrates superior predictive performance in identifying successful synergistic combinations compared to traditional target selection methods. Compared to traditional methods, the use of artificial intelligence provides better results in selecting M&A targets and predicting synergies. AI more accurately identifies successful synergistic combinations, considering important elements such as revenue growth rate, market capitalization/EBITDA ratio, and debt to equity. In addition, the integration of text-based features increases the accuracy of the model, allowing the assessment of qualitative elements of compatibility between firms (Zhang *et al.*, 2024).

Moving from the due diligence stage to the actual adoption of artificial intelligence in companies, it is found that the adoption of AI is still limited due to the diversity of data, the need for human communication and cultural resistance to change. Managers should prepare organizations for the transition to AI, following Kotter's 8-step change model, namely: urgent awareness among the team; building the change leadership team; developing the AI implementation strategy; clearly communicating the vision for the transformation; initiating concrete actions; generating short-term gains; accelerating progress and definitively establishing the change in the organization's culture (Rien, 2018). In the current merger and acquisition environment, which is undergoing a profound transformation, companies must adopt new technologies to remain competitive. Emerging technologies such as cloud ERP, artificial intelligence, blockchain and quantum computing make the financial integration process more efficient, more precise and more strategic. These innovations reduce the difficulty of traditional mergers and acquisitions and create new sources of value. In the future, technology will become an important factor in the success of mergers and acquisitions, reshaping the entire process. However, realizing this potential requires investments in safety, cybersecurity, a professional workforce and the application of best practices (Tokachichu *et al.*, 2024).

Less pleasant aspects of AI adoption refer to overinvestment or possible cyberattacks. Those companies that give high priority to AI technologies tend to adopt more aggressive investment policies, which drive mergers and acquisitions. Managers of these companies often engage in acquisitions out of a desire to build an empire, which can have a negative impact on shareholder wealth through

overinvestment. Effective corporate governance, both internal and external, can mitigate these tendencies, provide controls and advice, and thus protect shareholder interests. In addition, the negative synergies arising from mergers and acquisitions in the context of AI automation highlight the risk that these transactions will destroy company value. In addition, companies that lean towards automation tend to finance mergers and acquisitions with available cash, which would otherwise be used to cover operational risk, exacerbating the problem of overinvestment (Gounopoulos *et al.*, 2023). At the same time, robust regulations are needed to ensure the ethical use of artificial intelligence (Cazzaro, 2024).

Mergers and acquisitions offer significant growth opportunities, but rarely create shareholder value without difficulty, not least because of the challenges associated with cultural integration and the realization of synergies. The results of mergers and acquisitions vary greatly across industries, with the size of the deals having a large impact on the price. In innovative industries, such as technology, companies have a greater potential to realize the expected synergies, while in regulated areas, such as financial services, integration is more difficult (Alghizzawi *et al.*, 2025).

These issues highlight the importance of careful planning and strong leadership for post-merger integration in order to obtain real benefits from the merger and acquisition transactions.

3. DATA AND METHODOLOGY

The main objective of this study is to determine how artificial intelligence goes beyond the due diligence process and is adopted by companies, influencing both their productivity and the consolidation and strategic repositioning of companies through involvement in mergers and acquisitions. To determine the impact of digital technologies on mergers and acquisitions, the study considers the recent period 2021-2024. Annual data is taken for companies with at least 250 employees from European Union member countries, namely Austria, Belgium, Bulgaria, Czech Republic, Croatia, Finland, France, Germany, Italy, Ireland, Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden, Hungary. The selection of states and the analyzed period was made based on data availability. Panel data were automatically collected with an annual frequency from the websites of the World Bank (Development Indicators, DataBank), European Commission (Eurostat Database), Institute for mergers, acquisitions and alliances. The regression model tables were constructed by processing the panel data in the statistical-econometric program Eviews.

The multiple linear regression model uses as dependent variable Mergers and Acquisitions (MA), expressed as an annual number of M&A transactions (Figure 2).

As independent variables, various dimensions related to technology adoption within companies are used, variables that are expressed as a total percentage of enterprises (Table 2):

- Enterprises use machine learning for data analysis (DATA_ANAL);
- Enterprises use AI technologies performing analysis of written language (WRIT_LNG);
- Enterprises use AI technologies automating different workflows or assisting in decision making (AUT_WORK);
- Enterprises use AI technologies generating written or spoken language (GEN_LNG);
- Enterprises use AI technologies identifying objects or persons based on images (IDENT_OBJ);
- Enterprises use AI technologies for logistics (LOG);
- Enterprises use AI technologies for marketing or sales (MKT_SALE);
- Enterprises use AI technologies for production processes (PROD);
- Enterprises use AI technologies for ICT security (ICT_SEC).

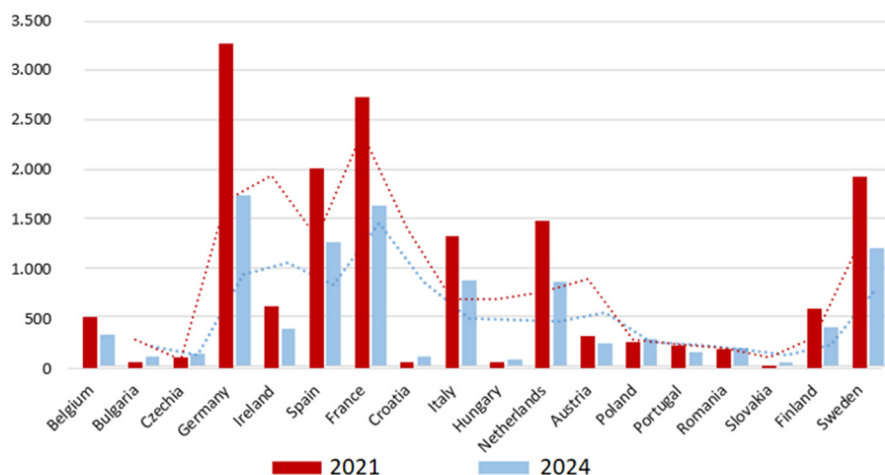


Figure 2. Evolution of the number of mergers and acquisitions in the period 2021-2024

In addition to these variables, are also taken into account Education level of population by educational attainment level (ED_POP); Unemployment rate (UNEMP); Government expenditure on education ($\bar{GEE}$), GDP per capita growth rate (GDP), expressed as Annual growth rate of the ratio between GDP and the number of inhabitants; Inflation rate (INF), which takes into account the Annual growth rate of the Harmonized Index of Consumer Prices.

Table 2. Description of the dependent variable and independent variables

Variable	Symbol	Calculation method	Data source
<i>Dependent variable</i>			
Mergers and Acquisitions Operations	MA	Annual number of mergers and acquisitions	Institute for mergers, acquisitions and alliances
<i>Independent variables</i>			
Enterprises use machine learning for data analysis	DATA_ANAL	Percentage of enterprises	Eurostat
Enterprises use AI technologies performing analysis of written language	WRIT_LNG	Percentage of enterprises	Eurostat
Enterprises use AI technologies automating different workflows	AUT_WORK	Percentage of enterprises	Eurostat
Enterprises use AI technologies generating written or spoken language	GEN_LNG	Percentage of enterprises	Eurostat
Enterprises use AI technologies identifying objects or persons based on images	IDENT_OBJ	Percentage of enterprises	Eurostat
Enterprises use AI technologies for logistics	LOG	Percentage of enterprises	Eurostat
Enterprises use AI technologies for marketing or sales	MKT_SALE	Percentage of enterprises	Eurostat
Enterprises use AI technologies for production processes	PROD	Percentage of enterprises	Eurostat
Enterprises use AI technologies for ICT security	ICT_SEC	Percentage of enterprises	Eurostat
Education level of population	ED_POP	Percentage of population	Eurostat
Unemployment rate	UNEMP	Percentage of total workforce	World Bank
Government expenditure on education	GEE	Percentage of GDP	Eurostat
GDP per capita growth rate	GDP	Annual growth rate	World Bank
Inflation rate	INF	Annual growth rate	Eurostat

For the multiple linear regression model we estimate the following model:

$$\begin{aligned}
 MA_{i,t} = & \alpha_0 + \beta_1 DATA\_ANAL_{i,t} + \beta_2 WRIT\_LNG_{i,t} + \beta_3 AUT\_WORK_{i,t} + \\
 & \beta_4 GEN\_LNG_{i,t} + \beta_5 IDENT\_OBJ_{i,t} + \beta_6 LOG_{i,t} + \beta_7 MKT\_SALE_{i,t} + \beta_8 PROD_{i,t} + \\
 & \beta_9 ICT\_SEC_{i,t} + \gamma_1 ED\_POP_{i,t} + \gamma_2 UNEMP_{i,t} + \gamma_3 GEE_{i,t} + \gamma_4 GDP_{i,t} + \gamma_5 INF_{i,t} + \varepsilon_{i,t}
 \end{aligned}
 \tag{1}$$

where MA represents the number of mergers and acquisitions of country i in year t ; βx - represents the set of independent variables; $y x$ - represents the control variables; ε - represents the standard error.

4. RESULTS AND DISCUSSION

The descriptive statistics of the variables used in the research (Table 3) illustrate for mergers and acquisitions a minimum of 28 operations and a maximum of 2726. The average, located at 613 operations, suggests the presence of low-number operations in several countries.

Table 3. Descriptive statistics for the multiple linear regression model

	Mean	Median	Max.	Min.	Std. Dev.
M A	613.41	303.50	2726	28	694.94
WRIT LNG	11.44	10.97	26.06	2.96	6.24
AUT WORK	16.51	13.80	38.73	4.78	8.57
DATA ANAL	14.25	12.44	32.45	3.27	8.32
ED POP	35.37	35.80	58.50	11.90	10.45
GEN LNG	6.24	5.27	16.39	0.99	4.02
ICT SEC	12.20	12.06	31.02	2.42	7.23
IDENT OBJ	11.24	10.53	26.45	2.36	5.26
LOG	6.12	5.50	15.82	1.32	3.63
MKT SALE	8.10	6.99	19.09	2.18	4.38
PROD	10.87	10.93	24.77	2.22	5.41
UNEMP	6.22	6.14	14.78	2.60	2.55
GDP	3.63	3.48	14.03	-8.05	4.60
INF	5.21	4.10	17.00	0.90	3.56
GEE	4.85	4.90	7.30	2.80	1.04

Enterprises use of AI technologies performing analysis of written language (WRIT_LNG) oscillates between a minimum of 2.96% and a maximum of 26.06%, with a balanced average of 11.44%. Enterprises that use AI technologies automating different workflows or assisting in decision making (AUT_WORK) have a balanced average of 16.51 located between a minimum of 4.78% and a maximum of 38.73%. Enterprises use machine learning for data analysis (DATA_ANAL) suggest, with an average of 14.25, that it is close to the minimum of 3.27% and less than the maximum of 38.73%. Education level of population (ED_POP) oscillates between 11.9-58.5%.

Enterprises use AI technologies generating written or spoken language (GEN_LNG) has a low adoption in companies with a minimum of 0.99% of companies,

while the maximum reaches 16.39%. Enterprises that use AI technologies for ICT security (ICT_SEC) have an average of 12.2%, a minimum of 2.42 and a maximum of 31.02%.

Enterprises use AI technologies identifying objects or persons based on images (IDENT_OBJ) oscillates between 2.36-26.45%, with an average of 11.24. Lower values are recorded for the variable Enterprises use AI technologies for logistics (LOG), adopted in companies with a minimum of 1.32% and a maximum of 15.82. For Enterprises using AI technologies for marketing or sales (MKT_SALE) a balanced average between the minimum and the maximum is found, of 8.1%, while the average of 10.87% for Enterprises use AI technologies for production processes (PROD) is slightly close to the minimum of 2.22. The unemployment rate (UNEMP) takes values between 2.6% and 14.78, with an average of 6.22%. The most pronounced decrease in GDP per capita (GDP) was -8.05 percent, while the positive average of 3.63 suggests few negative values. Inflation rate (INF) and Government expenditure on education (GEE) have averages balanced between minimum and maximum.

The correlation matrix (Table 4) illustrates a strong positive relationship between Enterprises use AI technologies performing analysis of written language (WRIT_LNG) and Enterprises use AI technologies automating different workflows or assisting in decision making (AUT_WORK). Also positively correlated with Enterprises use AI technologies performing analysis of written language (WRIT_LNG) are Government expenditure on education (GEE), Enterprises use machine learning for data analysis (DATA_ANAL), Enterprises use AI technologies generating written or spoken language (GEN_LNG), Enterprises use AI technologies identifying objects or persons based on images (IDENT_OBJ), Enterprises use AI technologies for logistics (LOG), Enterprises use AI technologies for marketing or sales (MKT_SALE), Enterprises use AI technologies for production processes (PROD), Enterprises use AI technologies for ICT security (ICT_SEC), Unemployment rate (UNEMP).

Table 4. Correlation matrix for the multiple linear regression model

	WRIT_LNG	AUT_WORK	GEE	DATA_ANAL	ED_POP	GEN_LNG	ICT_SEC	IDENT_OBJ	INF	LOG	M_A	MKT_SALE	PROD	GDP	UNEMP
WRIT_LNG	1														
AUT_WORK	0.86	1													
GEE	0.38	0.51	1												
DATA_ANAL	0.95	0.94	0.45	1											
ED_POP	-0.11	-0.01	-0.13	-0.06	1										
GEN_LNG	0.81	0.83	0.36	0.88	0.02	1									
ICT_SEC	0.89	0.89	0.51	0.92	-0.06	0.90	1								
IDENT_OBJ	0.86	0.87	0.45	0.87	-0.19	0.84	0.90	1							
INF	-0.36	-0.32	-0.07	-0.37	0.13	-0.31	-0.32	-0.39	1						
LOG	0.88	0.91	0.54	0.90	-0.15	0.80	0.93	0.90	-0.25	1					
M_A	0.24	0.25	0.21	0.38	-0.16	0.38	0.32	0.27	-0.36	0.16	1				
MKT_SALE	0.86	0.96	0.39	0.93	-0.07	0.87	0.90	0.90	-0.40	0.91	0.28	1			
PROD	0.91	0.90	0.45	0.92	-0.09	0.85	0.93	0.92	-0.28	0.92	0.24	0.89	1		
GDP	-0.36	-0.32	-0.08	-0.36	-0.04	-0.41	-0.37	-0.23	-0.45	-0.37	0.05	-0.29	-0.36	1	
UNEMP	0.24	0.23	0.10	0.30	-0.49	0.35	0.20	0.40	-0.42	0.15	0.56	0.31	0.24	0.17	1

With mergers and acquisitions (M_A) the correlation is weakly positive. Weak negative correlations are established between Enterprises that use AI technologies performing analysis of written language (WRIT_LNG) and Education level of population (ED_POP), GDP per capita growth rate (GDP), Inflation rate (INF).

Correlations with the variable Enterprises use AI technologies automating different workflows or assisting in decision making (AUT_WORK) are mainly positive for: Enterprises use machine learning for data analysis (DATA_ANAL), Enterprises use AI technologies generating written or spoken language (GEN_LNG), Enterprises use AI technologies identifying objects or persons based on images (IDENT_OBJ), Enterprises use AI technologies for logistics (LOG), Enterprises use AI technologies for marketing or sales (MKT_SALE), Enterprises use AI technologies for production processes (PROD), Enterprises use AI technologies for ICT security (ICT_SEC), Unemployment rate (UNEMP), Government expenditure on education (GEE), Mergers and Acquisitions (M_A). Education level of population (ED_POP), GDP per capita growth rate (GDP), Inflation rate (INF) are in weak negative correlation with the Enterprises use AI technologies automating different workflows or assisting in decision making (AUT_WORK) variable.

Government expenditure on education (GEE) has weak negative correlations with the variables related to Education level of population (ED_POP), GDP per capita growth rate (GDP), Inflation rate (INF). It has moderate positive correlation with the other variables, except Unemployment rate (UNEMP) with weak positive correlation.

Enterprises use machine learning for data analysis (DATA_ANAL) has a weak negative correlation with Education level of population (ED_POP) and a moderate negative correlation with GDP per capita growth rate (GDP) and Inflation rate (INF). Strong positive correlations are established with Enterprises use AI technologies generating written or spoken language (GEN_LNG), Enterprises use AI technologies identifying objects or persons based on images (IDENT_OBJ), Enterprises use AI technologies for ICT security (ICT_SEC), Enterprises use AI technologies for logistics (LOG), Enterprises use AI technologies for marketing or sales (MKT_SALE), Enterprises use AI technologies for production processes (PROD). With the other variables, the correlations are moderately positive, respectively: Unemployment rate (UNEMP), Mergers and acquisitions (M_A).

Most of the correlations for Education level of population (ED_POP) are negative, except for Enterprises use AI technologies generating written or spoken language (GEN_LNG) and Inflation rate (INF).

Enterprises use AI technologies generating written or spoken language (GEN_LNG) is positively correlated with most variables, except Inflation rate (INF) and GDP per capita growth rate (GDP). The same negative correlations with

inflation and GDP are also found for the variable Enterprises use AI technologies for ICT security (ICT_SEC) and the variable Enterprises use AI technologies identifying objects or persons based on images (IDENT_OBJ).

Inflation, in turn, is moderately negatively correlated with Enterprises use AI technologies for logistics (LOG), Enterprises use AI technologies for marketing or sales (MKT_SALE), Enterprises use AI technologies for production processes (PROD), Unemployment rate (UNEMP), GDP per capita growth rate (GDP), Mergers and acquisitions (M_A).

The variable Enterprises that use AI technologies for logistics (LOG) is negatively correlated with only one variable, GDP. The correlations with mergers and acquisitions are all positive, while GDP continues to have negative correlations with Enterprises who use AI technologies for marketing or sales (MKT_SALE) and Enterprises use AI technologies for production processes (PROD).

The empirical results of the regression model highlight both positive and negative impacts (Table 5). A statistically significant impact is exerted by Enterprises use of AI technologies performing analysis of written language (WRIT_LNG), causing a decrease in mergers and acquisitions by 192 units. This decrease is caused by the use of technologies, especially in the due diligence process, to automatically analyze contracts and reports, in which hidden risks and inconsistencies between companies are more easily identified, leading to a decrease in M&A. It is also found that the use in compliance with regulations, companies being more cautious in M&A decisions.

Another negative impact is determined by the increase by one unit of Enterprises using AI technologies for generating written or spoken language (GEN_LNG). The decrease in mergers and acquisitions occurs when technologies generating written or spoken language allow companies to develop innovative processes and solutions internally, reducing the need for external acquisitions for expansion or know-how. Increased efficiency and lower operating costs facilitate the adoption of an organic growth strategy, at the expense of expansion through M&A.

However, several variables are driving M&A activity. Enterprises use machine learning for data analysis (DATA_ANAL) drives M&A growth because it provides advanced analysis of financial, operational and market data, contributing to the faster and more accurate identification of suitable targets for acquisitions. Improvements are also taking place in the due diligence process, through a more realistic assessment of potential synergies and the optimization of post-acquisition integration.

Enterprises use AI technologies for ICT security (ICT_SEC) drives M&A with 146 units, as it provides advanced data protection during critical M&A processes, such as due diligence and post-M&A integration. Companies that use

AI for cybersecurity can more effectively manage cyber risks during transactions and are also perceived as trusted leaders attractive as acquisition targets.

Table 5. Empirical results of the regression model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	173.5935	700.8551	0.247688	0.8070
WRIT_LNG	-192.5223	55.12720	-3.492328	0.0024***
AUT_WORK	-74.14406	60.88790	-1.217714	0.2382
DATA_ANAL	253.4313	72.24595	3.507896	0.0024***
GEN_LNG	-136.5912	64.96257	-2.102614	0.0491**
ICT_SEC	146.5389	41.33855	3.544849	0.0022***
IDENT_OBJ	16.50612	69.31463	0.238133	0.8143
LOG	-62.75740	111.3141	-0.563787	0.5795
MKT_SALE	-61.05322	107.8186	-0.566259	0.5778
PROD	-65.20164	73.39988	-0.888307	0.3855
ED_POP	5.276449	8.922042	0.591395	0.5612
UNEMP	145.6694	54.83011	2.656742	0.0156**
GDP	-7.993286	26.62573	-0.300209	0.7673
INF	-13.10988	25.95000	-0.505198	0.6192
GEE	-52.65937	118.8259	-0.443164	0.6627

Notes: a. Dependent Variable: Zscore(MA); ***,** and * Variables are significant at 1%, 5%, 10% level.

The unemployment rate (UNEMP) stimulates mergers and acquisitions when high unemployment causes company valuations to fall and makes them more attractive for low-cost acquisitions. More vulnerable companies thus become accessible targets. Increased labor availability is also a sign of easy access to available employees, reducing post-M&A integration costs and time.

Several variables are not statistically significant. Enterprises use AI technologies automating different workflows or assisting in decision making (AUT_WORK) may have a marginal impact due to common use in many companies. The variable Enterprises use AI technologies identifying objects or persons based on image (IDENT_OBJ) may only be relevant in certain industries such as security and has no influence on large-scale M&A. Enterprises use AI technologies for logistics (LOG) may have an impact on internal efficiency and less on merger decisions. Enterprises that use AI technologies for marketing or sales (MKT_SALE) do not outline clear synergies for M&A. Enterprises use of AI technologies for production processes (PROD) may be a common process in mature industries, thus not being a primary decision-maker for acquisitions.

Education level of population (ED_POP) does not directly affect M&A decisions or the attractiveness of a country for M&A. Government expenditure on education (GEE) also acts in the same sense. Labor market conditions, as reflected

by GDP per capita growth rate (GDP) and Inflation rate (INF), may influence the pace or timing of M&A transactions, but are not decisive factors for M&A.

Table 6. Regression model performance indicators

R-squared	0.738963	Akaike info criterion	15.43495
Adjusted R-squared	0.546619	Schwarz criterion	16.10835
F-statistic	3.841892	Hannan-Quinn criterion	15.66460
Prob(F-statistic)	0.003683	Durbin-Watson stat	1.723117

The regression model is statistically significant with $\text{Prob(F-statistic)} < 0.05$ (0.003683), explaining approximately 74% of the variation in the dependent variable ($\text{R-squared} = 0.7389$). Corrected for the number of variables, the model explains approximately 55% of the variation ($\text{Adjusted R-squared} = 0.5466$). The Durbin-Watson test close to value 2 indicates a suitable model from the perspective of autocorrelation (Table 6).

5. CONCLUSIONS

In the context of accelerated technology and the constant desire of companies to expand and amplify success, this paper investigates the impact of adopting artificial intelligence in company processes on mergers and acquisitions operations. The analysis was conducted for a sample of countries in the European Union, analyzed between 2021-2024.

Mergers and acquisitions have been both stimulated and slowed by the adoption of artificial technology. Enterprises use of AI technologies in performing analysis of written language determine a decrease in mergers and acquisitions caused by the use of technologies in the due diligence process, to automatically analyze contracts and reports, a way in which hidden risks and inconsistencies between companies are more easily identified, leading to a decrease in M&A. A negative impact is also determined when Enterprises use AI technologies generating written or spoken language allow companies to develop innovative processes and solutions internally, reducing the need for external acquisitions for expansion or know-how. Increased efficiency and lower operational costs facilitate the adoption of an organic growth strategy, at the expense of expansion through M&A.

The variables that drive M&A activity are Enterprises use machine learning for data analysis because it provides advanced analysis of financial, operational and market data, contributing to the faster and more accurate identification of suitable targets for acquisitions. Enterprises use AI technologies for ICT security increase M&A because they provide advanced data protection during critical M&A processes, such as due diligence and post-M&A integration. Unemployment rates increase M&A when high unemployment causes company valuations to decrease and increases the attractiveness of low-cost acquisitions.

Increased labor availability is also a sign of easy access to available employees, reducing post-merger integration costs and time.

The findings highlight the need to prioritize investments in AI for data analysis and IT security, as it demonstrates a high level of digital maturity and adaptability essential for strategic partnerships. However, caution is also needed in the use of artificial intelligence in language generation and analysis, as it is negatively associated with M&A and balancing investments with more efficient AI solutions. Macroeconomic conditions such as the unemployment rate should be on the attention of investors when periods of high unemployment can create opportunities for market consolidation. For the use of AI in logistics, marketing, production or visual identification, an insignificant influence is found, suggesting the possible redirection of technologies towards those with substantial impact when M&A is targeted.

The limitations of the research consist of the sample limited to 18 EU member states and the reduced time period between 2021-2024 due to the lack of data availability. Future research directions include the expansion of the data and the analysis sample, as well as the inclusion of other variables in the testing.

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ON THE REAL SWIFTNESS OF JUSTICE, WITH AND WITHOUT ARTIFICIAL INTELLIGENCE

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Abstract:

With its specific techniques and algorithms, AI seems to be ubiquitous in contemporary society. As a social phenomenon, law cannot be an exception. In the procedural field, AI brings indisputable advantages in terms of making normative, doctrinal and case-law databases accessible, but also in terms of speeding up judicial proceedings because the use of algorithms generates effects in real time. If either the legal remedies are ineffective or they intervene very late in relation to the time of the violation of the rights, the preservation of the rights is no longer possible or current, which is tantamount, in practice, to the non-existence of remedies to protect the rights.

Improvements in AI will certainly speed up the processing of legal information in the future, but it is impossible to predict whether this will be accompanied by an increase in the quality of case resolution, bearing in mind that the law is subject to the action of a multitude of factors: moral, religious, economic and social.

Keywords: law; procedural celerity; artificial intelligence; homo juridicus roboticus.

JEL Classification: K40.

1. ENSURING SPEED – A CONDITION FOR THE PRESERVATION OF RIGHTS

Starting from the W. Gladstone's motto that justice delayed is justice denied, we focus our research on natural rights, which in the ideal dimension, are recognized and respected; rights are created normatively, by regulation, are not only guaranteed by the state, but also enforceable against it, and rights in the legal relations between legal subjects are negotiated and assumed, legal obligations are performed according to the assumption.

In the real world, however, there are a multitude of factors which affect rights, and which require judicial protection aimed at restoring or limiting the infringement of those rights. In most cases, judicial protection must be immediate and effective, so as not to deprive the right itself of its content. If either the legal remedies are ineffective or they intervene very late in relation to the time of the violation of the rights, the preservation of the rights is no longer possible or

current, which is tantamount, in practice, to the non-existence of remedies to protect the rights.

The expeditiousness of proceedings is not only a desideratum, but also one of the essential procedural objectives. The desire to ensure that cases are settled in due time does not imply any abdication of the quality requirements of the judicial act, regardless of the subject matter in which it is to be decided.

In order to identify a procedural model that meets the requirements of swiftness, it is necessary to take a comparative overview of the sequential elements of procedures that are often used in practice, starting with the ordinary civil procedure, passing through the tax procedure and ending with the sports procedure specifically designed for the world's major sporting competitions.

2. COMMON CIVIL PROCEDURE AND ADMINISTRATIVE-FISCAL PROCEDURE

Observing from a distance the provisions of para. (1) art. 241 of the Civil Procedure Code: "*For the investigation of the lawsuit, the judge shall set short deadlines, even from one day to the next*", the impression given would be that in civil trials in Romania, benefiting from short deadlines enshrined in law, cases are settled in a very short period of time, almost instantaneously.

In reality, in the common judicial procedure, at the level of the first court in the pyramid of the judicial system, not only are terms not currently granted from one day to the next, that is, two terms in one week, but the counter-performance has reached the point where terms are granted from one year to the next, which marks a negative historical record in this area.

It is problematic that even the special procedures enshrined in the Code of Civil Procedure, such as the issuing of payment orders or small value claims, are marked by a hard-to-explain immobility which is antithetical to the need to resolve cases urgently.

As a result, the requirements of speed, which are extremely important in a functioning justice system, are not ensured in the ordinary civil judicial procedure, which represents an unacceptable departure from one of the fundamental principles and desires on which the new Code of Civil Procedure was built in Romania (Put, 2024).

A slow justice system induces and maintains in the minds of the litigants not only the procedural uncertainty of the solution, but also the uncertainty of when it will be pronounced and when the litigation will be finalized. This leads to a decline in public confidence in the efficiency and reliability of the justice system, which is not only a legal but also a social problem.

The tax inspection is the epitome of tax control, the procedural framework in which the effects of rights and the reverberations of tax obligations are intertwined. Lato sensu, tax inspection is "the activity carried out by the competent bodies with a view to establishing the tax situation, identifying the appropriate tax

treatment and verifying the accuracy with which taxpayers fulfill their tax reporting and payment obligations, in accordance with the legislation in force". (Costaș, 2016)

From the perspective of the duration of the tax inspection, the provisions of Art. 126 of the Tax Procedure Code are clear: "(1) The duration of the tax inspection shall be determined by the tax inspection body, depending on the objectives of the inspection, and may not exceed:

(a) 180 days for large taxpayers, taxpayers/payers with secondary establishments, regardless of size, and non-resident taxpayers;

b) 90 days for medium taxpayers;

c) 45 days for other taxpayers.

(1), which does not include the periods of legal suspension of the tax inspection, the tax inspection shall cease, without issuing a tax inspection report and a tax assessment decision or a decision not to change the tax base. In this case, the tax inspection body may resume the tax inspection, with the approval of the hierarchical body superior to the one that approved the initial tax inspection, once for the same period and the same tax liabilities, subject to the provisions of Article 117 paragraph. (1)".

Depending on the nature of the taxpayers and taking into account their classification into large, medium and small taxpayers, the legislator sets the maximum legal duration of the tax inspection. However, tax practice confirms the existence of two circumstances that tend to extend the legal duration: the various suspension periods that the tax authority may impose with unquestionable factual autonomy, and the various cases where the periods laid down by law are exceeded without any effective penalty.

In the case of unannounced inspections and documentary checks, which are other forms of tax inspection which should be carried out quickly, and anti-fraud inspections, the legislature does not lay down the legal time-limits, as it does in the case of tax inspections. As regards the verification of personal tax situation, according to the provisions of para. (6) of Art. 140 of the Tax Code: The duration of the personal tax audit shall be determined by the central tax authority and may not exceed 270 days calculated from the date of commencement of the tax audit.

Taking into account the fact that very often the issuance of the tax assessment decision does not also mark the finalization of the procedures and the finalization of the taxpayer's payment obligations, it is certain that adding the period during which the tax appeal is settled, i.e. the actual duration of the tax judicial process, will lead to a long period of time between the beginning of the tax inspection and the finalization of the court decision, which is likely to seriously affect the desire for speed.

In practice, the impression is that the procedure is accelerated when the tax is to be levied, whereas when the situation is uncertain and a basis for the tax is being sought, the procedure drags on.

Summarizing the elements that describe the specific nature of the matter, we consider that the requirements of celerity are not ensured in the tax procedure in Romania. The situation is even more dramatic if criminal proceedings start and develop in parallel with tax proceedings. Apart from the uncertainty regarding the priority of the procedural institutions, the duality of tax and criminal proceedings also creates uncertainty regarding the duration of tax proceedings, which depends on the duration and outcome of criminal proceedings. In this context, as has been rightly pointed out in the doctrine, several hypotheses of parallel proceedings must be taken into account, the fate and duration of the tax proceedings also depending on the prior determination of tax liabilities by a tax assessment decision, the outcome of the civil action in the criminal tax evasion proceedings, the principle of the uniqueness of the tax inspection (Costaş and Tofan, 2023).

3. PROCEDURE BEFORE THE CAS AD HOC CHAMBERS

The Court of Arbitration for Sport in Lausanne is known and recognized in the international sports and legal world for the specificity of the appeal procedure, which is the one in which, after going through the appeals of the domestic sports procedure, sports disputes of a patrimonial nature are finally settled, at least in principle, and which, in terms of duration, is within the limits of the expectations of the sports world.

In addition to the appeals procedure, the conduct of major international sporting competitions calls for the establishment of specialized 'tribunals' to settle disputes that arise before, in particular in connection with qualification for, or, more particularly, during, such competitions, quickly and in real time.

The CAS Ad-hoc Chamber offers a real model of fast-track justice, while preserving the classical judicial principles of impartiality, adversarial proceedings, active role, etc. It is made up of arbitrators appearing on a special list, a president, a co-president and a Court Bureau. The special list of arbitrators is published before the opening of the Olympic Games. The CAS will set up an ad-hoc Chamber Court Office on the site of the Olympic Games. This office is placed under the authority of the CAS Secretary General. The arbitration will be conducted in English or French.

According to Article 18 of the Rules of Arbitration applicable to the CAS ad hoc Division for the Olympic Games: *"The Panel shall take a decision within 24 hours of the submission of the Request. In exceptional cases, this time limit may be extended by the President of the ad hoc division if circumstances so require"*. Article 21 of the same Regulation provides that *"the decision shall be immediately enforceable"*.

Thus, built on the model and principles of the arbitration courts, the sports arbitration conducted by the CAS in major sports competitions is the epitome of efficient, swift and real justice, offering solutions in hours rather than years. Therefore, the ad hoc arbitration institutionalized and conducted by the CAS truly

embodies the qualitative and swift justice which, in the common, public procedure, unfortunately remains a mere wish.

4. ARTIFICIAL INTELLIGENCE – BETWEEN SPEED AND QUALITY

Artificial intelligence is one of the most discussed and disputed topics in public discourse lately. In a world where time is a most precious, irreversible commodity, AI's indisputable advantages, such as quality and speed of execution, standardization and rhythmicity, or the lack of problems that an ordinary employee may have with pay, leave or family issues, make AI a highly tempting option.

With its specific techniques and algorithms, AI seems to be ubiquitous in today's society, taking over and subjugating the vulnerabilities of "Generation X", the world's teenagers.

It has been emphasized that artificial intelligence (AI), as a technological revolution and through its uses, generates multiple and major challenges for human society in general, and for the legal world in particular, with the implications that go with it. It is increasingly also becoming a legal object, and some even a subject of law (Dutu, 2024). After the multiplication of ethical charters and other soft law instruments, particularly international and European, and the transition to the stage of accentuated legality (through national laws or relevant European regulations), the law of artificial intelligence is becoming progressively more consistent and constraining, tending towards an implacable automation.

We are of the opinion that AI falls under the notion of legal object, and not under the legal category called "subject of law" reserved exclusively for human beings, at least in the context of the "classical law" that we know and practice, but this topic remains open in the perspective of the future legal status that will most likely have to be conferred to robots (Put, 2024).

4.1. State of play

At the moment, the appearance is that artificial intelligence is little emergent in the domestic judicial order. However, reality confirms the incidence of AI in law from many perspectives. Thus, while in the past the judge used to dictate to the court clerk what should be recorded and the clerk typed on a typewriter, today not only does the court clerk use a computer and predefined models of the procedural documents, but, for some years now, audio recordings from the courtroom have also been introduced to ensure the accuracy of the recordings in case the content of the discussions between the persons in the courtroom is at issue.

Then, the accessibility of information on EU legislation, comparative law, pending proceedings, real-time case-file data are major benefits of information technology and progress in informatics (*E.g.* <https://www.curteadeapelcluj.ro/> is

an extremely useful website for litigants and lawyers because it allows not only to track the judicial status, but also to consult the case file, which is scanned and available by using the file number and password communicated exclusively to the litigants).

The legislative programs which allow articles from legislative acts to be directly and quickly retrieved and transposed into procedural documents, in particular into the actual court decisions, and the various websites containing case-law collections are useful for judges, lawyers and legal advisers.

The websites of the various public institutions and of national, European and international courts facilitate effective access for individuals to the legal information necessary for voluntary legal compliance.

4.2. Legitimate expectations

Looking prospectively and realistically, we expect the impact of AI in the common process to grow exponentially in the future. Law is an essentially social phenomenon, created by people for people. Therefore, regardless of the inherent technological evolution, law, according to its primary function, will not be able to be completely robotized, i.e. neither the judge, the prosecutor nor the litigants are substitutable by a robotic surrogate. What could be replaced in the future might not be the decision-maker, but possibly the recorder, the person who records the conduct of judicial proceedings, such as the court clerk.

However, it is doctrinally supported and propagated the so-called theory of transhumanism that anticipates a future combination of humans and machines (robots) that will generate cyborgs that will be "*more capable and powerful than either of them*", which would emphasize the idea that "*artificial intelligence is the next stage of evolution*" (Craiovan, 2023). From this perspective, it is difficult to predict what this distortion of the human being through and under the influence of technology might look like, and even more difficult to predict what a judicial process might look like in 50 years' time in the USA, Japan, Saudi Arabia or Romania.

Legislative bodies and governments must establish transparent regulatory frameworks for AI. These regulations must delineate principles of ethics, foster transparency mandates, and stipulate the responsibility of these AI systems. Achieving an optimal equilibrium between fostering innovation and safeguarding the rights of individuals is a highly challenging endeavor and requires the training of regulators and lawmakers to understand these technologies. (<https://unu.edu/article/ai-and-law-navigating-future-together>)

From a speed perspective, robotization will also mean speeding up judicial procedures. Algorithms will certainly bring the added speed that the justice system so badly needs, but will they also bring added quality, will they maintain a specifically human empathy, will they be able to achieve a proportioning of circumstances, a highlighting and valorization of the specifics of each case, an

identification of the genuine judicial truth? These are questions to which honest, realistic answers cannot yet be provided.

Despite the fact that a large number of algorithm-based systems are being used in justice, they will not replace the judge in the near future. However, it seems that it is only a matter of time before we see more widespread use of these systems to assist judges in their decision-making. In other words, the role of AI will be that of an adjunct, an assistant in the decision-making process (Pășcui, 2020).

Lastly, at both normative and judicial level, in the specific juris-dictio, not only purely legal, but also moral, religious and social elements must be taken into account. "*Can law be understood without including any necessary reference to those values that it may seem desirable for law to embody, notably morality and justice? Is it possible, in other words, and it is desirable, to identify valid law without reference to other kinds of normative or evaluative standards?*" (Veitch *et al.*, 2018).

5. CONCLUSIONS

From the foregoing on the actual implications and impact of AI, it is clear that we are currently at an intermediate stage of evolution in terms not only of the judicial component, but of all the social sectors concerned.

In this context, it is uncertain and impossible to predict how the transition from homo juridicus to homo juridicus roboticus can be made. Ab initio, we can easily predict that the development or generalization of algorithms in the judiciary will certainly speed up proceedings at all levels, but we do not know whether the solutions will also improve in quality.

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TRANSFORMING AGILE PROJECT MANAGEMENT THROUGH ARTIFICIAL INTELLIGENCE

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Abstract

In the context of the rapid transformations of the past decade, Artificial Intelligence (AI) is significantly reshaping processes across all industries, including – perhaps most notably – software development. This paper explores the multifaceted role of AI in transforming Agile project management practices, highlighting key innovations, challenges, and benefits. Based on a review of the literature combined with exploratory case examples from current industry practices, the study identifies AI-driven technologies that enhance decision-making and forecasting capabilities. While AI offers significant advantages – such as automating routine tasks and enabling predictive insights – its integration also presents critical challenges. These include concerns related to data privacy and security, overreliance on technology, limitations in integration, and the pressing need for project managers to develop new competencies in a rapidly evolving technological landscape. The paper aims to provide a structured perspective on how AI can be strategically embedded into Agile processes to enhance project outcomes. The findings suggest that AI not only boosts productivity but also redefines team dynamics and strategic decision-making, contributing to a deeper understanding of how AI can sustainably support modern project management.

Keywords: agile project management; artificial intelligence; agile framework; machine learning; natural language processing.

JEL Classification: O22; O33; L86; M15.

1. INTRODUCTION

The Agile methodology has gained significant popularity, particularly within companies engaged in software development. Its widespread adoption can be attributed primarily to its natural embrace of change and its emphasis on technical excellence (Shankarmani *et al.*, 2010). Grounded in four core values and twelve

principles, Agile software development has been adopted by numerous teams and organizations as an adaptive response to the dynamic evolution of technology.

Agile teams are typically small, with three to ten members, who generally develop products through short, fixed-length iterations lasting between one and four weeks. In some Agile frameworks, such as Kanban, delivery occurs on a continuous basis. Regardless of the specific framework adopted by the team, the overarching objective remains consistent: delivering high-quality functionality on time to meet customer expectations. While Agile practices are characterized by flexibility and the frameworks are fundamentally empirical, their high level of adaptability often presents challenges. Project managers must identify and select those practices that most effectively facilitate both team and project evolution over the long term. Consequently, they are required to demonstrate strong analytical skills and critical thinking abilities to identify and address obstacles that impede team performance- obstacles that are often subtle and difficult to detect.

The recent evolution of artificial intelligence (AI) offers significant opportunities to enhance project outcomes by automating various tasks, whether related directly to project implementation (e.g., code generation, automated testing, bug fixing, training of the team members) or to activities that support development (e.g., planning, estimation, team member selection). The integration of AI technologies can substantially reduce the time allocated to non-value-adding activities, streamline communication, facilitate decision-making, and improve responsiveness to the uncertainties inherent in Agile software development.

This paper examines the ways in which AI-driven transformations enhance the execution of projects implemented through Agile methodologies and improve team performance. The paper is structured as follows: Section 1 introduces the topic; Section 2 reviews the relevant literature on Agile project management and AI applications in project management; Section 3 presents examples of specific activities where AI supports transformation within Agile teams; and Section 4 offers concluding remarks based on the analysis conducted.

2. LITERATURE REVIEW

2.1. Background of agile project management

A substantial body of scholarly research has explored the challenges and advantages associated with software development using Agile methodologies. Formalized in 2001 through the Agile Manifesto, this approach sought to address the shortcomings inherent in traditional project management models – classified by the Project Management Institute as "predictive project management" – which required the development of highly detailed, upfront plans encompassing all intended functionalities of the final product.

Initially, Agile frameworks such as Scrum, Kanban, Lean Software Development, and Extreme Programming (XP) were designed to support small-scale projects. Over time, these frameworks have been expanded and adapted,

forming the foundation for large-scale Agile methodologies, including the Scaled Agile Framework (SAFe), Large-Scale Scrum (LeSS), and Nexus, to accommodate the needs of complex, enterprise-level initiatives) (Reddaiah *et al.*, 2016); Pieroni *et al.*, 2018; Neve and Agarwal, 2024).

Each framework is accompanied by a defined set of practices, roles, and events that the team adheres to in order to work in an Agile manner and deliver incremental value to customers (Bahi *et al.*, 2024). Among these, Scrum is the most widely adopted Agile framework. Teams applying Scrum develop products incrementally and iteratively by dividing the work into sprints, typically lasting between two and four weeks, with a two-week duration being the most common. Customer requirements are formulated as user stories, which are sufficiently small to be implemented within a single sprint or iteration (Alsaadi and Saeedi, 2022). At the end of each sprint, the team is expected to deliver only fully completed functionalities – designed, implemented, and tested – to the customer.

Formulating requirements whose scope exceeds the timeframe of a sprint would be against Agile principles and practices. Such requirements do exist, referred to as epics, but they must be decomposed into smaller, manageable user stories before being incorporated into a sprint. Estimation of user stories is most commonly performed using story points, which reflect the total effort required to complete a backlog item or another unit of work (Goswami *et al.*, 2016). The number of story points, often determined using the Fibonacci sequence, should simultaneously account for the complexity of the requirement, the volume of work necessary for its completion, and the associated risk or uncertainty.

Collaboration is a fundamental characteristic of Agile methodologies. In Scrum, communication is facilitated through four key events: (1) *Sprint Planning*, conducted before the start of each sprint to plan the work to be completed; (2) *Daily Standup (Daily Scrum)*, held daily to communicate progress and ensure team synchronization; (3) *Sprint Review*, at the end of the sprint, for presenting the deliverables and gathering stakeholder feedback; and (4) *Sprint Retrospective*, aimed at reviewing processes and identifying opportunities for improvement (Bahi *et al.*, 2024). The Agile approach promotes the formation of cross-functional, self-organizing teams, capable of delivering a potentially shippable product at the end of each iteration.

2.2. Background of artificial intelligence in project management

The evolution of AI in recent years has been remarkable, driven by significant advancements in the infrastructure underpinning information and communication technologies. Within project management, AI offers diverse opportunities for process optimization and overall performance enhancement at the project level (Cristaldo *et al.*, 2021). It is currently leveraged for a wide range of activities, including requirements formulation, predictive analysis, optimization of planning based on historical data, automation of repetitive tasks,

dynamic updating of project schedules in response to changes, cost estimation, risk prediction, detection of team overload and bottlenecks, monitoring team communication, and assessing team members' morale, among others (Chou *et al.*, 2013; Costantino *et al.*, 2015; Xu and Lin, 2015; Wauters and Vanhoucke, 2016; Hsu *et al.*, 2020; De Oliveira *et al.*, 2023; Taboada *et al.*, 2023). By relieving team members and project managers from routine tasks, AI enables them to allocate more time to strategic and creative activities. Moreover, it significantly reduces the likelihood of human errors.

In recent years, the advent of Generative AI (GenAI) has received widespread attention, particularly due to the availability of accessible tools such as ChatGPT, DeepSeek, and Gemini. GenAI can be employed across a broad spectrum of project management activities, from planning to monitoring and control, delivering remarkable results. Various tools are used to generate reports, create or refine requirements, perform real-time translations to eliminate communication barriers, draft or interpret messages, and more.

According to Felicetti *et al.* (2024), GenAI acts as both an enabler of efficiency and a driver of growth, reshaping competitive dynamics. Its adoption facilitates the identification of problems, opportunities, and threats at a level that surpasses conventional knowledge domains and traditional search routines. Despite the growing interest, the literature focusing on AI applications in project management remains relatively limited. Bahi *et al.* (2024) discuss how generative AI enhances workflow efficiency and mitigates challenges in software projects through activities such as code generation and predictive analytics. Similarly, they demonstrate how AI enables proactive risk anticipation and real-time collaboration through its predictive capabilities.

Other scholars have compared the expertise of human project managers with AI-driven systems, highlighting that AI, when effectively integrated, can significantly enhance decision-making processes during the project planning phase (Barcaui and Monat, 2023). Furthermore, Felicetti *et al.* (2024) analysed the factors influencing project managers' use of generative AI. Their findings reveal that an innovative attitude, peer influence, and good task–technology fit substantially affect the ways in which AI is employed – whether creatively or in unexpected manners.

3. APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN AGILE PROJECT MANAGEMENT

Both formally and informally, numerous Agile teams increasingly integrate AI into project-related activities. Within projects developed using Agile methodologies, AI can be employed to automate estimations and streamline sprint planning. Machine learning (ML) algorithms are leveraged to analyse historical project data and generate more accurate predictions regarding the time, costs, and resources required.

Estimation accuracy plays an important role in ensuring proper project planning. Estimation errors may lead to delayed product deliveries, suboptimal resource allocation, or budget overruns (Younas *et al.*, 2025). Over time, organizations accumulate substantial volumes of data related to estimated versus actual task durations, team members' expertise, the frequency of requirement changes, activity complexity and type, encountered bottlenecks, and more. By leveraging these datasets, ML models can be trained to learn the relationships between task characteristics and their actual completion times. Consequently, each newly added task can be automatically estimated based on learned patterns. Such capabilities enable more accurate scheduling, optimize resource allocation, reduce project risks, and enhance delivery predictability. To improve estimation accuracy and enable comparative analysis of outcomes, several applications have been developed that integrate ML techniques (Prasada Rao *et al.*, 2018; Raza and Espinosa-Leal, 2024) or Deep Learning approaches (Arachchi and Amalraj, 2023). Organizations may either adopt existing solutions, such as Forecast.ai – which can be integrated with Jira for advanced prediction capabilities – or develop customized solutions using platforms such as Azure Machine Learning, integrated with Azure DevOps.

Prioritizing the backlog constitutes another critical activity within projects developed under Agile methodologies. Business value is the principal criterion guiding the ordering of user stories; however, other factors also influence prioritization, such as dependencies among user stories, the impact on product quality, user experience, business objectives, and resource availability. AI-based systems can leverage historical project data to assign scores to each task, thereby suggesting an optimal implementation order. Natural Language Processing (NLP) techniques can be employed to extract keywords from user stories which, when correlated with project objectives, generate relevant insights for backlog prioritization.

Utilizing NLP and machine learning, Izhar *et al.* (2024) developed a model that systematically analyses and prioritizes user requirements based on their semantic significance, employing advanced text pre-processing, cosine similarity, Term Frequency-Inverse Document Frequency (TF-IDF), tokenization, log-likelihood calculations, and K-Means clustering. Automating the prioritization process enhances the Product Owner's ability to align development with stakeholder expectations and enables more efficient resource allocation.

The regular organization of meetings is a well-established practice within Agile methodologies. The use of virtual assistants and chatbots to facilitate daily stand-up meetings (for example, Standuply or Slack's Geekbot), to send reminders, centralize impediments, and provide answers to frequently asked questions (such as Workbot or Power Virtual Agents integrated with Microsoft Teams) represents another valuable application of AI. Such tools can significantly enhance team efficiency by delivering rapid responses and offering contextually

relevant suggestions to emerging issues. Moreover, they serve as useful instruments for familiarizing team members with Agile practices and for promoting the application of Agile values and principles across various domains (Mekic *et al.*, 2024).

AI-driven applications can also be employed to monitor team dynamics and sentiment, aiming to track the emotional well-being of team members, identify emotional bottlenecks, and prevent burnout or conflicts (Madampe *et al.*, 2020; Araque *et al.*, 2022). By analysing conversations among team members, these systems can send early warnings to Scrum Masters, enabling proactive interventions before disruptive events occur that could slow or derail project progress.

Furthermore, predictive models can be utilized to identify potential risks and bottlenecks, signalling likely delays, errors, or defects and offering preventive suggestions (Dam *et al.*, 2019; Orantes-Jiménez *et al.*, 2021). Agile project management applications may also be used to detect stagnating tasks, monitor key performance indicators, and apply predictive models to risk assessment.

In recent years, the adoption of GenAI has become increasingly widespread. The potential and effective use of GenAI across different phases of Agile project implementation has been explored by scholars such as Dhruva *et al.* (2024), Haidabrus (2024) and Cinkusz *et al.* (2025). Their findings reveal that GenAI can play a significant role in defining project scope, generating user stories and decomposing them into tasks, describing the roles and required competencies for task execution (knowledge, skills, experience), facilitating estimation, providing technical consultancy to avoid development blockages, assisting team members in familiarizing themselves with Agile processes, and tracking project progress.

As GenAI continues to become increasingly integrated into daily workflows, the accuracy of the information it produces is expected to improve. Nevertheless, ethical concerns persist, including the necessity of validating the information provided based on context, and the imperative to ensure data security. For example, sensitive information should not be shared with GenAI tools (Bahi *et al.*, 2024).

4. CONCLUSIONS

Many companies, particularly those operating in the software development sector, manage projects by applying Agile methodologies. Although Agile has evolved over time, the values and principles articulated in 2001 remain the foundation for Agile teams. AI has increasingly contributed to this evolution, supporting teams throughout all stages of project development – from the initial idea to launch, and subsequently during product updates and eventual decommissioning.

Despite significant progress, the maturity level of AI remains limited. Its potential is immense, and the extent of the transformations it may drive is difficult to fully anticipate. In the field of Agile project management, AI is currently

employed to support a wide range of activities, including the formulation of project goals, definition and testing of requirements, effort estimation, facilitation of team communication, and forecasting.

This paper provides a synthesis of the key activities and practices influenced by the evolution of AI, highlighting the transformations it is bringing to Agile project management.

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THE IMPORTANCE OF THE RESILIENCE OF HEALTH INSTITUTIONS IN THE EVOLUTION OF HEALTH SERVICES IN ROMANIA

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Abstract

Medical problems and economic crises that have hindered the evolution of society are as much a part of human civilization as the efforts to eradicate them. Problems related to public healthcare and efforts to support it represent a global challenge that has evolved over time from population health surveillance to epidemic eradication, then to the identification of health needs, to the development of health promotion strategies and, finally, to the status of evaluating and maintaining health services in the face of challenges. 21st century Romania is faced with underfinancing of the health system, poor access to medical services, a hospital network often not in line with the requirements of scientific progress and insufficient education in terms of medical information and prevention, although the theoretical concern to analyse the health system and its efficiency exists, as demonstrated by the multitude of reports and studies conducted by researchers in the field. The present study approaches the interdisciplinary theme of health system resilience, presenting the process of establishing the health system with its economic, social, and medical implications, in order to show an overview of the evolution of the Romanian medical system. Romanian healthcare and population insurance against medical, economic and social risks is a permanent concern of both decision-makers and the population. This article aims to examine the events that formed the basis of the establishment of health services in Romania, respectively their evolution, in order to show that through a strategic and integrated approach, health institutions can become more efficient, accessible and prepared for the future. This research also aims to highlight the importance of the resilience of health institutions to ensure the continuity and efficiency of health services, especially in the context of crises such as pandemics or economic difficulties. A resilient health system has the capacity to adapt to changes and maintain its functionality for the benefit of the population.

Keywords: resilience; healthcare; financing; sustainability; health insurance.

JEL classification: B15; H10; I18; O1.

1. INTRODUCTION

Over the past decades, health systems globally have been subject to major challenges, generated by health crises, economic pressures, demographic changes

and the continuous need to adapt to technological innovations. Pandemics, such as the 1918 Spanish influenza or, more recently, the 1918 Influenza Pandemic Covid-19, have highlighted the need for increased responsiveness and adaptability of health institutions and the importance of a strong organizational framework to ensure continuity of health services in situations of uncertainty and systemic stress. In this context, health system resilience has become an increasingly used field of study, especially after the 2014 Ebola pandemic in West Africa and the Covid-19 pandemic, the World Health Organization (WHO) is asking national governments to increase the resilience of their health systems. At the same time, economic crises such as the 2008 crisis or accelerated inflation in various regions have reduced people's access to health services. The scale and complexity of the events facing health systems differ according to context, covering a multitude of situations, from national crises to everyday challenges. As hospitals are complex facilities providing vital health services, their resilience is important in mitigating the societal repercussions of disasters. However, in Romania, organizational resilience remains an under-explored concept.

The resilience of hospital facilities has become a preoccupation of the modern world, representing a complex process comprising a series of activities influenced by managers' decisions and the impact of their actions on the course of activities as well as on the results in the event of a crisis. It is well known that managerial decisions are reflected in the functioning of hospital facilities and thus in the health status of the population, which is essential for economic well-being and is considered a factor supporting socio-economic development. The concern of managers to provide high performance health services and the rapid increase in expenditure in this sector, together with the growing number of requests from patients, have heightened the need to identify all the factors influencing these aspects.

2. LITERATURE REVIEW

In 1973, Holling introduced the concept of resilience in the context of ecological systems, demonstrating how these systems can absorb and adapt to unpredictable disturbances (Holling, 1973). His theory was extended by (Levin, 1998) and (Walker and Salt, 2006) to the field of complex systems, including economics, politics and organizations. According to them, resilience is the capacity of systems to respond effectively to crises and change, emphasizing the importance of adaptability in the face of disturbances.

In 2007, McManus et al. provided a framework for assessing organizational resilience, based on research in ten New Zealand organizations. Their study showed that resilience depends not only on formal crisis response plans, but also on factors such as situational awareness and the ability to manage critical vulnerabilities. (Beer, 2009) contributed to our understanding of organizational

resilience by exploring how authentic leadership and an open organizational culture can help organizations adapt and perform in unpredictable environments.

Britt *et al.* (2012) proposed a framework for building resilience at the individual and community levels, particularly in the context of natural disasters. It emphasizes that resilience is not a fixed trait, but a capacity that can be strengthened through planned interventions and collaboration between different social actors.

More recent studies, Liu and Zhao (2015), have investigated the resilience of hospital networks, proposing collaborative planning models to optimize the use of resources in crisis situations. They demonstrated that increasing cohesion and collaboration among healthcare facilities can significantly improve the response to high demands during crises. We also mention the studies developed by Xiao and Cao (2017), Petrie *et al.* (2018), Patterson and Clark (2020). Tengblad and Oudhuis (2020) propose a comprehensive theoretical framework for understanding and developing organizational resilience at the EURAM 2019 Conference in Lisbon.

In 2017, the WHO declared resilience as an essential pillar of public health, emphasizing the need for health systems to be able to respond and adapt rapidly in the face of crises, a point also addressed by Arsenault *et al.* (2022). In this context, studies conducted in France and Spain during the COVID-19 pandemic emphasized the importance of a robust infrastructure and agile management to maintain health system functionality (Gonzalez *et al.*, 2020).

To emphasize the importance of the term, in 2021, the World Health Organization (WHO) adopted the term 'resilience' with reference to health, targeting sustainable development goals, in 'Health and well-being and the 2030 Agenda for Sustainable Development in the WHO European Region: an analysis of policy development and implementation' (WHO, 2021). Other research on health system resilience includes: Arsenault *et al.* (2022), Catussi Paschoalotto *et al.* (2023), Luke *et al.* (2023), Zhao *et al.* (2023), Al Asfoor *et al.* (2024), Zhong *et al.* (2024). Over time, the aim of researchers has been to translate health system resilience into an indicator that could be easily assessed: 'resilience research is the shift from purely conceptual thinking to looking for operational ways and means to build resilience' (WHO, 2017).

3. THE EVOLUTION OF THE HEALTH SERVICES IN ROMANIA

The evolution of health services in Romania is a complex subject, reflecting the country's economic, political and social transformations, influencing both access to and quality of health care. From the inter-war period to the present day, the Romanian health system has gone through numerous changes, starting with a centralized health system, up to the integration into the European Union and the implementation of fundamental reforms.

From the 17th century onwards, the first forms of public hospital appeared. The term "hospital" is attested in 1646 (Ionescu and Romanescu, 1970), and in 1704 the first modern hospital was established in Bucharest (Besciu, 2011). In parallel with the Church's efforts, timid attempts to organize a state medical system appeared, especially in the second half of the 18th century. Thus, pre-modern hospitals in the Romanian countries evolved from the charitable initiatives of the Church and the rulers towards institutionalized forms of care, inspired by Western European models (Chirita, 1997).

Modern hospitals were established in Romania, such as the Filantropia Hospital in Bucharest (1813), the first modern civil hospital. Other important institutions followed: the Grigore Alexandrescu Hospital (1886), the Rescue Society (1906) and the Central Military Hospital (1859) (National Archives Central National Historical Archives Service Administrative and Cultural Archives Office).

During the inter-war period, Romania enjoyed a relatively well-organized health system compared to other Eastern European countries (Reianu, 2020). During this period, regional and national hospitals were established and the health infrastructure was beginning to develop more rapidly. However, health services were accessible only to a small part of the population, mostly to those with higher incomes (Bucur-Deckard, 2002). After World War II, during the communist period, health services were nationalized and centralized, with the state taking full control of the health sector. The aim was to provide free access to health services for all citizens, but unfortunately this also resulted in a low efficiency of the system due to excessive bureaucratization and poor allocation of resources (Carroll, 2002).

After 1989, following the fall of the communist regime, Romania began a process of transition towards a more modern healthcare system closer to international standards (Pusca, 2018). During this period, the first major reforms were implemented, which aimed at opening the healthcare system to more Western practices and privatizing some services (Barna, 2014). However, the transition was marked by economic and social instability, which led to funding shortages and an underdeveloped healthcare infrastructure (Cace *et al.*, 2010).

After joining the European Union in 2007, Romania started to adopt clearer health policies, aiming to improve access to health services and introduce a more functional health insurance system (Abrán *et al.*, 2016). Thus, new forms of hospital management were implemented and reforms were introduced in the social health insurance system, leading to the consolidation of a health system based on a public-private mix. During this period, measures were introduced to modernize hospital infrastructure, but financial challenges and the lack of clear human resource management policies prevented a significant improvement in health services (Vlădescu *et al.*, 2016).

The year 2010 marked a period of economic austerity, which directly affected the health system (Owen, 1991). The reduction of public funds allocated to hospitals and the lack of investment in health infrastructure led to successive crises in hospitals, and health professionals were under major pressure (Rechel and McKee, 2009). In Romania, these issues led to an increase in the migration of doctors and medical staff to other countries. However, during this period significant progress has also been implemented, such as the partial digitization of the health system (electronic patient records, online appointments, etc.) and improved access to certain innovative treatments, thanks to EU support.

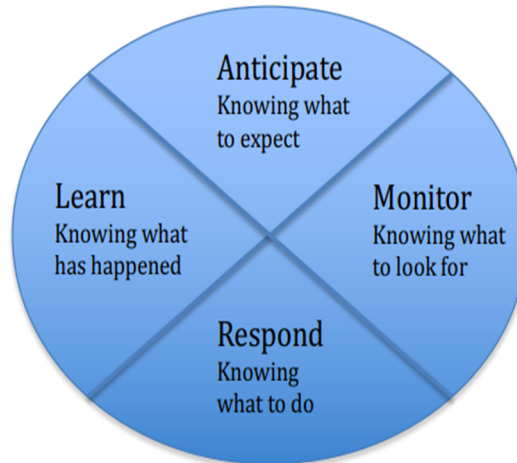
4. THE RESILIENCE OF HEALTH INSTITUTIONS

In an economic context marked by rising health care costs, an ageing population and the challenges posed by health and economic crises, strengthening the resilience of health facilities becomes a strategic priority for every state (Frenk and Knaul, 2002). Existing literature suggests that the resilience of a health system is influenced by several factors that include: (1) Financial and human resources: various studies have emphasized the importance of investments in hospital infrastructure and continuous staff training to enable institutions to respond quickly and effectively to health crises (Murray *et al.*, 2017). (2) The resilience of health organizations: organizations with a flexible structure that enables rapid reactions and well-informed decisions in the face of sudden changes demonstrate superior resilience (Lyng *et al.*, 2021). (3) Technology and innovation: digitalization and adoption of advanced technologies play a crucial role in developing a rapid and effective response to crises (Baker *et al.*, 2021). (4) Coordination and collaboration between institutions: collaboration between hospitals, government authorities, international organizations and NGOs is essential in ensuring a coherent and effective crisis response (Krasnopevtseva *et al.*, 2025).

According to Hollnagel *et al.* (2011) on (1) monitoring, (2) anticipating, (3) responding, and (4) learning abilities. If an organization has these skills, it is much better equipped to analyze and solve problems in a structured and practical way, and even more importantly it has the ability to learn from experience and improve the functioning of the system itself (Figure 1).

According to the literature (Achour and Price, 2010; Biddle *et al.*, 2020; Luke *et al.*, 2023), a resilient health system needs a (1) robust, modernized and adaptable infrastructure. In Romania, many hospitals operate in old buildings that are not up to current safety and efficiency standards. Investments in the renovation and expansion of health facilities, in modern medical equipment and efficient supply networks must become a constant for the proper functioning of the health sector. (2) Digitalization is, according to Iyamu *et al.* (2021) and Zheliuk *et al.* (2024), also a key resource for the efficiency, transparency and continuity of health services. An integrated information system that enables rapid access to

patient health data, resource management and communication between institutions can reduce response time and administrative errors. An important step was taken during the pandemic with the introduction of platforms for vaccination and reporting, but there is a need to scale up this process. Telemedicine, electronic health records and clinical management applications are indispensable tools for a resilient system, especially in remote or overstretched areas. (3) The health workforce is an important resource of any organization and health system.



Source: adapted from Hollnagel *et al.* (2011)

Figure 1. Four dimensions of the resilient organization

Thus, according to the literature (Forsgren *et al.*, 2022; Sheikhrabari *et al.*, 2022), the medical workforce is undesired to be well trained, motivated and protected. Romania is facing an acute human resource crisis, exacerbated by the exodus of medical professionals abroad. Continuing training, modern specializations, career opportunities and decent working conditions are key elements to build a resilient healthcare workforce. It also requires a human resource management system that anticipates long-term needs and balances between urban centers and deprived areas.

Institutional resilience depends on how the health system is governed (Debie *et al.*, 2024). Reforming administrative structures, reducing bureaucracy, clarifying responsibilities and evidence-based decision making can bring a qualitative leap in responsiveness. An effectively governed system is transparent, accountable and open to collaboration with civil society, academia and the private sector. In addition, it is essential to build trust between decision-makers, health professionals and the population, a decisive factor in any health crisis.

5. RESILIENCE OF HEALTH INSTITUTIONS IN THE CONTEXT OF THE COVID19 PANDEMIC IN ROMANIA

The Covid-19 pandemic has challenged all health systems worldwide, highlighting the weaknesses and strengths of health institutions (Barabadi *et al.*, 2020). In Romania, the pandemic has highlighted the acute need for reform, investment and effective coordination in the health system. At the same time, it has demonstrated the importance of institutional resilience, the ability to respond quickly, adapt and maintain its essential functions in the face of unprecedented challenges. Moreover, the literature (Patterson and Clark, 2020; Arsenault *et al.*, 2022; Catussi Paschoalotto *et al.*; 2023; Dagenais *et al.*, 2023; Ridde *et al.*, 2023; Zhao *et al.*, 2023) shows that several health systems have faced difficulties in the fight against Covid-19.

Resilience is not reduced to the ability of hospitals to treat patients, but involves a set of factors: adequate infrastructure, well-trained staff, effective leadership, equipment stocks, coherent communication and, last but not least, public trust (Wang *et al.*, 2020). In Romania, the beginning of the pandemic caught the health system by surprise with underfunded hospitals, insufficient medical staff and poor institutional organization. However, some hospitals were rapidly reorganized into Covid-19 units, emergency procurement was activated, and digitization of the reporting system made rapid progress. Another key issue was the mobilization of human resources, as medical staff worked under unprecedented conditions of exhaustion and risk. However, the lack of a pandemic preparedness plan and clear protocols led to chaos in the first months. Public communication was often inconsistent, fueling public distrust and resistance to protective measures or vaccination. Inequalities between regions and inequitable access to services also exposed a chronic problem in the Romanian health system: the significant urban-rural divide.

The Covid-19 pandemic has shown that a resilient health system is not built in times of emergency, but through strategic investment and long-term vision. To build real resilience in the future, Romania needs clear public policies focused on prevention, sustainable financing, digitalization and continuous training of health professionals. Primary and community healthcare networks need to be strengthened so that hospitals do not remain the only "front line" in the face of crises. Moreover, health system reform must be oriented towards transparency, equity and institutional accountability. The Covid-19 pandemic was a turning point in the evolution of health services in Romania. The health system was subjected to unprecedented challenges and the shortcomings of infrastructure and human resources became evident. However, the pandemic accelerated the digitization of services and brought to the forefront the urgent need for investment in hospitals, medical staff and public health systems. Many hospitals were modernized to cope with the health crisis and medical education was rapidly adapted to the new pandemic conditions.

The resilience of a health institution requires: (1) A capacity to respond rapidly to health emergencies. (2) Adaptability to external pressures (epidemics, staff migration, economic crises). (3) Continuity of essential services in situations of systemic stress. (4) Public trust and transparency in communication. (5) Competent leaders and clear decision-making systems.

Directions to strengthen resilience: (1) Strategic investments in infrastructure, modern regional hospitals, equipped emergency centers, efficient medical circuits. (2) Staff training and retention, incentives to stay in the public system and in disadvantaged areas. (3) Management reform, professionalization of hospital leadership and depoliticization of decisions. (4) Increased digitalization, interoperability between databases, telemedicine, automated decision algorithms. (5) Continuity and crisis response plans, simulated, tested and constantly updated. (6) Partnerships with private sector and NGOs, effective collaborations in crisis situations.

6. CONCLUSIONS

The impact of the medical and economic crises has highlighted the structural limitations of the Romanian healthcare system and the urgent need for transformation. Without resilient institutions capable of operating coherently and efficiently in the face of pressures, any progress cannot be sustainable. Thus, strengthening the responsiveness and resilience of the health system must no longer be seen as a secondary objective, but as a national priority.

The resilience of health institutions is a necessity in a world of instability, rapid change and recurrent crises. The effects of the Covid-19 pandemic are still being felt across the globe, revealing stark realities about health systems and the links between health and the global economy. Recent years have shown that healthcare is not just a sector in its own right, but part of the whole economy. As trade, industry and services have been paralyzed, the pandemic has shown that the economic health of a nation is as vital as the health of its citizens.

Over time, Romanian society has been deeply affected by the overlap between medical problems and economic crises, which have slowed down socio-economic development and exposed the fragility of public institutions. The economic crisis of 2008-2010 had a severe impact on the healthcare system, leading to budget cuts, hiring freezes and mass migration of medical staff to other EU countries. These imbalances left deep scars in the responsiveness of health institutions. The Covid-19 pandemic, which occurred in a context already marked by underfunding and inequity, highlighted the lack of emergency preparedness: overcrowded hospitals, insufficient equipment, poor coordination and a population with low confidence in the system. However, some institutions have managed to adapt their work rapidly, demonstrating forms of institutional resilience. Health institutions in Romania have demonstrated a basic resilience in the face of crises, but remain structurally deeply vulnerable. Strengthening them

cannot be achieved through isolated interventions, but through a coherent and integrated strategy, with a focus on investment, professionalism and transparency. Building resilient health institutions, able to function effectively in times of crisis as well as in times of stability, is essential to prevent the recurrence of these difficulties in the future. Such resilience is not only about emergency response, but also about strategic planning, sustainable investment, human resource preparedness and trust in healthcare.

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AUTHORITY VS. TOPICAL AUTHORITY (RELEVANCY) IN THE WORLD OF AI

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Abstract

This article examines the distinctions between relevance, authority, and topical authority in SEO, with a focus on how artificial intelligence (AI) is reshaping content strategy and ranking dynamics. While topical authority is often treated as a novel ranking factor, the paper argues it is more accurately viewed as a structured extension of relevance rather than a separate algorithmic signal.

Through a two-phase model – relevance filtering followed by authority-based sorting – the article clarifies how search engines evaluate and rank content. It challenges common misconceptions, such as the overemphasis on content quality alone, and underscores the continued importance of external trust signals like backlinks and brand recognition.

The paper also analyzes AI's role in expanding semantic coverage and scaling content production, while highlighting its limitations in generating true authority. The conclusion advocates for a hybrid SEO strategy that leverages AI for relevance optimization while relying on human expertise and relationship-building to earn authority. In an age of automated content, long-term visibility still depends on authentic credibility and experiential knowledge.

Keywords: *SEO; topical authority; authority; relevance; digital marketing,*

JEL Classification: M31.

1. INTRODUCTION

In the rapidly evolving industry of Search Engine Optimization (SEO), few terms have garnered as much attention – and confusion – as topical authority. Over the past several years, the phrase has become a mainstay in the SEO discussion, used by marketers, influencers, and course creators alike. It is frequently portrayed as a distinct and critical ranking factor, one that content strategists must urgently master if they aim to have their content show up on the first page of search engines (also referred to as SERPs). However, this widespread enthusiasm for the term has given rise to a conceptual ambiguity that threatens to obscure the actual mechanics behind how search engines evaluate and rank web content. We could even go as far as saying that topical authority has become a buzzword that is generally used

to sell expensive courses to people who want to learn how to write engaging content that search engines will reward with good rankings.

This article critically examines the true nature of topical authority and challenges the notion that it represents a standalone ranking signal. It argues that topical authority is not a new metric, but rather a rebranding of the more established concept of relevance. On their own platform, Google states that: “The most basic signal that information is relevant is when content contains the same keywords as your search query. For example, if those keywords appear in the headings or body text of a webpage, the information might be more relevant”. In time the SEO and content industry has broadened the scope of the term to encompass ideas like content depth, topical clustering, and internal linking structures. These elements ultimately serve to enhance a page’s or domain’s semantic alignment with user queries – i.e., their relevance in the eyes of search algorithms as described in the Search Quality Evaluator Guidelines document provided by Google.

At the same time, the article revisits the concept of authority, which continues to serve as the decisive factor for search rankings once relevance has been established. Authority is primarily constructed through external signals such as backlinks from trusted sources, brand recognition, and user trust indicators (Page *et al.*, 1999). Without authority, even the most semantically aligned content may fail to achieve visibility on competitive search engine results pages (SERPs). This is because search engines do not yet have the capacity to discern between good content and poorly written content, having therefore to rely on these external factors that validate the quality of the information.

The need to clarify these distinctions has become even more important with the proliferation of artificial intelligence (AI) in content creation. AI has significantly accelerated the volume and speed at which digital content is produced, leading to saturated topical clusters and diluted informational ecosystems. While AI models can facilitate keyword targeting and semantic optimization – thereby improving relevance – they cannot independently generate the kinds of authority that search engines continue to reward. In this context, understanding the boundaries between relevance and authority is crucial for developing robust SEO strategies in an AI-driven environment.

Through a combination of theoretical clarification, empirical insights, and strategic recommendations, this article aims to provide SEO practitioners, digital marketers, and researchers with a more coherent framework for understanding how websites are evaluated and ranked. By distinguishing between what search engines recognize as relevant content and what they trust as authoritative, we hope to move beyond industry jargon and toward evidence-based, algorithmically aligned SEO practices.

2. DEFINITIONS AND CONCEPTUAL CLARIFICATIONS

Clear distinctions between key concepts are essential for understanding the workings of modern SEO. Although the terms relevance, authority, and topical authority are often used interchangeably in the industry, they represent distinct operational elements in how search engines evaluate and rank content. Misinterpreting these terms not only leads to flawed strategies but also contributes to the propagation of ineffective SEO practices.

2.1. Relevance

In the context of information retrieval systems like Google Search, relevance refers to the extent to which a webpage's content aligns with the intent behind a user's query (Manning *et al.*, 2008). It is a content-driven metric that determines whether a page should be included in the pool of potentially rankable results. Relevance is assessed through a combination of semantic matching, keyword usage, contextual cues, and increasingly, natural language understanding models such as BERT (Devlin *et al.*, 2019) and MUM (Nayak, 2020).

The most important observation is that a webpage does not need to contain the exact keyword to be considered relevant. Search engines now evaluate semantic proximity, using co-occurrence data, topic modeling, and search intent signals to determine relevance even when keywords are paraphrased or implied. Additionally, backlinks with a keyword-rich anchor text can further reinforce relevance, allowing external sites to "signal" what a page is about.

2.2. Authority

Once a webpage is deemed relevant for a query, the next step in the ranking process involves evaluating its authority. Authority is an extrinsic metric, determined by how trustworthy or credible a source appears in the broader digital ecosystem. The most significant signal of authority remains the quantity and quality of backlinks from other domains (How Google Search Works). Not all links are equal – those from well-established, contextually related websites pass more link equity (also referred to as link juice in the SEO industry).

Factors that influence authority:

- Domain age and reputation: Older domains with a consistent history of accurate content tend to rank better. These also tend to rank for more search queries.
- User behavior metrics: Signals like dwell time, bounce rate, and return visits may serve as indirect proxies for trust. In theory, search engines such as Google look at how the user interacts with a page to judge if the content is a good fit for the search query.
- Mentions in reputable sources: Brand citations and unlinked references can also contribute to authority recognition. As a rule, sites with high reputation transfer more authority to the pages they link out to.

The key takeaway is that authority is built externally and cannot be fabricated solely through on-page optimization.

2.3. Topical authority: a semantic rebranding of relevance

Topical authority is often described as the degree to which a website demonstrates expertise and depth across a subject area. Here are the definitions for topical authority from three well known digital marketing platforms:

Ahrefs: Topical authority is an SEO concept where a website aims to become the go-to authority on one or more topics. Building topical authority is about helping search engines understand a website's topic so that it has better potential to rank for topically related keywords (Sheridan, 2023).

Semrush: Topical authority refers to a website's expertise and credibility on a particular subject. And building it through high-quality content is a powerful way to establish your expertise and credibility on subjects relevant to your business. This helps with earning your target audience's trust, improving your search engine rankings, and possibly driving more conversions (Go, 2024).

SurferSeo: Topical authority in SEO is your website's perceived expertise and reliability about a specific subject. If your site has high topical authority, Google considers it more trustworthy and ranks it higher in search results than sites it considers less credible (Frederick, 2024).

While these descriptions seem to imply a SEO dimension, a closer inspection reveals that topical authority is, in essence, contextualized relevance. For instance, a website that publishes 50 articles on different aspects of machine learning will have higher topical authority for that subject than a general tech site with one machine learning article. However, the site's high topical authority is achieved through layered and interconnected relevance – not through a unique algorithmic mechanism.

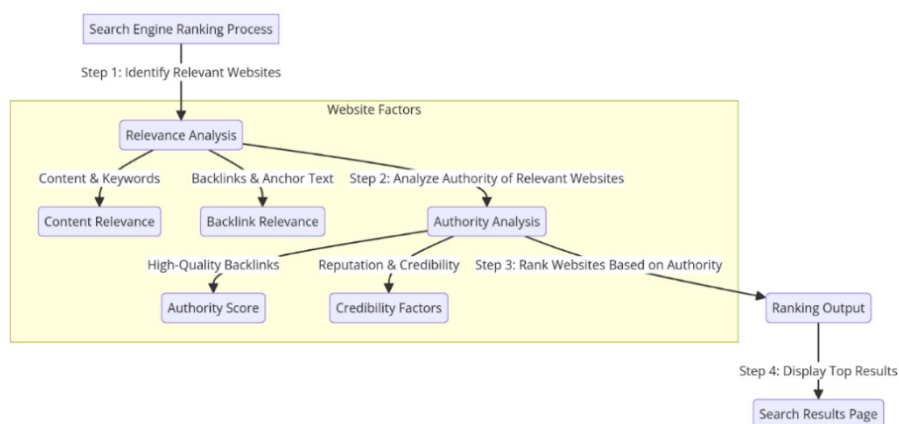
The confusion arises because the industry has begun to treat topical authority as an authority type, when in fact it is a content structuring strategy designed to optimize semantic relationships (DeMott, 2023) and signal topical coverage to search engines. Common implementations include:

- Content hubs or topic clusters – structuring content around main topics that are supported by secondary articles.
- Internal linking strategies – using either silo structures or contextual linking associated with topical clusters so that search engine crawlers have an easier time in discovering related pages and content.
- Semantic keyword mapping - Semantic keywords are words or phrases that are conceptually related to a given keyword or topic (Handley, 2024). In other words, Google doesn't just look for the user's search terms on a page. It tries to match the meaning of the query with the meaning of the page.

While these techniques improve a website's perceived depth and breadth, they function by enhancing relevance signals, not by replacing the need for traditional authority.

3. HOW SEARCH ENGINES ACTUALLY RANK CONTENT

Understanding the actual ranking mechanics used by modern search engines is essential for distinguishing between relevance, authority, and the so-called topical authority. While industry terminology often blends these concepts, search engines operate on a structured, multi-phase system grounded in principles from information retrieval and graph theory (Suzart, 2020). This section outlines the two-stage ranking process and explores how both relevance and authority contribute to final search engine results page (SERP) positions. Figure 1 illustrates how search engine algorithms try to provide the best result for search queries:



Source: created by the author

Figure 1. Search engine ranking process

The initial phase in the ranking pipeline involves identifying all documents that are relevant to a user's search query. This process is executed using a variety of techniques:

Keyword Matching: Though less critical than in earlier SEO eras, exact or partial matches still play a role, particularly in page titles, headers, and anchor text.

Semantic Search Algorithms: With the introduction of models like BERT and MUM, Google has shifted toward intent-based matching, which enables it to understand paraphrased, implied, or contextually related language.

Content Clustering: Pages that belong to a broader semantic topic cluster often benefit from enhanced relevance detection due to internal link signals and co-occurrence of related entities.

If a webpage fails to demonstrate sufficient semantic alignment with the query, it will not appear in the search results, regardless of its authority. In other words, authority has no bearing if relevance is not first established.

3.1. Phase two: authority-based sorting

Once a candidate set of relevant documents has been identified, the second phase begins: ranking these documents by authority. Search engines apply a range of signals to determine which relevant pages are the most trustworthy or influential:

Backlink Analysis: Pages with inbound links from domains that are themselves authoritative are given higher weight in rankings.

Topical Relevance of Linking Domains: Links from sites within the same semantic field contribute more than unrelated or generic domains.

Behavioral Signals: User engagement metrics such as dwell time, bounce rate, and click-through rate may serve as secondary signals, though their role is debated and likely context-dependent.

This two-step process – relevance filtering followed by authority sorting – can be seen as a foundational principle of modern search engine architecture. Relevance is a necessary condition for ranking, but not a sufficient one.

A useful analogy for understanding how authority functions in SEO is drawn from the academic publishing field. In academia, the perceived importance and credibility of a scientific paper are heavily influenced by how often it is cited by other reputable research articles. A paper that consistently receives references from high-impact journals accumulates academic authority, signaling to the broader community that its findings are valuable, trustworthy, and influential.

Similarly, in the domain of search engine optimization, a website's authority is not determined solely by the quality of its content, but by the volume and quality of inbound links it receives from other authoritative websites. Each backlink functions much like a scholarly citation: it is an external validation of the site's relevance, trustworthiness, and importance within its field. Notably, just as not all academic citations carry equal weight – citations from top-tier journals are valued more highly than those from obscure sources – not all backlinks contribute equally to authority. Links from established, high-authority domains in relevant topical niches are weighted far more heavily by search engines than links from unrelated or low-trust sites.

This academic citation model, as shown in Table 1, also illustrates the cumulative nature of authority. A newly published scientific paper, no matter how groundbreaking, will not be immediately recognized as authoritative until it has undergone peer acknowledgment and widespread citation. In parallel, a newly launched website, even with exceptional content, will not rank highly until it builds a network of endorsements – backlinks – that signal its trustworthiness and influence to search engines. Thus, both in academia and SEO, authority is not a

static or intrinsic quality but an emergent property that must be earned over time through external validation.

Table 1. How academic papers and websites gather authority

Academic paper	Website
Grows in authority through citations	Grows in authority through backlinks
Citations from top journals carry more weight	Backlinks from high-authority sites carry more weight
Authority builds slowly over time	Authority builds slowly through link acquisition
Peer acknowledgment is critical	External endorsement via links is critical

Source: created by the author

3.2. The ranking formula in practice

To illustrate this dual-phase approach, consider a hypothetical search for “best noise-cancelling headphones 2025”. This keyword is targeted by both amateur and professional publishers as it clearly has commercial intent – the user is looking to buy. Therefore, we will often encounter the following scenario:

Site A is a brand-new blog of a person who is very passionate about music, knows a lot about HiFi equipment, may even have technical knowledge on the subject. The site has a well-written review with the target keyword and supporting semantically related phrases but being new has no backlinks.

Site B has a less in-depth article but is published by a well-known tech site with thousands of backlinks and years of reputation. Publishers like Cnet, New York Times, Wired and others often occupy the first positions in the SERP for search queries like the one being discussed.

Although both are relevant, Site B will almost certainly rank higher due to its higher authority, even if its content is inferior in objective quality. This example illustrates the asymmetry in SEO performance: relevance is necessary to qualify for ranking, but authority is essential to compete for top positions. This is a consistent pattern across most competitive search queries and forms the empirical basis for authority-focused SEO strategies.

3.3. Misinterpretations and overreliance on tools

A major contributor to confusion around SEO strategy stems from widespread reliance on third-party authority metrics such as Domain Authority (DA) from Moz or Domain Rating (DR) from Ahrefs. These metrics were created to mimic the Page Rank Algorithm developed by Google that “determines the relative importance of a page within the World Wide Web. It does so by looking at the quantity and quality of other pages linking to it and then assigning a value to it based on those backlinks” (Ahrefs SEO Glossary). While the page rank metric was publicly available until 2016, the rise in the practice of buying and selling

links in order to influence rankings made Google remove this feature from its suite of tools.

Both DA and DR are heuristic models built to simulate elements of Google's PageRank algorithm, attempting to quantify a domain's relative "strength" based on its backlink profile. However, these scores are calculated using proprietary formulas and incomplete link indexes. As such, they may differ significantly between tools, and neither is directly factored into Google's ranking algorithms. Overemphasizing these numbers can mislead SEO practitioners into prioritizing vanity metrics over actionable signals such as link relevance, link quality, and topical trust.

A critical pitfall arises when website owners pursue backlinks solely to boost DA or DR without considering whether those links are contextually relevant or trustworthy. In Google's framework, a single backlink from a topically authoritative, high-trust site can outweigh dozens of irrelevant or low-quality links, regardless of the linking domains' DA or DR scores. Authority in SEO is context-sensitive, and is evaluated based on thematic relevance, trustworthiness, and natural link profiles – not just raw link quantity or artificial numerical scores.

Furthermore, an overreliance on DA/DR can obscure strategic priorities. For instance, in highly specialized verticals, a site with modest DR but deep topical relevance and strong community trust can outperform a higher-DR generalist site. SEO strategies, therefore, should emphasize earning authoritative endorsements from within the same topical ecosystem, rather than chasing inflated DA/DR metrics detached from the actual search intent and content quality.

Understanding the limitations of third-party metrics allows SEO practitioners to develop strategies grounded in the operational realities of modern search engines. Authority remains indispensable for high rankings, but it must be cultivated through real, topic-relevant, and trust-driven endorsements, not artificially optimized through superficial numeric benchmarks.

4. COMMON MISCONCEPTIONS AND INDUSTRY MYTHS

Despite significant advancements in how search engines retrieve and rank information, persistent misconceptions continue to circulate within the SEO industry. Many of these myths originate from oversimplifications of algorithmic processes, misinterpretations of search engine guidelines, or commercial interests aiming to promote particular services and tools (influencers or agencies trying to sell courses or qualifications). This section critically examines some of the most pervasive myths, particularly those that blur the boundaries between relevance, authority, and topical authority.

4.1. “Content is king” – a misguided doctrine

One of the most enduring myths in SEO is the assertion that “content is king.” While high-quality, relevant content is undeniably essential for achieving initial

relevance, it is not, by itself, a guarantee of high search engine rankings (Google Search Central). Numerous empirical studies and practical observations demonstrate that even excellent content will fail to rank competitively if it lacks sufficient authority signals such as backlinks, brand citations, and user trust indicators.

The misunderstanding stems from a failure to recognize that search engines are algorithmic systems, not human readers. Google does not "read" content in a human sense to judge its quality subjectively. Instead, it relies on external signals – primarily link structures and user behavior patterns – to infer a document's authority and importance (Fishkin, 2015). Without these signals, content, no matter how high its intrinsic quality, is unlikely to achieve prominence in competitive search landscapes.

A useful analogy for understanding how search engines evaluate authority – without truly "reading" content – comes from the music industry. Table 2 shows how the workings of the music industry could be compared to the algorithms employed by search engines. Imagine a developer tasked with creating an artificial intelligence (AI) system capable of determining whether a song is "good." One method would be to engineer an advanced AI capable of listening to each track, understanding musical composition, interpreting lyrical depth, and assessing emotional impact. However, designing such an AI would be incredibly complex, subjective, and error-prone, given the nuances of artistic quality.

Table 2. How SEO authority mirrors the music industry

Music industry	Search engines
Building AI to judge music quality is complex and subjective	Building AI to judge content quality is complex and subjective
Sales data serves as a proxy for a song's success	Backlinks serve as a proxy for a page's authority
Popular songs are assumed to have value based on sales	Authoritative pages are assumed to have value based on backlinks
Success is estimated by external validation	Authority is inferred through external trust signals

Source: created by the author

A far simpler and more scalable approach would be to measure *sales data*. If a song sells millions of copies, it is generally assumed to be popular and, by extension, of significant value to listeners. In this model, commercial success serves as a proxy for quality, even if the true artistic merit varies.

Search engines like Google employ a comparable method for assessing web content. Rather than "reading" and judging the subjective quality of each page – an extraordinarily difficult computational problem – Google relies on external authority signals to approximate content quality. Chief among these signals are

backlinks from other reputable websites, which function much like "sales numbers" in the music analogy. A webpage that receives numerous endorsements through backlinks is treated as more valuable, regardless of subjective assessments of its writing, design, or originality.

Thus, just as sales are not a perfect measure of musical artistry but serve as an effective approximation at scale, backlinks and authority metrics serve as scalable proxies for content trustworthiness in the vast ecosystem of web pages. This reality underscores why content alone – no matter how well-written – cannot guarantee high rankings without accompanying external validation.

Just as high sales – not intricate musical analysis – indicate a song's success, backlinks and trust signals – not subjective content evaluation – indicate a webpage's value to search engines.

4.2. Anchor text over-optimization and the risks of manipulation

Another myth is the belief that more keyword-rich anchor text links always yield better rankings. While exact-match anchors can indeed boost relevance for specific keywords, excessive or manipulative use of this tactic can trigger penalties from search engines (Ashbridge, 2023). Google's Penguin algorithm update specifically targeted unnatural link profiles characterized by over-optimized anchor text, resulting in significant ranking penalties for many sites.

Modern SEO best practices advocate for a natural anchor text distribution, mixing branded, generic, partial match, and contextual anchors to reflect organic linking behavior. The goal is not to "game" the system but to build a credible link profile that withstands algorithmic scrutiny.

4.3. The myth of authority without relevance

A further misconception holds that a highly authoritative domain can rank for any topic, regardless of content relevance. While strong domain authority can sometimes provide a competitive advantage in marginal or highly ambiguous queries, relevance remains a prerequisite for ranking consideration. Search engines initially assess *whether* a page's content aligns with a user's query before applying authority as a sorting factor. Without clear topical alignment, even the most authoritative domains will struggle to achieve meaningful visibility for unrelated searches.

Consider, for instance, a highly reputable financial news website, such as Investopedia.com. Its domain possesses substantial authority due to decades of publishing trusted, well-cited financial content. However, if Investopedia were to publish a single, superficial article reviewing the "Top 10 Home Coffee Makers," it would not automatically outrank niche appliance review sites like Wirecutter or The Spruce Eats, both of which have deep topical relevance and established authority within the home appliances and consumer goods space. Despite Investopedia's higher general domain authority, its lack of content depth, topical

cluster support, and audience trust in the home goods vertical would prevent it from easily displacing specialist sites.

This illustrates that authority amplifies relevance but does not substitute for it. Search engines prioritize content that fits a coherent topical ecosystem, where related articles, internal linking structures, and consistent audience engagement reinforce the site's credibility within that subject domain. Thus, effective SEO strategies must develop both relevance and authority simultaneously, ensuring that domain strength is contextually appropriate to the targeted queries. Table 3 highlights common myths in the SEO industry, where minimal entry barriers enable individuals to self-identify as SEO experts, regardless of formal training. The second column shows what actually happens in the SEO race.

Table 3. Dispelling myths

Myth	Reality
High-authority domains can rank for anything	Authority amplifies relevance but cannot replace it
Publishing one article is enough to compete in new topics	Search engines reward topical ecosystems, not isolated content
Strong brands automatically dominate all queries	Content depth, topical clustering, and audience trust are still necessary
Authority overrules content relevance	Relevance is the first filter; authority sorts among relevant candidates

Source: created by the author

Dispelling these persistent myths is critical for aligning SEO strategy with the actual operational principles of modern search engines. Content quality, while necessary, must be complemented by authority-building activities. And most importantly, relevance and authority must be developed in tandem, respecting the nuanced demands of semantic search and trust-based ranking systems.

5. THE ROLE OF AI IN SHAPING RELEVANCE AND AUTHORITY

The rapid development of artificial intelligence (AI) technologies has profoundly transformed the digital content landscape, with direct implications for how relevance and authority are constructed in SEO. While AI-driven models have enhanced the speed, scale, and semantic sophistication of content production, they have simultaneously introduced new complexities and risks. Understanding the evolving role of AI is critical for developing strategies that strengthen both relevance and authority in an increasingly automated ecosystem.

5.1. AI's impact on relevance: scale, semantic matching, and saturation

One of AI's most significant contributions to SEO is its ability to generate large volumes of semantically optimized content rapidly. Tools based on large

language models (LLMs), such as OpenAI's GPT series or Google's internal BERT and MUM technologies, enable content creators to produce articles, product descriptions, and blog posts that are finely tuned to capture user intent.

Up to now AI excels at:

- *Semantic keyword coverage*: Ensuring that related terms, entities, and contextual language appear naturally within the text.
- *Content clustering*: Assisting in the rapid creation of topic clusters and pillar content models, thereby enhancing topical relevance.
- *Gap identification*: Highlighting under-served queries and enabling content strategies that fill search intent voids.

However, this scaling of relevance brings about content saturation. As AI makes it easier to flood the internet with surface-level, semantically correct content, achieving mere relevance is no longer a competitive advantage. While semantic relevance remains necessary for inclusion in search results, it is no longer sufficient for competitive rankings. In increasingly saturated topical environments, content must go beyond merely matching user queries; it must also demonstrate depth, originality, and experiential authority to distinguish itself from the vast array of AI-generated and low-effort materials now populating the web.

- *Depth* refers to the comprehensive treatment of a subject. Shallow overviews that briefly touch on a topic are easily replicated by AI and widely available online. By contrast, content that delves into nuanced subtopics, provides detailed breakdowns, offers case studies, and explores complex scenarios is far more likely to signal true expertise. For example, a superficial blog post listing "5 Marketing Tips" would struggle to compete against a detailed 5,000-word guide that explains not only the tips but also their psychological foundations, real-world applications, and potential pitfalls across different industries.
- *Originality* involves contributing new insights, perspectives, or research rather than merely summarizing existing knowledge. Search engines increasingly reward content that brings something novel to the conversation. A generic article on "best smartphones in 2024" would find it difficult to outperform a review based on first-hand testing results, or one that introduces a unique ranking methodology (e.g., battery efficiency under extreme temperature conditions), providing information unavailable elsewhere.
- *Experiential authority* emphasizes content produced by individuals or entities with first-hand, verifiable experience in the subject matter. Google's E-E-A-T framework explicitly prioritizes authors who demonstrate real-world interaction with their topics. For instance, an article titled "*How to Train for a Marathon*" authored by a certified running coach who has completed multiple marathons – and includes personal anecdotes, custom training plans, and images from races – will

rank more favorably than a generic AI-compiled summary sourced from publicly available blogs.

In short, *depth* ensures a comprehensive exploration of the topic, *originality* adds distinctive value to the informational landscape, and *experiential authority* authenticates the credibility of the author and the content itself. These factors are becoming decisive differentiators in environments where basic relevance is abundant but genuine expertise and value are increasingly scarce.

Thus, while AI enables broader and faster relevance coverage, it simultaneously raises the baseline standards for what counts as valuable and distinguishable content in search results.

5.2. AI's limits: authority remains a human-driven asset

Despite AI's strengths in optimizing for relevance, it is fundamentally limited in its ability to generate authority. Search engines continue to rely on external signals – particularly backlinks from reputable, contextually relevant sources – to infer trust and credibility. These endorsements must be earned through human relationships, genuine brand reputation, and editorial discretion.

AI cannot autonomously:

- Secure high-quality backlinks from trusted domains.
- Build brand recognition and loyalty among real-world audiences.
- Foster genuine citations in authoritative publications.

Efforts to automate backlink generation often fall into the realm of black-hat SEO and are prone to penalties under search engine quality guidelines. Authority remains an organic, human-centered phenomenon: it is conferred by independent actors, not manufactured at scale through automated content output.

Thus, while AI can amplify a site's relevance footprint, building authority still demands deliberate human effort, including relationship-building, digital PR strategies, thought leadership initiatives, and community engagement.

5.3. Search engines' response: emphasizing E-E-A-T and authenticity

Recognizing the challenges posed by AI-generated content, search engines have adapted by placing greater emphasis on *E-E-A-T* signals: Experience, Expertise, Authoritativeness, and Trustworthiness. Figure 2, as shown in the Google Search Quality Evaluator Guidelines, gives the exact meanings of these terms. These definitions are provided by Google for their human evaluators, to help them determine if a piece of content is indeed valuable. Using this feedback, the search algorithms are improved.

	Experience: Consider the extent to which the content creator has the necessary first-hand or life experience for the topic. Many types of pages are trustworthy and achieve their purpose well when created by people with a wealth of personal experience. For example, which would you trust: a product review from someone who has personally used the product or a "review" by someone who has not?
	Expertise: Consider the extent to which the content creator has the necessary knowledge or skill for the topic. Different topics require different levels and types of expertise to be trustworthy. For example, which would you trust: home electrical rewiring advice from a skilled electrician or from an antique homes enthusiast who has no knowledge of electrical wiring?
	Authoritativeness: Consider the extent to which the content creator or the website is known as a go-to source for the topic. While most topics do not have one official, Authoritative website or content creator, when they do, that website or content creator is often among the most reliable and trustworthy sources. For example, a local business profile page on social media may be the authoritative and trusted source for what is on sale now. The official government page for getting a passport is the unique, official, and authoritative source for passport renewal.

Source: *Google Search Quality Evaluator Guidelines*, available at:
<https://services.google.com/fh/files/misc/hsw-sqrg.pdf>

Figure 2. E-E-A-T as described by Google

Recent algorithm updates have increasingly prioritized:

- *First-hand expertise:* Content created by individuals with verifiable, direct experience in the subject matter.
- *Credibility of the source:* Preference for recognized authorities within a domain.
- *Original reporting and insights:* Rewarding content that adds new information rather than rehashing existing sources.

AI, while capable of paraphrasing and summarizing existing knowledge, struggles to produce the original thought and subject-matter depth that these signals reward. As a result, human-led contributions are becoming more – not less – critical for achieving sustainable visibility in an AI-influenced search environment.

To sum up, artificial intelligence has noticeably expanded the playing field for relevance by enabling rapid, scalable, and semantically rich content production. However, the construction of authority remains stubbornly resistant to automation, rooted instead in human credibility, trust networks, and external validation. SEO practitioners must therefore adopt a hybrid strategy: leveraging AI for relevance optimization while investing in human-driven authority building efforts to remain competitive in a landscape increasingly shaped by automation and algorithmic scrutiny.

6. CONCLUSION

While the digital marketing ecosystem evolves under the twin pressures of automation and information saturation, the distinctions between *relevance*, *authority*, and *topical authority* become more crucial than ever for sustainable SEO success. This article shows that while relevance serves as the necessary filter that determines inclusion in search engine results, authority remains the decisive

factor in competitive ranking hierarchies. Contrary to recent industry trends that elevate topical authority as a novel concept, it is clear that topical authority is fundamentally an expression of layered relevance, not a standalone metric.

The proliferation of AI technologies has redefined the competitive baseline for semantic relevance, making it easier to produce content that satisfies keyword matching and user intent on a surface level. However, AI cannot independently generate the trust signals, brand loyalty, and authoritative endorsements that are critical for achieving enduring visibility. Authority continues to be a human-driven asset, earned through meaningful engagement, experiential expertise, and genuine contributions to one's topical ecosystem.

SEO practitioners, content strategists, and digital marketers must therefore recalibrate their methodologies. Success in the AI-driven landscape requires a hybrid strategy: harnessing AI for scalable, semantically optimized relevance, while investing human creativity and relationship-building efforts to cultivate true authority. The fusion of these two dimensions – intelligent automation aligned with authentic expertise – will distinguish the ephemeral from the enduring in the evolving search environment.

To sum up, clarity about the operational roles of relevance and authority empowers practitioners to move beyond industry buzzwords and anchor their strategies in the true mechanics of search algorithms. As the digital environment is increasingly shaped by automation, human authenticity, trust, and experiential insight will remain irreplaceable competitive advantages.

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THE IMPACT OF AI ON EU ADMINISTRATIVE RULES

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Abstract

Artificial Intelligence (AI) is an evolving technology that has a significant impact on many sectors, including European Union (EU) administration. In the European Union, administrative regulations play a key role in ensuring the proper functioning of the rule of law and the protection of fundamental rights.

Our paper aim is to see whether EU laws regarding AI have brought added value and efficiency to both the public administration and the final beneficiary, the citizen.

The methodology of research is based on the analysis of the EU regulations in the field of the AI and a critical overview on the transposition legislation in Romania, mainly at the level of public administration authorities. The results of our analysis show that Romania, as a member state of the European Union, has adopted and take over the European Union regulations and directives that refer to Artificial Intelligence, those related to algorithmic transparency, accountability of automated decisions, AI ethics and international collaboration. The public administration authorities take the measures for making the regulations effective. While the EU legal framework on AI has laid a solid foundation for responsible and transparent implementation, its true added value lies in the extent to which member states, such as Romania, effectively transpose and operationalize these norms within their public administrations to better serve the citizens.

Keywords: *artificial intelligence; legislative regulations; AI Act; GDPR.*

JEL Classification: K23; K24; O33; H83.

1. INTRODUCTION

Artificial Intelligence (AI) is an important factor behind the rapid development of technologies and has a direct impact on regulations in all areas, including the European Union (EU) administrative and regulatory areas. AI influences data protection regulations, algorithmic transparency, protection of citizens' rights, ethics and accountability of automated decisions.

Artificial intelligence refers to computer systems that can perform tasks that would normally require human action: machine learning, big data analysis, speech and visual recognition, and decision-making. In government, AI is used to improve the efficiency and transparency of governance, including in decision-making processes, service delivery, performance evaluation of different institutions and data management.

Our paper aim is to investigate the impact of European Union legislation on artificial intelligence on public administration and the citizen, as the final beneficiary. In this regard, the research methodology used is the analysis of the European regulatory framework and its transposition and implementation at the level of public administration in Romania, as an EU member state. The conclusions of our research are that the Romanian state has managed to integrate European regulations and directives regarding artificial intelligence, such as those on responsibility, ethics, transparency and international cooperation in this field.

2. ADMINISTRATIVE REGULATIONS OF THE EUROPEAN UNION

The European Union emphasizes the proper functioning of the rule of law, the protection of fundamental rights and the maintenance of a fair business environment in view of the complex confrontations related to the regulation of IA.

Among the European Union's regulations on IA, we can notice:

The General Data Protection Regulation (GDPR): The main aim of the GDPR is to create a framework of trust in the relationship between companies and users, protecting personal data from misuse. AI has an important role to play in data protection regulations, in particular in the collection, processing and use of personal data. The sheer volume of sensitive personal data being handled requires careful attention to their privacy and security. In this context, the GDPR was adopted to protect the rights of European citizens and impose strict requirements on data processing.

The Requirements for algorithmic transparency and explainability were defined by The European Union that started to specifically regulate transparency in the use of AI algorithms. First of all, citizens need to be informed when interacting with an AI system and be shown how algorithms make decisions that can sometimes affect their lives. In addition, Article 13 of the AI “Act” (Council of the European Union, Artificial intelligence act) specifies that there must be an opportunity to explain how AI arrives at decisions, which may include information about the data used and the algorithms. For example, in the case of employee selection or credit setting systems, the EU emphasizes the importance that these automated decisions are explainable and do not discriminate against individuals based on personal characteristics (such as age, gender, education level or ethnicity). Furthermore, machine learning algorithms can learn from historical data that reflects social or economic biases, which can lead to unfair decisions. Citizens can demand explanations or challenge automated decisions made by AI

systems if they suspect discrimination or technical error. Transparent systems increase the chances of early detection and resolution.

In April 2021, the European Commission proposed a Regulation on Artificial Intelligence – AI Act (Coteț, n.d.), which is a comprehensive framework for AI regulation. It aims to establish clear rules for the use of AI in the EU, based on the risks posed by the various applications of this technology. The proposed law includes the classification of AI applications into four risk categories and sets strict requirements.

Under the AI Act the four risk categories are as reflected in Table 1.

Table 1. Comparative table of risk categories for AI systems and the responsibilities of involved stakeholders

Risk Level	Definition	Examples of AI Applications	Obligations Imposed by the AI Act	Involved Stakeholders and Responsibilities
Unacceptable Risk	AI systems that are prohibited due to their potential to infringe on fundamental rights, violate human dignity, or pose a major threat to public security or health.	- Social scoring - Advanced psychological manipulation techniques	- Total ban (these systems cannot be placed on the market or used within the EU). - Strict monitoring and severe sanctions for non-compliance.	- Developers: Cannot design or commercialize such systems. - Suppliers/Distributors: Must not introduce or distribute these systems on the market. - Users: Prohibited from using such systems, as they are banned.
High Risk	AI systems with a significant impact on the proper functioning of society, requiring stringent compliance measures and continuous monitoring.	- Medical diagnosis - Recruitment and personnel screening - Creditworthiness assessment	- Strict certification and audit obligations. - Increased traceability and transparency (algorithm documentation, data quality). - Ensuring cybersecurity and implementing	- Developers: Must ensure systems comply with safety standards, using transparent and secure algorithms. - Suppliers/Distributors: Responsible for certifying products and ensuring compliance with audit and traceability requirements.

Risk Level	Definition	Examples of AI Applications	Obligations Imposed by the AI Act	Involved Stakeholders and Responsibilities
			error reporting mechanisms.	- Users: Must use solutions in accordance with regulations and report any incidents.
Limited Risk	AI systems that interact directly with users and pose a moderate risk. Users must be informed about the involvement of AI algorithms, but without the strict requirements applicable to high-risk applications.	- Virtual assistant chatbots - Automated response applications (e.g., quick replies to simple queries)	- Obligation to inform users that they are interacting with an AI system. - Compliance with minimum requirements for data protection and safety.	- Developers: Must ensure adequate data protection for users and clarify AI's role. - Suppliers/Distributors: Must provide precise usage instructions to ensure compliance with legal frameworks. - Users: Must adhere to usage guidelines and refrain from using systems abusively.
Minimal Risk	The majority of AI applications that do not impact fundamental rights. These require no special obligations and are encouraged to foster innovation.	- Recommendation systems - Spam filters - Auto-complete functions in software	- Appropriate security measures to prevent misuse. - No additional specific requirements, but compliance with general regulations (e.g., GDPR) is necessary. - Maximum freedom for innovation and commercialization within the EU.	- Developers/Suppliers/Distributors: May place such products on the market with minimal restrictions, provided they comply with general regulations. - Users: Free to use these systems in any legally permitted context.

Source: Coteț (n.d.)

The European Union's Artificial Intelligence Regulation sets four levels of risk for AI systems and imposes obligations corresponding to each category.

- Systems with unacceptable risk pose a threat to human safety, rights or livelihoods. These include behavioral-cognitive manipulation or social scoring. They are completely banned, and their use or commercialization carries severe penalties.
- Applications considered as high risk, such as those used in medical diagnostics, employment screening, autonomous driving, or the identification of persons involved in criminal activities or investigations require strict requirements and obligations for certification, auditing and increased transparency and human oversight.
- For systems with limited risk, such as chatbots and auto-responders, the legislation only requires user information and compliance with minimum data protection requirements.
- Low-risk applications, such as spam filters, recommendation systems or games, are not subject to strict regulation, but only to general rules in order not to discourage innovation in AI.

The AI Act aims not only to regulate, but also to increase public confidence in new technologies by encouraging a more equitable relationship between AI providers and end-users.

1. Requirements for ethics and accountability of automated decisions: Ethics in artificial intelligence refers to the rules, clear norms and moral principles that must be respected in the development, deployment and use of artificial intelligence technologies. As AI is increasingly used in administrative decision-making, the EU wants to regulate the use of these technologies as ethically and responsibly as possible. The aim is to ensure that AI systems do not perpetuate prejudices or social and economic inequalities. This is why the EU is promoting the development of a testing and certification infrastructure for AI systems, including ethical and social assessments. It is not yet known who will take responsibility if an AI system makes a wrong decision and someone is affected by it (High-Level Expert Group on Artificial Intelligence, 2019; Bidașcă, 2023).
2. Requirements for international collaboration and standardization: Artificial intelligence (AI) is finding applications in more and more areas. In addition to the benefits, there are challenges related to safety, ethics and interoperability. That is why clear and global standards are needed. International standards will be unanimously respected ensuring fairness and safety in the development and use of AI. Such standards provide a common language and a basis for collaboration for experts around the world. Standards also play a key role in supporting legislation and public policy. EU regulations influence not only Member States but also other regions of the world, as many globalized companies operate in the Union.

International collaboration is needed to ensure consistent and effective regulation. They are part of a wider EU vision to create a safe and responsible framework for the development and use of AI.

3. REGULATIONS TO WHICH ROMANIA ADHERES OR WHICH IT HAS ALREADY ADOPTED

Romania, as a member state of the European Union, has adopted and taken over the European Union regulations and directives that refer to Artificial Intelligence, those related to algorithmic transparency, accountability of automated decisions, AI ethics and international collaboration. Romania also continues to actively participate in the development of international standards and to support European and global initiatives for a fair and responsible regulatory framework in the field of AI.

Here are the main regulations that Romania complies with or has already taken on board:

1. Regulation on Artificial Intelligence (AI Act). Romania will apply the regulations laid down in the AI Act on the use and development of AI systems, as soon as it will enter into force at EU level, currently in the approval process.
2. The General Data Protection Regulation (GDPR). Romania has already implemented the GDPR (Regulation (EU) 2016/679) in its national legislation and ensures the protection of personal data in the context of the use of AI systems.
3. National Strategy for Artificial Intelligence. Romania has adopted the National Strategy for Artificial Intelligence (2021-2027), which is aligned with the European Plan for Artificial Intelligence.
4. International collaboration. Romania participates in international initiatives for the standardization and regulation of AI, collaborates with other EU Member States and international organizations such as OECD, G7 and G20. Romania wants AI to be promoted in a responsible and fair way, based on ethical principles. To this end, Romania collaborates with the European Committee for Standardization (CEN) and the International Electrotechnical Committee (IEC) for the development of technical standards in the field of IA.

4. IMPACT OF AI ON EU ADMINISTRATIVE RULES

The impact of artificial intelligence (AI) on European Union (EU) administrative regulations has become a topic of major interest in recent years as AI technologies have advanced greatly. To address the associated challenges and opportunities, the EU adopted in 2024 the AI Regulation, the first comprehensive global legislative framework aiming to ensure the responsible development and use of artificial intelligence systems in the European space.

The implementation of this Regulation has significant implications for the administrative structures of the Member States. The aim is to prioritize citizens and respect their fundamental rights. To this end, each country has to designate competent authorities by 2 August 2025, responsible for overseeing the application of the rules and carrying out monitoring activities, which requires the allocation of additional resources and the training of specialized staff, which can be a challenge for national administrations. In addition, coordination between the EU and Member States is essential to ensure uniform application of the regulation. According to a 2024 report by the European Court of Auditors, this coordination has so far had limited effects due to a lack of effective governance tools (European Commission, 2024).

In addition to administrative challenges, the Regulation also offers significant opportunities. The role of the implementation of the AI Regulation is to put in place an innovative, balanced and efficient framework at global level, capable of mitigating risks and supporting the launch and growth of European AI startups. By establishing a clear and predictable framework, a favorable environment for innovation and investment in AI is created. The EU aims to become a world leader in the development of safe and ethical artificial intelligence, which can boost economic growth and improve public services. However, success depends on the ability of national and European administrations to effectively implement new regulations and work closely together to overcome emerging challenges in this dynamic field.

5. COMPARATIVE STUDY: CITY OF HELSINKI AND SECTOR 4 OF BUCHAREST

Local public administrations in the EU use AI for citizen interaction, public service management, institutional efficiency and citizen participation. At local level, citizens' first contact is with the city hall, which is the basic administrative unit.

We aim to draw a parallel between the way Helsinki City Hall and Bucharest City Hall Sector 4 AI use. The City of Helsinki is a global role model for algorithmic transparency and digital ethics. Sector 4 of Bucharest is an example of pragmatic adoption of AI in Romania.

In 2017, Finland created a national strategy for IA, based on the ethical goals and values set by the EU. The City of Helsinki has succeeded in taking these goals and translating them to the local level, with a focus on transparency and end-beneficiary.

Sector 4 has implemented AI solutions systematically, although Romania did not have a comprehensive national strategy on the implementation and use of artificial intelligence by 2024. In 2024 through the National Plan for Recovery and Resilience (PNRR) several local projects were supported (APTI, 2021).

5.1. Algorithmic transparency

In order to be as transparent as possible, but also to empower the citizen, Helsinki launched in 2020 the Register of Algorithms. This AI Register is, in fact, a platform that explains to citizens what kind of data is used by each algorithm implemented in public services, the purpose for which it is used and how and why it works (City of Helsinki, 2020).

AI Register was born out of collaboration between local government, academia and the private sector. Forum Virium Helsinki (FVH) is the innovation company of the City of Helsinki. Its goal is to make Helsinki the smartest city in the world. Here companies can test products and services in a real setting. At the same time, it involves citizens through a civic group called "Trial Troops" to participate in workshops to help find smart city solutions, to offer suggestions, to test and come up with feedback for certain products and services. In this way, they manage to eliminate algorithmic bias (Autoritatea de Management pentru Programul Regional București-Ilfov 2021-2027, 2025).

Sector 4 does not have such a transparent algorithm, details about how it works are not public, which can lead to issues of accountability and trust (Popescu, 2022). In Sector 4 AI is used for traffic management, processing online applications, paying taxes, fees and fines. The city hall website is very well structured, intuitive and easy to use. Their slogan is "No queues at the counter" (Direcția Generală de Taxe și Impozite Locale Sector 4, 2025).

5.2. Areas of practical application

Helsinki

- Optimization of social services: it is carried out by an AI algorithm that makes a predictive analysis of social support requests in order to identify urgent (critical) cases and act as quickly as possible, reducing intervention time.
- Citizen interaction: is realized through the Hanna chatbot. It provides automated answers to citizens' questions in areas such as taxes, fees, car permits, building permits, schooling (Helsinki City Council, 2021).
- Predictive urban planning: it is realized by analyzing citizens' mobility preferences.

Sector 4 of the Municipality of Bucharest

- Traffic management: real-time, based on urban surveillance cameras and sensors.
- Automatic detection of infrastructural faults: through video analysis (e.g. potholes, vandalism).
- Citizen interaction: through the city hall platform or through the free mobile application by scanning a QR code (e.g. digital ticketing).

5.3. Results and impact

In terms of response time an improvement can be seen in both cases (in Table 2). Helsinki has managed to reduce the response time to requests by 40%, which means that they have implemented a more efficient system for processing requests compared to that of Sector 4, which has a decrease of about 35%.

The difference in satisfaction percentages clearly indicates that Helsinki residents are much more satisfied with the public services and other urban aspects of their lives. The administration of Sector 4 should see this low percentage as a challenge and the solution would be to try to understand what makes its citizens unhappy and then look for solutions.

Table 2. Results and impact

Comparison indicator	Helsinki	Sector 4 Bucharest
Response time to requests	decrease by 40%	decrease by ~35%
Citizen satisfaction	82%	65%
Access to algorithmic	public and fully documented	does not exist
Use of AI in extensive planning	integrated in urban decisions	limited to existing infrastructure

Source: own computation

Helsinki in order to bring its citizens closer and gain their trust has provided public and fully documented access to algorithmic information, which translates into full transparency of making decision. Sector 4 uses a less developed information system that provides limited citizen understanding and participation in decisions.

Helsinki uses AI in urban planning in an extensive way, which leads to more accurate and effective decisions. Sector 4, because it has less advanced technology at its disposal, only uses AI for current infrastructure.

In conclusion, at local level in Romania, there is progress in terms of response time to requests and the use of technologies in infrastructure, but there is still a lot of work to be done in terms of access to modern technologies and its use to increase citizen satisfaction.

6. CONCLUSIONS AND RECOMMENDATIONS

Helsinki and Sector 4 Bucharest are two different models, but adapted to the realities in each country. Helsinki can be considered as a model to follow in optimizing administrative processes, improving communication with citizens, creating a relationship of mutual trust, a local governance at the heart of which the final beneficiaries are at the center. It is a proactive system, emphasizing ethics and active citizen participation. Sector 4 has a limited infrastructure, but under

these conditions it has nevertheless managed to implement AI solutions effectively. It is a reactive and pragmatic system offering ad hoc solutions. These differences stem from the gaps in terms of technologization, digitalization, resistance to change or innovation between Eastern and Western Europe. Romania has a higher percentage of the population that does not know or does not want to use different smart devices (smartphone, PC, laptop). This has also contributed to the demographic exodus of young people which Romania has experienced in recent years, with older people remaining in the country. In order for Romania and its citizens to reap the benefits that AI offers, it needs to develop transparent algorithm mechanisms, continually refer to ethical principles, involve citizens in decision-making and invest in the digital education of public officials. Success lies in a balanced collaboration between technological innovation, democratic governance and the protection of fundamental human values.

The next research developments will be about advanced technologies to anticipate city needs, accurate predictions and service optimization. Platforms will emerge where public decisions can be influenced by citizens in real time. There will also be a greater focus on protecting citizens' rights against automated decisions. Even if there are huge amounts of data that can be easily correlated by AI, the correct understanding and responsible use of it is human nature.

The research is limited by the different level of technologies implemented and used.

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SUSTAINABILITY AND INSOLVENCY: OPPOSING FORCES OR STRATEGIC ALLIES? A SYSTEMATIC LITERATURE REVIEW

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Abstract

Insolvency represents one of the most significant contemporary economic challenges, with major implications for both society as a whole and the business environment. It affects not only the financially distressed company but also employees, creditors, suppliers, and other stakeholders involved in the enterprise's operations. In the context of a global economic climate marked by instability and rapid change, sustainability has become a priority for the business sector, offering long-term development perspectives and the potential to mitigate risks to which a company may be exposed. Sustainable practices, when integrated into corporate strategies, no longer constitute merely ethical choices, but may serve as mechanisms for preventing insolvency risk and ensuring business continuity. Based on these premises, the present study aims to answer the following research question: "What are the main trends identified in the academic literature regarding the relationship between the adoption of sustainability initiatives and the insolvency of companies?". From a methodological standpoint, a systematic literature review (SLR) will be conducted, integrating both quantitative and qualitative approaches. Relevant publications from the fields of accounting, taxation, and management will be examined, using the Scopus, Web of Science and Google Scholar databases for the period 2014–2024. Based on well-defined keywords and selection criteria, significant studies related to the research topic will be identified. Preliminary findings suggest that the relationship between the two concepts can be analysed from two perspectives: the first highlights that integrating sustainability objectives into a company's strategy may reduce the risk of insolvency; the second considers the possibility of adopting such objectives within insolvency proceedings to avoid bankruptcy. The limitations of this study are related to the databases used and the subjectivity of the selection process (criteria, keywords, interpretation of article relevance). The originality of this research lies in its systematic approach to the literature concerning the relationship between sustainability and insolvency, as well as in the methods employed to highlight this connection.

Keywords: *sustainability; insolvency; ESG; CSR; insolvency risk.*

JEL Classification: M41; M14; Q01; Q56.

1. INTRODUCTION

In an economy characterized by intense competition, the stability and viability of an entity depend on how it manages risks, as both current and future performance can be influenced by various unforeseen factors (Holt, 2009). This reality explains the growing interest among financial specialists in developing methods for assessing and forecasting the uncertainties that frequently arise in business operations. Moreover, in the current context of economic transformation, there is increasing pressure to transition toward long-term sustainable business models (Khalil *et al.*, 2024). Over the past decades, the concept of sustainability has evolved significantly. While it was initially focused on profit maximization, it now encompasses social, environmental, and governance dimensions as well (Thiele, 2024). Insolvency, on the other hand, plays a crucial role in the modern economy by providing a legal and structured framework for companies facing financial distress. It allows them to restructure their debts or be liquidated in an orderly manner. The primary objectives of insolvency law are to protect creditors and to offer companies the opportunity either to recover or to exit the market without causing economic instability (Nagy and Ghica, 2020).

The Triple Bottom Line represents an accounting approach that defines sustainability by integrating three essential dimensions: economic viability, social responsibility, and environmental stewardship (Goel, 2010). This framework considers both the management of natural resources and the economic and social context in order to create long-term value (Goel, 2010). Building on this idea, two opposing theories explain the impact of sustainability on corporate financial performance: the Value-Creation Theory and the Value-Destruction Theory (Yu and Zhao, 2015). While the former argues that assuming social and environmental responsibility reduces the risk of jeopardizing a company's financial performance or viability, the latter claims that engaging in sustainability-related activities may shift attention away from profitability, prioritizing stakeholder satisfaction at the expense of shareholder interests (Alshehhi *et al.*, 2018). Alongside Agency Theory, Legitimacy Theory, and Stakeholder Theory, these frameworks help conceptually explain the link between business sustainability and insolvency risk. Poor investment decisions related to sustainable development – such as investing in underperforming sustainability instruments or allocating insufficient financial resources – can adversely affect a company's financial performance, thereby increasing its risk of insolvency. Conversely, companies that fail to invest in sustainability may damage relationships with stakeholders and lose legitimacy in the eyes of investors, creditors, or the broader society.

The objective of this article is to analyze the relationship between corporate sustainability and insolvency, providing an in-depth understanding of how sustainable development goals (economic, social, and environmental) may influence the occurrence of insolvency.

2. METHODOLOGY

To characterize the current state of knowledge regarding the relationship between sustainability and a company's insolvency, this paper adopts the Structured Literature Review (SLR) approach proposed by (Massaro *et al.* 2016), with the aim of thoroughly evaluating and analysing the literature. This research method has been widely employed over time in various fields (accounting, auditing, management), facilitating the identification of new perspectives, the formulation of critical views, and the establishment of future research directions as well as the underlying research questions (Massaro *et al.*, 2016). Scopus, Web of Science and Google Scholar were selected and used as the primary databases for extracting relevant articles published during the period 2014–2024. The sample analysed includes both articles and papers published in conference proceedings. According to Massaro *et al.* (2016), the SLR process is based on ten stages, illustrated in Table 1:

Table 1. The SLR process

1. Establishing the protocol	6. Evaluating reliability
2. Formulating research questions	7. Ensuring validity
3. Search process	8. Coding and analysis
4. Assessing the impact of articles	9. Perspectives and critical reflections
5. Developing the analytical framework	10. Future research directions

Source: Massaro *et al.* (2016, p. 5)

2.1. Developing the SLR protocol and formulating research questions

The protocol for the literature review serves to rigorously document the research process, thereby enhancing the reliability of studies and ensuring transparency (Yin, 2009). A comprehensive protocol should include the justification of the research question, the proposed methods, and the approach for identifying, assessing, and synthesizing studies, thus providing a standardized framework for conducting the research (Petticrew and Roberts, 2008). With regard to the relationship between sustainability and a company's insolvency, the literature review protocol includes (Table 2):

Table 2. Literature review protocol

Research Questions	How has literature on the relationship between sustainability and insolvency evolved?
	What are the main themes and findings identified in the literature on the relationship between sustainability and insolvency?

	What are the future research directions proposed in studies examining the link between sustainability and insolvency?
Method Used	Structured Literature Review (SLR)
Types of Studies Included	Articles and papers published in conference proceedings
Study Selection Criteria	➤ Written in English ➤ Publicly available (Open Access) ➤ Having more than 30 citations (according to Google Scholar)
Sources for Search	➤ Scopus ➤ Web of Science ➤ Google Scholar
Approach to Evaluation and Synthesis	Specific SLR stages

Source: Issam and Abdellatif (2017, p. 540)

2.2. The literature search process

In the first stage of this analysis, relevant databases were selected for extracting pertinent publications: Scopus and Web of Science. The choice of these two databases was based on criteria such as international recognition, extensive coverage of the finance and accounting fields, and indexing in prestigious databases. The focus was on articles that directly or indirectly address the link between sustainability and insolvency. Additionally, the search for publications relevant to this analysis was extended to Google Scholar in order to develop a more comprehensive understanding of the relationship between sustainability and insolvency. In the second stage, the scope and publication period were defined. The research concentrated on articles and papers published between 2014 and 2024. The targeted research areas were those classified under “Business, Management and Accounting” and “Economics, Econometrics and Finance”. The final stage involved establishing the keywords used in the search process. To identify the most relevant publications for the subject under investigation, a search strategy was designed with the following structure: *TITLE-ABS-KEY (“sustainability” OR “ESG” OR “ESG AND performance” AND “insolvency” OR “insolvency AND risk” OR “bankruptcy”)*. This ensured that all key terms important to the chosen topic were comprehensively covered.

Initially, a total of 3,551 publications were retrieved from the Scopus database, 5,426 publications from the Web of Science database, and 12,400 from Google Scholar. Given the impossibility of analyzing such a vast number of articles, the inclusion criteria were applied alongside a manual analysis to assess relevance and avoid duplicates, resulting in a final total of 117 publications that comprise the sample subjected to analysis.

2.3. Impact of the analyzed articles

At this stage, the impact of the analyzed articles was assessed through their citations on Google Scholar, which represents an important criterion for identifying relevant works within a field. To facilitate this process, the software Publish or Perish 8 was used to extract citation data and metrics. The frequent citation of publications reflects major directions in the development of the field and contributes to understanding its evolution. In the literature, researchers often seek to identify the most influential works within a domain, commonly referred to as “citation classics” (Garfield, 1964). The top ten most cited publications from the Scopus and Web of Science databases are presented in the Table 3:

Table 3. Top 10 most cited articles (Citations recorded on May 1, 2025)

Title	Author	Year	No. of citations
Social Capital, Trust, and Firm Performance: The Value of Corporate Social Responsibility during the Financial Crisis	K.V. Lins, H. Servaes, A. Tamayo	2017	2159
The role of ESG performance during times of financial crisis: Evidence from COVID-19 in China	D. C. Broadstock, K. Chan, L.T.W. Cheng, X. Wang	2021	866
The long-term benefits of organizational resilience through sustainable business practices	N. Ortiz-de-Mandojana, P. Bansal	2016	743
Do environmental, social, and governance activities improve corporate financial performance?	J. Xie, W. Nozawa, M. Yagi, H. Fuji, S. Managi	2019	660
Corporate social responsibility and financial performance: A non-linear and disaggregated approach	J. Nollet, G. Filis, E. Mitrokostas	2016	455
Sustainable development, ESG performance and company market value: Mediating effect of financial performance	G. Zhou, L. Liu, S. Luo	2022	404
Does corporate social responsibility reduce financial distress risk?	S. Boubaker, A. Cellier, R. Manita, A. Saeed	2020	313
On the relation between corporate social responsibility and financial performance	A.Awaysheh, R.A. Heron, T. Perry, J.I. Wilson	2020	291
ESG disclosure and firm performance before and after IR: The moderating role of governance mechanisms	K. Albitar, K. Hussainey, N. Kolade, A.M. Gerged	2020	288

Title	Author	Year	No. of citations
Corporate social responsibility and financial performance relationship: A review of measurement approaches	A.Galant, S. Cadez	2017	283

Source: own elaboration

This stage provides an overview of the scientific influence and impact of the top ten most cited articles in the established sample. The data presented allow for the assessment of scientific impact from the perspective of total volume of citations that indicates long-term recognition and cumulative influence over time.

2.4. Defining the analytical framework

A systematic literature review (SLR) is an empirical endeavour that seeks to investigate the evolution of knowledge within a specific field, aiming to formulate well-substantiated answers to clearly defined research questions (Massaro *et al.*, 2016). As in any empirical study, it is important for the researcher to establish in advance which elements will be examined and how the relevant data will be collected and interpreted (Massaro *et al.*, 2016) (Table 4).

Table 4. Defining the analytical framework

No.	Analysis criterion	Examples of studies applying this criterion
1.	Year of publication	Guthrie <i>et al.</i> (2012); Serenko and Dumay (2015)
2.	Geographic context	Broadbent and Guthrie (2008); Guthrie <i>et al.</i> (2012); Massaro <i>et al.</i> (2016)
3.	Topics addressed in the literature	Broadbent and Guthrie (2008); Guthrie <i>et al.</i> (2012)
4.	Research methodology	Parker (2005); Broadbent and Guthrie (2008); Guthrie <i>et al.</i> (2012)
5.	Sector of activity	Rimmel <i>et al.</i> (2009); Bruggen <i>et al.</i> (2009)

Source: Massaro *et al.* (2016, p. 13)

2.5. Reliability and validity

Within the systematic literature review process on the relationship between sustainability and insolvency, a key aspect is the quality control of the data included in the analysis. Given that the literature investigated originates from diverse sources, it is necessary to apply rigorous methods for the selection and coding of publications to ensure the reliability and validity of the analysed works. In this respect, the recommendations of Perry and Krippendorff (2013) were applied, and specific search criteria for articles in the Scopus, Web of Science and Google Scholar databases were established. By reproducing the steps of the

literature search, the results should be consistent and accurate according to the established criteria. Regarding validity, according to White and McBurney (2012), there are three types of validity: internal, external, and construct validity. Internal validity was ensured by defining the analytical framework. External validity was confirmed through the literature search process, where the criteria for identifying publications relevant to the study were detailed. The third type, construct validity, refers to the quality of the data used in the analysis, which was supported by examining the impact of the articles (as evidenced by the ranking of the top ten most cited articles).

2.6. Coding of the analysed publications

Data analysis represents one of the most complex stages of qualitative research, with coding serving as a central element that enables the coherent and meaningful structuring and interpretation of textual content (Basit, 2003). After selecting only the relevant studies that include empirical estimates, tests, or significant results, the next step involved identifying their essential features and applying a coding process (Massaro *et al.*, 2016). To accomplish this, the NVivo (15) software was employed to code the sample established in the previous stages, to quantify the criteria defined within the analytical framework.

3. QUANTITATIVE ANALYSIS RESULTS

The quantitative analysis conducted in this systematic literature review aimed to answer the question “*How has the literature on the relationship between sustainability and insolvency evolved?*”, using a scientific approach to extract the essential features from a complex situation and formulate a new generalizable theory (Franklin, 2008). The study involved rigorous coding of the sample to observe the progress of the literature through the selected attributes, identifying temporal, conceptual, geographic, and methodological trends (Table 5).

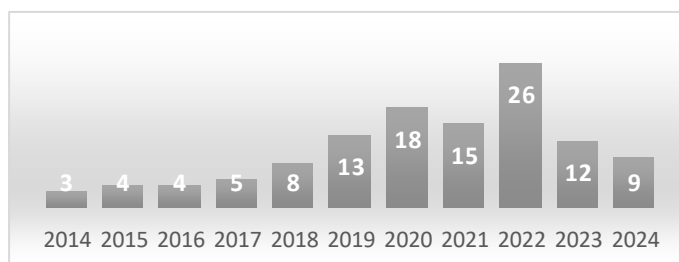
Table 5. Results of sample coding

Attribute	Coding and results	
<i>Year of Publication (A)</i>	➤ A01 – 2014 → 3 ➤ A02 – 2015 → 4 ➤ A03 – 2016 → 4 ➤ A04 – 2017 → 5 ➤ A05 – 2018 → 8	➤ A06 – 2019 → 13 ➤ A07 – 2020 → 18 ➤ A08 – 2021 → 15 ➤ A09 – 2022 → 26 ➤ A010 – 2023 → 12 ➤ A011 – 2024 → 9
<i>Geographic context (B)</i>	➤ B01 – Europe → 44 ➤ B02 – America → 11 ➤ B03 – Africa → 5 ➤ B04 – Asia → 22	➤ B05 – Middle East → 5 ➤ B06 – Oceania → 1 ➤ B07 – Global → 29

Attribute	Coding and results	
<i>Topics addressed in the literature (C)</i>	➤ C01 – Impact of CSR on financial performance → 49 ➤ C02 – Impact of ESG/Sustainability on financial performance → 46	➤ C03 – Relationship between ESG and insolvency → 16 ➤ C04 – Relationship between ESG and financial performance during crises → 6
<i>Research Methodology (D)</i>	➤ D01 – Empirical study → 88 ➤ D02 – Case study/interview → 4 ➤ D03 – Theoretical study → 11	➤ D04 – Mixed methods → 11 ➤ D05 – Content analysis → 1 ➤ D06 – Commentary → 2
<i>Sector of activity (E)</i>	➤ E01 – Banking/Finance → 12 ➤ E02 – Manufacturing → 9 ➤ E03 – Tourism → 2 ➤ E04 – Construction → 1	➤ E05 – Automotive/Aviation → 3 ➤ E06 – Corporate/IT → 2 ➤ E07 – Oil and Gas → 2 ➤ E08 – Food → 2 ➤ E09 – Other → 84

Source: own elaboration

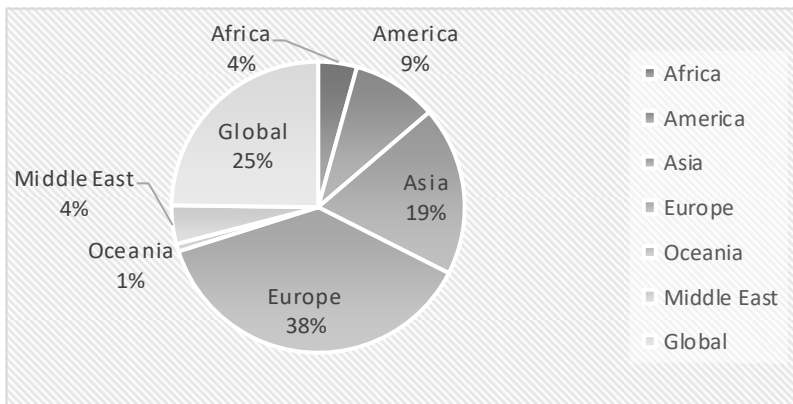
The temporal analysis of the literature (Figure 1) from the period 2014-2024 indicates a marked increase in interest regarding the link between sustainability and insolvency, especially between 2020 and 2022, when research focused on the interaction between ESG/CSR practices and financial risks such as insolvency. Conversely, the fewest publications come from 2014. This evolution has been influenced by the intensification of discussions on climate change, the adoption of the Sustainable Development Goals (UN, 2015), and recent global regulations, all of which have fueled this growth trend.



Source: own processing based on Table 5

Figure 1. Temporal analysis of literature

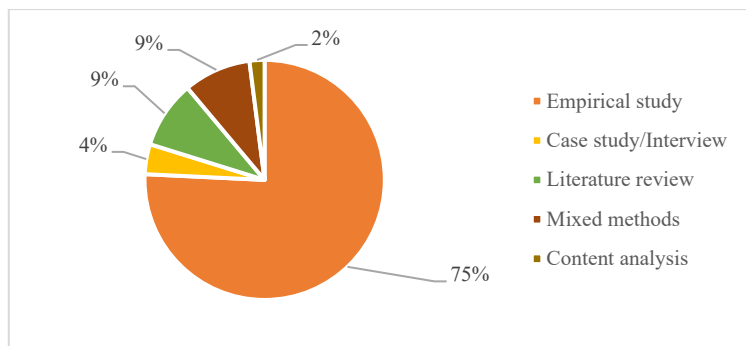
The analysis of the geographical context within this SLR reveals that, although the publications are globally distributed, there is a pronounced concentration in the European area, accounting for 38% of the total sample (Figure 2). Studies of a global nature, encompassing countries from multiple geographical regions (typically analyzing firms at an international rather than merely national level), constitute 25% of the examined literature. Meanwhile, publications originating from Asia and the Americas combined represent approximately 28% of the sample. In contrast, Africa and the Middle East are markedly underrepresented, each contributing only 5 studies (8% collectively), while Oceania is reflected by a single relevant publication. This distribution underscores a predominant scholarly focus on developed economies, particularly within Europe.



Source: own processing based on Table 5

Figure 2. Geographic context analysis

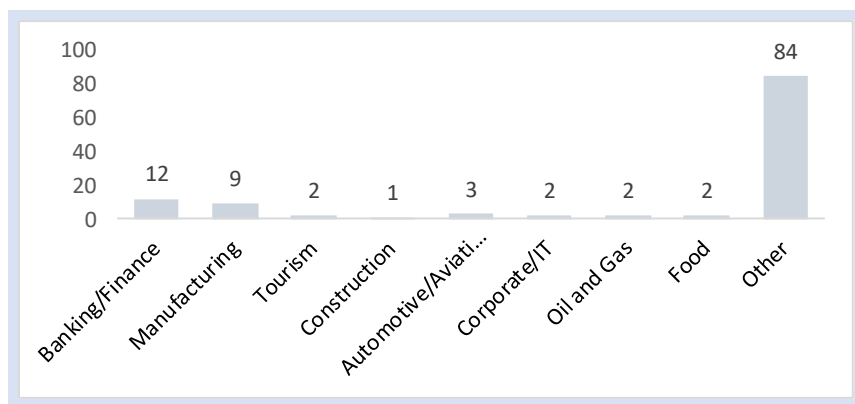
From a methodological standpoint (Figure 3), the analysis reveals that the publications constituting the sample are predominantly characterized by quantitative empirical approaches. The majority of the studies (approximately 80% of the total) employ empirical methods such as statistical analyses based on financial and non-financial datasets (including financial indicators, stock performance, Z-scores, ESG scores, etc.) (Mirzaei, 2024). This strong reliance on quantifiable evidence underscores a scholarly orientation toward establishing a solid empirical foundation for the relationship between ESG/CSR practices and insolvency or financial performance. By contrast, the remaining 20% of the analyzed publications comprise theoretical studies or employ mixed methods, thereby contributing to the conceptual development and deeper understanding of these intertwined phenomena.



Source: own processing based on Table 5

Figure 3. Research methodology analysis

Regarding the sectoral profile of the analysed literature (Figure 4), it is evident that most studies (84 publications) do not focus on a specific sector. Instead, they examine the relationship between sustainability and insolvency or financial performance within a general, multi-sectoral context, often relying on large samples of firms listed on various renowned stock exchanges and included in global market indices. While this transversal approach enhances the broad applicability of the findings, it may also overlook important sector-specific nuances. The results further indicate a notable scholarly interest in the banking and financial sector, with 12 dedicated studies, suggesting the significance of exploring sustainability within financial institutions, particularly in relation to how sustainability objectives can impact credit risk, capital costs, and regulatory compliance. Additionally, analyses have also been conducted within the manufacturing sector.



Source: own processing based on Table 5

Figure 4. Sectorial profile analysis

In conclusion, the results of the quantitative analysis highlight a research field that is currently undergoing a process of rapid expansion. According to the findings, recent years have witnessed a growing interest in the topic under investigation, while the geographical context reveals that the studies have been conducted primarily in developed economies.

4. QUALITATIVE ANALYSIS RESULTS

From the perspective of the themes addressed in the literature (Attribute C), four major directions have been identified that explore, either directly or indirectly, the relationship between sustainability and insolvency. This analysis contributes to answering the research question: *“What insights and perspectives does the published literature offer regarding the relationship between sustainability and insolvency?”*

4.1. The impact of Corporate Social Responsibility on financial performance

Corporate Social Responsibility (CSR) encompasses a set of voluntary actions through which companies engage with stakeholders in an ethical and responsible manner, exceeding legal requirements to generate a positive social impact (Chetty, Naidoo and Seetharam, 2015). Over time, the concept of business sustainability has evolved, with CSR now representing an essential component of a broader, long-term strategic approach (Jan and Marimuthu, 2015).

Within this framework, Yury Karaleu argues that CSR yields significant advantages for both companies and society at large. At the corporate level, CSR enhances a firm’s reputation, mitigates risks, lowers costs, and facilitates access to potential financing, while globally it promotes sustainability and innovation (Karaleu, 2018). A key aspect highlighted is how CSR serves as a means of managing the social risks associated with insolvency, given that job losses and unpaid wages resulting from bankruptcy can produce substantial adverse social consequences (Karaleu, 2018).

The relationship between corporate social responsibility (CSR) and firms’ financial performance has been extensively explored in the literature, yielding both positive and negative outcomes. Studies focusing on companies in the food and beverage industry have shown that robust CSR governance enhances social and environmental performance, while social components (such as employee focus and community engagement) translate into superior financial results and lower insolvency risk (Nirino *et al.*, 2020). Similarly, research on Taiwanese companies found that investments in employee-related CSR (including diversity, labor rights, and workplace safety) significantly contribute to value creation for the firm and higher financial returns (Lin *et al.*, 2019).

Moreover, investigations conducted in diverse contexts, from small and medium-sized enterprises in Ghana (Ansong, 2017) to publicly listed firms on prestigious global stock exchanges, have reported a positive correlation between

CSR engagement and financial performance. Companies adopting responsible practices tend to be rewarded by the market and stakeholders through higher valuations, while firms with elevated ESG scores demonstrate greater operational efficiency and corporate reputation (Awaysheh *et al.*, 2020).

Nonetheless, the literature also highlights neutral findings, suggesting a relationship more complex than a simple linear one. A study analyzing South African companies concluded that there were no significant long-term effects on financial performance despite CSR engagement, although it did observe positive short-term market reactions following the publication of sustainability reports (Chetty *et al.*, 2015). Thus, CSR effects may vary depending on the timeframe and the manner in which CSR principles are implemented, precluding a straightforward depiction of this relationship.

Some studies have highlighted a nonlinear relationship between CSR and financial performance. For instance, research conducted on companies listed on the Indian Stock Exchange revealed a “U-shaped” link between ESG scores and firm market value (Tobin’s Q), indicating that at low levels of CSR engagement, increased social responsibility is initially associated with a decline in performance due to immediate costs. However, once a certain threshold is surpassed, additional CSR efforts lead to significant increases in firm value (Sung Kim and Oh, 2019). This notion is further supported by the study of Nollet, Filis, and Mitrokostas on S&P 500 firms, which identified a similar “U-shaped” relationship, demonstrating that CSR investments may negatively impact profitability in the short term but become beneficial after crossing a critical level of involvement (Nollet *et al.*, 2016). Moreover, the economic context and firm-specific characteristics can significantly influence the relationship between CSR and financial performance.

4.2. Impact of ESG/Sustainability on financial performance

The implementation of sustainability standards can have a positive impact on a company’s financial performance. Although such measures often entail high short-term costs, such as investing in environmentally friendly equipment or adopting higher safety standards, they yield benefits that help consolidate and sustain business operations over the long term (Abdi *et al.*, 2022).

The analysis conducted by Sandberg and Abrahamson in the European food industry concluded that there is a positive relationship between ESG scores and financial performance, suggesting that effective governance alongside well-developed social and environmental policies contribute to enhancing firm value (Sandberg *et al.*, 2023). However, findings from the aviation sector indicate that the impact of ESG on financial outcomes is moderated by factors such as firm size and age, with larger and more mature companies deriving greater value from sustainability investments (Abdi *et al.*, 2022). Research by Tan and Zhu highlights that managerial awareness and financial constraints significantly shape how ESG scores translate into ecological innovation, thereby directly affecting financial

performance (Tan and Zhu, 2022). A similar perspective is offered by Yang and collaborators, who identified a U-shaped positive relationship between ESG scores and environmental practices, implying the existence of an optimal ESG performance threshold beyond which financial impacts turn favorable (Yang *et al.*, 2024).

From a theoretical standpoint, Lee and Suh emphasize the necessity of an integrated approach to better understand how sustainability objectives influence financial performance, particularly by focusing on ESG reporting transparency and its link to economic outcomes (Lee and Suh, 2022). Meanwhile, the study by Albitair and Hussainey indicates that although there is evidence supporting a positive relationship between ESG and firm performance, the effects vary depending on the period and context analyzed (Albitair *et al.*, 2020). In an equivalent way, certain studies underscore the value relevance of non-financial disclosures, showing that companies listed on the Dow Jones Sustainability World Index, which exhibit a high degree of transparency regarding ESG performance, receive significantly better financial evaluations (Aureli *et al.*, 2020). Another topic pertinent to this research concerns the long-term performance of resilient and sustainability-oriented firms. The integration of sustainable practices into business strategies fosters organizational resilience and leads to superior long-term financial performance, particularly in economic contexts marked by volatility and crisis (Ortiz-de-Mandojana and Bansal, 2016). This view is also supported by other authors, who further point out that the effect of ESG on firm performance may vary depending on the industry as well as on the level of ESG policy integration (Nguyen *et al.*, 2022).

4.3. Relationship between ESG and insolvency

Environmental, social, and governance (ESG) practices have come to play an increasingly significant role in preventing, anticipating, and managing insolvency situations, particularly given the rising number of insolvent companies worldwide. In this context, Tuula Linna investigates how sustainability principles can be integrated into insolvency and restructuring proceedings, considering the diversity of resources involved (natural, human, social, etc.) (Linna, 2019). However, a conflict exists between creditor interests and sustainability, as in bankruptcy the administrator is required to maximize asset value to satisfy creditors, thereby limiting opportunities to promote sustainability objectives (Linna, 2020). In cases of insolvency or imminent financial distress, decisions regarding liquidation or restructuring must be grounded in a thorough viability assessment of the company and the interests of its creditors (Karaleu, 2018). The viability test determines whether the company can improve its financial situation through restructuring, while from the creditors' perspective, the evaluation focuses on the proposed restructuring plan's capacity to maximize debt recovery. Within this framework, financial performance (ESP) naturally constitutes a key component of the viability

assessment (Karaleu, 2018). Nevertheless, it is equally important to examine whether the company can achieve sustainable economic performance. ESG sustainability becomes particularly relevant when such standards are mandated by law or are necessary for the continued operation of the debtor company (Karaleu, 2018). Although implementing ESG elements often involves short-term costs, they may promote long-term economic sustainability. For creditors, this issue remains sensitive, as they typically seek prompt recovery of their investments. However, from a broader perspective, sustainability considerations can support restructuring as an alternative to liquidation.

From a legal perspective, G. Ballerini highlights the complexity of integrating sustainability principles into insolvency law, emphasizing both the structural and interpretative challenges of the current legal framework, as well as the opportunities related to incorporating public interest and environmental protection into judicial decisions (Ballerini, 2023). Similarly, Reckenzaun argues that, in the current context of the green transition, insolvency regulations should be adapted to foster long-term resilience and to provide a structured framework that enables financially distressed firms to reorganize in an orderly and responsible manner (Reckenzaun, 2014). Another important aspect found in the literature is the role of transparent communication of ESG practices when a company emerges from a crisis; credible and proactive communication of ESG commitments can serve as a strategic tool for restoring trust during periods of financial difficulty (Neumann and Forthmann, 2024). From a practical standpoint, the relationship between sustainability principles and insolvency risk is supported by empirical research. Landi and collaborators have shown that integrating ESG criteria into risk management strategies significantly reduces the financial risk faced by companies, including the risk of insolvency (Landi *et al.*, 2022). Additionally, Timur demonstrates that ESG scores can have predictive power in estimating the probability of insolvency, concluding that such scores – when well-balanced – may serve as early warning indicators (Timur, 2024).

4.4. Relationship between ESG and financial performance during crises

Global economic events have demonstrated that during periods of crisis, most companies – regardless of the sector in which they operate or their organizational structure – face challenges such as liquidity shortages or financial losses (Žiković, 2016). These difficulties may lead to insufficient funds to cover outstanding liabilities, which in certain cases can trigger insolvency. Ran Sarabany identified key factors including economic recessions, currency fluctuations, and financial market volatility, highlighting a correlation between corporate failure rates in Israel (1990-2002) and major economic events (Sharabany, 2004). Similarly, Bhattacharjee *et al.* observed in their study that macroeconomic instability significantly contributes to corporate failure (Bhattacharjee *et al.*, 2009).

The 2008 financial crisis, the Covid-19 pandemic, and the Russo-Ukrainian war have functioned as catalysts for severe economic shocks, leading to an increased corporate insolvency rate. This analysis underscores the causal relationship between external events and firms' vulnerability. Although the Covid-19 pandemic triggered a global health and financial crisis, the initial number of insolvent companies actually declined (Coutinho *et al.*, 2023). This was due to support measures implemented by most states to mitigate the impact and prevent widespread bankruptcies (Creditreform International, 2022). However, these interventions merely delayed the crisis's consequences, with the post-pandemic years witnessing a significant rise in insolvencies both nationally and across the European Union (Savickis, 2024). Hopes for a swift economic recovery following the pandemic were dashed by the outbreak of the war in Ukraine in 2022. The energy crisis triggered by the conflict fueled soaring inflation throughout Europe, surpassing 10%. In response to these adverse effects, central banks raised interest rates, but this decision added a new burden on already strained economies. These developments contributed to an increased number of insolvent firms, highlighting the fragility of global economies during times of crisis. Understanding the factors that can precipitate insolvency is crucial for conducting in-depth analyses of the relationship between sustainability and insolvency.

The study conducted by Broadstock and colleagues provides evidence from China during the COVID-19 pandemic, showing that firms with high ESG performance demonstrated greater resilience to economic shocks, achieving more stable financial returns and reduced volatility (Broadstock *et al.*, 2021). In Europe, research conducted by Chiaramonte and collaborators in the banking sector indicated that ESG strategies contribute to enhancing financial stability, lowering financial risk, and improving profitability (Chiaramonte *et al.*, 2022). Likewise, in the same sector, Citterio and King (2023) found that ESG scores can be effectively used to anticipate financial distress, particularly due to the governance and social responsibility dimensions (Citterio and King, 2023).

El Khoury and colleagues analyzed the performance of G20 companies during the COVID-19 pandemic and concluded that there is a positive relationship between sustainability practices and financial performance (El Khoury *et al.*, 2022). By contrast, Petitjean adopted a different initial stance, observing that overall ESG performance is not consistently associated with improved financial outcomes. However, a more detailed examination of environmental and governance policies revealed distinct positive effects (Petitjean, 2019).

5. FUTURE RESEARCH DIRECTIONS

To address the question concerning future research directions proposed in studies exploring the link between sustainability and insolvency, we examined the publications in our sample to identify avenues suggested by other researchers.

Given the varied conclusions of existing studies, a promising research direction would involve deepening the understanding of the causal relationship between ESG performance and insolvency risk by employing advanced quantitative methods capable of addressing issues of endogeneity and sample selection (Landi *et al.*, 2022). Additionally, there is a need for longitudinal analyses of the impact of ESG on financial performance, considering the temporal effects of profitability indicators and country-level variables (El Khoury *et al.*, 2022). Another important research avenue is the examination of small and medium-sized enterprises across various sectors and legal systems, especially since most empirical work has focused on large publicly listed firms (Petitjean, 2019). Relevant topics also include identifying types of CSR initiatives that can enhance firm financial performance (Xie *et al.*, 2019), exploring additional factors that influence the relationship between CSR practices and financial outcomes (Rossi *et al.*, 2021), and investigating the quantitative measurement possibilities of ESG dimensions (Sandberg *et al.*, 2023). Moreover, studies on how firms adapt their investment strategies during periods of crisis represent another valuable line of inquiry (Chiaramonte, 2022).

6. CONCLUSIONS

Overall, the literature review on the relationship between sustainability and insolvency highlights a growing field of research, fueled by concerns about corporate responsibility and the resilience of firms to major economic shocks. The studies reviewed indicate that integrating ESG principles and CSR practices can have significant effects on financial performance and insolvency risk reduction, although the results are not always convergent, varying depending on the economic context, industry, firm size, and time period analyzed.

Recent economic crises – including the 2008 financial crisis, the COVID-19 pandemic, and the Russo-Ukrainian war – have highlighted the vulnerability of companies and the importance of adopting sustainable strategies to ensure business continuity and restore investor and creditor confidence. The analysis also highlights that governance and transparency factors play a key role, and ESG reporting can serve as both financial assessment tools and early warning mechanisms against bankruptcy risk.

In conclusion, deepening this topic through rigorous causal studies, on diverse samples and in different economic contexts, represents a necessary direction for a complete understanding of how sustainability can contribute to reducing insolvency risk and creating sustainable long-term value for all stakeholders

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A COMPARATIVE HISTORICAL ANALYSIS OF TRADITIONAL ASSET CLASSES IN THE EUROPEAN UNION: THE CASE OF HEDGE FUNDS

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Abstract

The paper at hand provides a comparative historical analysis of the role of hedge funds within the global financial system, with a specific focus on their interactions with traditional asset classes such as equities and bonds. Hedge funds, known for their high leverage, active management, and diverse, often sophisticated investment strategies, have emerged as pivotal players in financial markets. These characteristics enable hedge funds to enhance market efficiency through liquidity provision, price discovery, and offering diversification benefits that are not readily achievable through conventional asset classes. However, their speculative nature, complexity, and reliance on leverage also introduce significant concerns related to financial stability, particularly during periods of market stress.

This study historically analyses how hedge funds and traditional asset classes respond to and recover from systemic shocks. The research methodology includes an analysis of performance metrics, recovery rates, and volatility patterns across various crises, highlighting the differential impacts on hedge funds versus equities and bonds. Empirical findings suggest that hedge funds generally exhibit higher resilience and quicker recovery from financial disruptions. This advantage is largely attributable to their flexible strategies, active risk management, and ability to dynamically reallocate capital in response to changing market conditions. The potential for rapid deleveraging, liquidity crises, and contagion effects during downturns underscores the dual nature of hedge funds as both stabilizers and potential destabilizers within the financial ecosystem.

The findings have critical implications for policymakers, investors, and regulators aiming to strike a balance between fostering financial innovation and maintaining systemic stability. While hedge funds can contribute positively to market efficiency and resilience, their capacity to propagate risk necessitates ongoing regulatory oversight and prudent risk management practices. A deeper understanding of these dynamics is essential for developing frameworks that can harness the benefits of hedge funds while mitigating their potential threats to financial stability.

Keywords: *hedge funds; financial stability; systematic risk; crises management.*

JEL Classification: G28.

1. INTRODUCTION

“Hedge funds often make headlines because of spectacular losses or spectacular gains” (Stulz, 2007; p. 175).

This is not the only quote stating the controversy and impact of the hedge fund industry (Eichengreen and Mathieson, 1999; Asness *et al.*, 2001; Carroters, 2017; Kruttli and Monion, 2013). It was found that “hedge funds seemed to be on the front page of every newspaper in the world” (Edwards, 1999; Bloomberg, 2007) stating their potential to “pose a threat to the stability of the entire financial system, once risks materialize” (Bussière *et al.*, 2015, p. 279).

Hedge funds in the European Union have faced unique challenges and recovery patterns compared to traditional asset classes, shaped by regulatory shifts and market dynamics. In the intricate landscape of modern finance, hedge funds represent a significant and often contentious component. The issue is not new (Haldane, 2014), however changing in size and shape. In the 1990s, hedge funds had grown to influence and shape financial markets. Even more influential than governments (Mallaby, 2019), in a world of increasing relations and dependencies. In response to international exposure to risks and policy implications, hedge funds (HFs) “may increase the risks to financial stability (King and Maier, 2009; Erede, 2013). The type of private, largely unregulated, and not supervised pools of capital are managed by competent investment firms, and they use plenty of complex methods to generate high returns for their investors, defined as “qualified purchasers” (Edwards, 1999). Individuals who make more than two hundred thousand dollars a year or possess a net worth of more than one million dollars exclusively from their primary residence (Achleitner *et al.*, 2009).

Hedge funds serve several key functions in global financial markets. First, they contribute to market efficiency by identifying and exploiting pricing inefficiencies through sophisticated trading strategies such as arbitrage and event-driven investing (Brown *et al.*, 2001). Thereby, hedge funds influence financial stability due to their growing impact and volatility. Many hedge fund strategies exhibit a low correlation with traditional asset classes such as equities and fixed income, making them an attractive investment for institutional investors and high-net-worth individuals seeking alternative sources of return (Stowell and Stowell, 2024).

Overall, an extensive body of literature examines hedge funds from multiple perspectives, including their role in promoting market efficiency, their contribution to liquidity, and their potential to exacerbate financial instability. Scholars have debated whether hedge funds serve as stabilizers or destabilizers within financial markets (Lu *et al.*, 2024). On one hand, proponents argue that hedge funds enhance market efficiency through sophisticated arbitrage strategies, liquidity provision, and the active management of risk (Zhai and Wang, 2023). By capitalizing on mispricing and market inefficiencies, hedge funds ostensibly

contribute to a more accurate reflection of asset values and, in turn, to overall market stability.

1.1. Importance of hedge funds and financial stability

The importance of hedge funds (the statistical units of the paper at hand) comes from the increasing size of the industry to USD 4.74 trillion in assets under management in the year 2024 with official predictions to grow to USD 5.47 trillion by 2029 (Statista Research Department, 2024). Other than the financial implications, the importance of the hedge fund industry also depends on its international basis, as the past showed major events that led to imbalances (Ogotseng, 2017). Thereby, HFs are an important price-setter and “reportedly dominate trading activities in the markets with broader economic importance” (King and Maier, 2009). By trading a volume of 40 percent in the leveraged loan market and more than 85 percent of distressed debt, they are the “key players in high yield debt and emerging market debt” (King and Maier, 2009). Their operational scope, the magnitude of their financial maneuvers, and their attractive returns raise questions about their implications for the stability of the broader financial system. International financial stability (FS) is a cornerstone of economic health, affecting everything from national economies to individual livelihoods (Clifford, 2008). The continuous functioning of the financial system provides essential lubrication that allows commerce, investment, and day-to-day business activities to proceed without significant disruption (Haldane, 2014). It ensures that economic actors can make financial decisions with a reasonable expectation of stability and security. However, the various instruments and strategies that hedge funds employ can introduce elements of volatility and risk, challenging the resilience of this system (Gregoriou, 2005). Thereby, financial stability is central to be considered as its fundamental precondition to achieve the central bank’s macroeconomic implications, such as price stability and a strong growing nation (Hellwig, 2014). Hence, connectedness to other financial institutions (FI) is an important determinant of financial stability (Bussière *et al.*, 2015).

Thereby, the global dimension of financial stability cannot be ignored, especially in an era of increased financial globalization. Cross-border capital flows, multinational banking operations, and interconnected financial markets mean that financial instability in one country can quickly spread to others. The global financial crisis of 2008 is a stark reminder of how interconnectedness can amplify systemic risk (Orlando, 2023). As such, international cooperation and coordination are vital in addressing global financial stability. Institutions like the Basel Committee on Banking Supervision, which develops global standards for bank regulation, play a crucial role in fostering international regulatory harmonization and cooperation (Basel Committee on Banking Supervision, 2011).

1.2. Research

The Research at hand is structured into different parts, starting with the literature review to provide a comprehensive examination of existing scholarly work, enabling a nuanced understanding of the topic while identifying gaps and areas for further exploration. Thereby, elucidating the current state of knowledge on hedge funds and financial stability, capturing both theoretical insights and empirical evidence. In the third part, there is the methodology of how the research is organized and the research objective as well as the Analysis addressing the diversity within the hedge fund industry itself. Hedge funds are not a monolithic group, they encompass a wide range of strategies and investment styles, each with distinct implications for financial stability. Strategies such as long/short equity, global macro, and event-driven investing offer different risk profiles and operational dynamics. The heterogeneity within the industry necessitates a granular analysis, recognizing that certain strategies may pose greater systemic risks than others. Research studies frequently employ classification schemes and typologies to dissect the nuanced differences across various hedge fund subcategories, thereby enriching the broader discussion of their impact on financial stability. The Conclusion synthesizes these diverse viewpoints as a discussion part, followed by answering the research question of *how quickly hedge funds recover after major financial crises compared to other asset classes*.

2. LITERATURE REVIEW

Starting to define the terminology concerning financial systems to consider several determinants, measurements, and definitions that influence the relationship as well as the developments within this sector and create a basis for future study. Ultimately, the literature review aims to provide a comprehensive and coherent narrative that situates hedge funds within the broader discourse on financial stability. By bridging theoretical frameworks, empirical evidence, and regulatory considerations, the chapter will offer a robust foundation for understanding the complex dynamics at play. This understanding is essential for informing policy recommendations and regulatory approaches, which will be discussed in the concluding sections of this paper.

2.1. Hedge funds and their history

So, hedge funds and the so-called hedge fund “industry” are often described as a potential transmission channel in the event of shock (King and Maier, 2009). Thereby, hedge funds are supervised as a limited liability partnership with principals that administer the fund and are also investors (Stowell and Stowell, 2024). Controvert, to define the management of the investment instrument called hedge funds it is more complex than one single definition, described as perusing from “a plethora of investment strategies and have different risk-return profiles” (Walden and Lajbcygier, 2023). In general, hedge funding is described as a full

array of hedging techniques to reduce portfolio volatility (Bali and Weigert, 2018). With the main goal of a positive return with limited swings in value and capital preservation. However, the method behind the hedging is rapid price discovery, massive mathematical and statistical processing, risk measurement and control techniques, and leverage as well as active trading in corporate equities, bonds, foreign exchange, futures, options, swaps, forwards, and other derivatives (Chattopadhyaya, 2011).

Emerging in the mid-20th century (Adam and Merkel, 2019), hedge funds have grown significantly in both number and influence, attracting significant sums of capital and becoming influential participants (Achleitner *et al.*, 2009). The strategy of hedge funding differs, and the management has fewer regulations compared to other investment strategies, nevertheless, some have been developed within the time being: The management of HFs is generally located onshore and registered in offshore jurisdictions including the Bahamas, Bermuda, British Virgin Islands, Luxemburg, Dublin, or the Cayman Islands (Edwards, 1999; Carroters, 2017). This is not the case with other mutual funds or regulated private investments. Modeled themselves to fit the US exemption under the Securities Act of 1933, the Securities Exchange Act of 1934, and the Investment Company Act of 1940, bringing little US regulatory oversight for hedge fund industries (Bali and Weigert, 2018). 2010 with the Dodd-Frank Wall Street Reform and Consumer Protection Act hedge funds are officially required registration. One point of the DFA is that investors need to have a net worth above USD one million excluding primary residence. Within private equity, stronger relations exist like the German Securities Act. Improving the creditworthiness of the transaction and thus reducing financial costs (Achleitner *et al.*, 2009). Thereby, hedge fund trading is managed by the Commodities Futures Trading Commission (CFTC) and supervised by the National Futures Association (King and Maier, 2009).

However, modern hedge fund history began with the sociologist and financial journalist Alfred Winslow Jones while writing about market behavior, he developed his Jones Hedge Fund (Ubide, 2006). The main idea was to use the complementary nature of leverage and short selling. Jones thereby used his understanding to create a more risk-averse approach than it sounds like (Zhai and Wang, 2023). When looking at leverage increases in debt-to-equity and short selling isolated from each other it is to be an increased exposure of risk (Ubide, 2006). In comparison to the S&P 500 stock index, the management of Jones Hedge Fund shows fewer negative returns and outperformance of the S&P 500 in the years 1962 until 1968 (Ubide, 2006). The way HFs make money can be laid down for two essential reasons, including diversification and fees (Asness *et al.*, 2001). Diversification consists out of passive market exposure combined with a rather low administrative cost apparatus.

2.2. Traditional asset classes

To gain an overview of other asset classes than hedge funds, as rather special investment vehicles, the literature shows that traditional asset classes include equities (stocks), fixed income (bonds), cash equivalents, real estate, and commodities. Each plays a distinct role in financial stability, balancing risk, return, and liquidity (see Table 1: Comparison of Traditional Asset Classes).

First, Equities (Stocks) represent ownership in companies and offer high return potential but come with significant volatility. Stocks are mainly used for long-term capital appreciation and can be categorized into growth, value, large-cap, small-cap, and emerging market equities (Greer, 1997). Second, fixed income (bonds) are debt instruments issued by governments, corporations, or municipalities (Jacquet, 2021). They provide regular interest payments and return the principal at maturity. Bonds range from low-risk government bonds to high-yield corporate bonds and inflation-linked securities. They serve as a hedge against stock market volatility and provide steady income (Inderst, 2011). Third, cash and equivalents include money market instruments, treasury bills, and bank deposits. They offer low returns but are highly liquid and protect against short-term market fluctuations (Jacquet, 2021). Fourth, real estate provides income through rental payments and potential appreciation. It is considered a hedge against inflation but is less liquid compared to stocks and bonds. Real estate can be held directly (physical properties) or indirectly through REITs (Real Estate Investment Trusts) (Inderst, 2011). Lastly, commodities include natural resources like gold, oil, and agricultural products. They are often used as an inflation hedge and diversification tool, but they can be highly volatile due to supply and demand dynamics (Greer, 1997).

Each asset class has different risk-return characteristics, which is why asset classes have different influences on financial stability (Jacquet, 2021). However, institutions provide solutions on how to guarantee their interplay of them.

Table 1. Comparison of traditional asset classes including HF's

Asset Class	Characteristics	Risk	Return Potential	Liquidity
Equities (Stocks)	Ownership in companies, price driven by earnings, market conditions	High (market, economic, company-specific risk)	High (historically ~7-10% p.a.)	High (public markets)
Fixed Income (Bonds)	Debt securities issued by governments or corporations, provide periodic interest payments	Moderate to Low (interest rate, credit risk)	Lower than equities (~2-5% p.a.)	High (for government bonds, moderate for corporate bonds)
Cash & Cash Equivalents	Short-term instruments (e.g., money market funds, treasury bills, deposits)	Very Low (inflation risk)	Low (~0-3% p.a.)	Very High
Real Estate	Physical or financial ownership of property, can provide rental income and appreciation	Moderate (market, liquidity, regulatory risks)	Moderate to High (~4-8% p.a.)	Low to Moderate
Commodities	Physical goods (gold, oil, agricultural products), value driven by supply-demand dynamics	High (market volatility, geopolitical risks)	Varies widely (~3-8% p.a.)	Moderate to High (depends on futures markets)
Hedge Funds & Alternatives	Actively managed investment strategies, often using leverage, derivatives, short-selling	Varies (strategy-dependent)	Varies (can outperform traditional assets, but higher fees and risks)	Low to Moderate (lock-up periods)

Source: Stockbauer (2025)

2.3. Financial stability

Aspects of financial stability include monetary stability, economic growth, institutions, infrastructure as well as markets and efficiency. One indicator is the “robustness of financial markets and their institutions, the state of expectations, and the reaction of central banks and other authorities” (Garbaravicius and Dierick, 2005). The financial system is stable when it is able to promote the productivity of the economy and prevent financial imbalances (Imanov *et al.*, 2017, p. 320). Measuring the level of financial stability is complex since many actors are involved in the process and may change the supposed outcome by single agreements or actions (Agarwal *et al.*, 2009a). Including the fact banks are responsible for stability and have a systematic relevance and political influence, as “banks are political” (Hellwig, 2014, p. 23). One example is that already simple transactions between countries, political actors, and economically dependent actors create future obligations for all involved parties (Financial Stability Forum, 2002). As a result, dependence is developed and ranges through multilateral networks where many parties interact, mostly even on an international level.

In general, two main functions within the financial system are relevant to the system of action (Sauert, 2014). The first one is the intermediation function to bring “resources accumulated by savers to investors who have identified productive uses for them” (Ubide, 2006). The second one is the payment function providing the most important means for the system to action. Whereby central banks have an essential part in decision-taking and policy implications, especially price changes and rates of exchange, inflation, interest rates, etc. (Hellwig, 2014), which is on purpose flexible to guarantee momentum. “Even though the central bank cannot go bankrupt, risks from the central bank’s assets can affect” (Hellwig, 2014, p. 11) the financial system as a whole. Importantly the clearing arrangements through which banks compensate one another for allegations arising from the payments made by their customers (Garbaravicius and Dierick, 2005). Thereby, many types of shocks increase financial stress and weaken the financial stability of households and businesses. Including systematic risks arising from correlations between counterparty credit risks and underlying risks in a complex and highly interconnected system of risk management through derivatives and other hedges (Erede, 2013). Consequently, the conditions of banks and other financial institutions will be weakened and lead to higher market interest rates as investors look for greater returns due to the perception of greater risk (Garbaravicius and Dierick, 2005). Whereas, central banks give access to financial stability reviews, including “current conditions, describe ongoing legal, regulatory, and institutional developments, and discuss proposals” (Chattopadhyaya, 2011, p. 89) to increase financial stability. Paying attention, to the need for financial institutions including the central banks can create interdependence among them by maintaining the public’s confidence to survive (Imanov *et al.*, 2017).

3. METHODOLOGY AND DATA

The research is to be done on qualitative literature including a historical and comparative analysis. The literature will consist of several divergent sources, including literature from libraries in Germany as well as online-accessible literature such as peer-reviewed articles, books and news articles, interviews, etc. Thereby, the foremost task in crafting a robust methodology is to lay out the research design. This entails a detailed blueprint mapping the journey from problem identification to the drawing of conclusions based on empirical evidence. Reflecting on the complexities associated with hedge funds and their potential impact on FS, a mixed-methods approach is warranted. By integrating qualitative dimensions, gaining a nuanced understanding that captures both the statistical patterns and the deeper insights into the qualitative facets of financial phenomena. This form of data provides contextual insights, allowing researchers to delve into the social, cultural, and environmental factors that shape human behavior and attitudes (Gomm *et al.*, 2009).

3.1. Methods in research design

Given the complexity of the topic at hand, this paper will systematically examine the development and operation of hedge funds, their interactions with the financial system, and their comparison to other asset classes. It will delve into the concept of financial stability, elucidating how hedge funds can impact stability, both positively and negatively. Through a comprehensive coding of qualitative data, this paper will aim to synthesize current knowledge and identify gaps that warrant further research.

Data collection, a cornerstone of the methodology, spans multiple sources to triangulate findings and bolster the study's credibility (Nahmias-Wolinsky, 2004). Secondary data from financial markets, enriched by proprietary datasets from regulatory bodies, provide a robust qualitative foundation. Triangulation is further achieved by integrating findings from academic literature, industry reports, and policy documents. The dynamism inherent in hedge fund operations, underscored by their diverse strategies and investment philosophies, necessitates rigorous statistical examination. A pivotal component of the methodology will be the deployment of econometric models to analyze secondary data sourced from financial databases such as Bloomberg and Thomson Reuters. These models, augmented by time-series analysis and regression techniques, are instrumental in identifying correlations and causal relationships amid variables such as hedge fund leverage, market volatility, and overall financial stability metrics.

3.2. Applied methodology

The study at hand focuses on the methodology of qualitative data analysis with a focus on the Grounded Theory (Corbin, 2017). The following steps are based on the implications founded in 1960 by Barnes Glaser and Anselm Strauss,

one of the most influential methodologies in qualitative research. Its primary contribution lies in its ability to generate new theories directly from data, without relying on pre-existing hypotheses (Skjott Linneberg and Korsgaard, 2019). Unlike traditional research methods, which often test established theories, Grounded Theory allows researchers to build concepts and theories that emerge naturally through data collection and analysis.

The reason the Grounded Theory methodological approach has been chosen is that it is particularly useful in fields where there is little prior research or where existing theories are insufficient (Corbin, 2017). Its inductive approach is well-suited to exploring topics that are not well understood or where existing theories may be inadequate (Cutcliffe, 2000; Dunne, 2011). Moreover, the iterative and flexible nature of Grounded Theory makes it applicable to a wide range of research contexts. It allows researchers to be responsive to the data, adapting their approach as new insights emerge (Cutcliffe, 2000). This makes Grounded Theory a highly versatile methodology, capable of generating nuanced theories that are grounded in real-world data, which is applicable to the data of the hedge fund industry over a long period. Therefore, the data is coded based on the key concepts and themes mentioned before including the complex structure of the hedge fund industry on the international level (Dunne, 2011).

4. RESEARCH OBJECTIVE

Examining how hedge funds recover from financial crises compared to traditional asset classes such as equities, bonds, and mutual funds. The research will evaluate the speed, magnitude, and sustainability of hedge fund rebounds after market downturns, identifying key factors that contribute to their resilience or underperformance. The thesis aims to assess the performance persistence of hedge funds and their relationship with market efficiency. Performance Persistence of Hedge Funds finds statistically significant performance persistence for hedge funds at quarterly, semi-annual, and annual periods. Investors use a quarterly momentum strategy to achieve superior returns. Thereby, some hedge fund managers consistently outperform others, challenging the idea that hedge fund returns are purely random.

The Market Efficiency applies Shiller's variance bound test to evaluate whether the JSE All Share Index follows the Efficient Market Hypothesis (EMH). Results violate Shiller's three variance inequalities, suggesting that the market shows inefficiencies. This implies that hedge fund managers may have opportunities to exploit market inefficiencies for excess returns.

The study accounts for survivorship bias, where poorly performing funds exit databases, potentially skewing results. Backfill bias is also identified, where funds report historical performance only after achieving positive results. Adjusting for these biases ensures that the study provides a more accurate picture of hedge fund performance. So that investors can benefit from momentum-based strategies in

hedge funds, particularly at quarterly horizons. The hedge fund industry can provide excess returns, but these are not purely due to manager skill, some come from market inefficiencies. Better benchmarking techniques should be developed to distinguish true alpha from beta-driven returns. Regulators should ensure transparent performance reporting to reduce survivorship and backfill bias.

Research question

Hedge funds have demonstrated a capacity to recover more swiftly from major financial crises compared to traditional equities and bonds. This resilience is attributed to their diverse strategies, risk management practices, and ability to capitalize on market inefficiencies, therefore, the research question arises of:

How quickly do hedge funds recover after major financial crises compared to other traditional asset classes?

When looking at the performance during financial crises, starting in 2008 with the Global Financial Crisis (GFC), hedge funds experienced significant losses, with some funds declining by up to 55 percent. However, many managed to recoup these losses by 2012, showcasing a robust recovery trajectory. In contrast, traditional equity markets took longer to rebound, and bond markets faced challenges due to liquidity constraints (Rudegeair, 2024). During the COVID-19 Pandemic in 2020, the early stages of the pandemic, global equity markets experienced sharp declines, with some indices dropping by over 20 percent. Hedge funds, however, demonstrated resilience, with multimanager firms experiencing losses of less than one percent during the same period. This performance underscores hedge funds' ability to navigate extreme market volatility effectively (Rudegeair, 2024). While considering the Risk-Adjusted Returns, over extended periods, hedge funds have consistently delivered superior risk-adjusted returns compared to equities and bonds. For instance, over a five-year horizon, hedge funds achieved a Sharpe ratio of 1.58, surpassing equities at 1.46 and bonds at -0.24. This indicates that hedge funds provide better returns per unit of risk taken (AIMA, 2018).

Different than that, the volatility and drawdowns show that hedge funds typically experience lower volatility and shallower drawdowns compared to global equities. During significant market downturns, such as the GFC, hedge funds' drawdowns were less severe, aiding in quicker recovery times. This resilience is partly due to their diversified investment strategies and active risk management (De Freitas, 2022).

5. HEDGE FUNDS IMPACT ON FINANCIAL STABILITY

The hedge fund industry has been the subject of various academic studies focusing on performance analysis, regulatory frameworks, and market dynamics. Several key pieces of literature provide insights into these areas. First, the performance analysis of HFs whereby a comprehensive study examined the performance of hedge funds with the impact on financial stability.

5.1. Financial stability

Hence, financial instability is likely to involve problems such as bank solvency, not just its liquidity (Hellwig, 2014). This creates challenges for the well-being of the overall economy, which is a threat not solely towards one nation, but due to globalization, it concerns more people and more sectors on an international level. Bringing about hidden insolvencies, that is when “the value of its assets is less than the value of its liabilities” (Christiano and Fischer, 1998; Hellwig, 2014, p. 42). Understanding the meaning of financial stability with the influence of asset classes entails recognizing its multifaceted nature, which encompasses robust financial institutions and markets, effective regulatory frameworks, resilience to shocks, rational behavior by market participants, and a stable macroeconomic environment (Dietz and Jenkins, 2018). The institutional frameworks governing financial stability, particularly the role of central banks and regulatory authorities, are crucial in monitoring and managing risks (Basel Committee on Banking Supervision, 2011). International cooperation and public confidence are also integral to maintaining a stable financial system in a globalized economy. As financial markets continue to evolve, the concept of financial stability will adapt, necessitating continued vigilance and proactive policy measures to address emerging challenges and opportunities for fostering a resilient and inclusive financial system (Erede, 2013).

A key characteristic of financial stability is the absence of systemic risk, which refers to the potential for a financial system-wide collapse stemming from the failure of a single or small group of entities (European Central Bank, 2007). Systemic risk manifests when interconnectedness within the financial system leads to the rapid transmission of financial distress, causing widespread economic fallout. Therefore, monitoring and managing systemic risk is a critical component of ensuring financial stability. Regulatory bodies and international organizations, such as the International Monetary Fund (IMF) and the Financial Stability Board (FSB), consistently assess systemic risks and formulate policies aimed at mitigating them.

Moreover, financial stability is defined by its resilience to adverse shocks (Aramonte *et al.*, 2023). This means that the financial system should be capable of withstanding disruptions originating from various sources, including economic downturns, political instability, and natural disasters. Resilience is bolstered by the presence of well-capitalized banks with adequate liquidity reserves, which can absorb losses without causing major disruptions to their operations (Jensen and Meckling, 1976). Additionally, a diversified financial system, with a wide range of financial products and services, enhances resilience by spreading and managing risk more effectively.

The institutional framework governing financial stability plays a pivotal role in its maintenance. Central banks, financial regulatory authorities, and international financial institutions are key players in this framework

(Garbaravicius and Dierick, 2005). Central banks, through their role in monetary policy and financial regulation, ensure that sufficient liquidity is available in the financial system and oversee the health of financial institutions. Regulatory authorities, such as the Securities and Exchange Commission (SEC) in the United States or the European Central Bank (ECB), monitor compliance with financial regulations and take enforcement actions when necessary. International institutions, like the IMF and the World Bank, provide a platform for cooperation and coordination among countries to strengthen global financial stability (Hellwig, 2014).

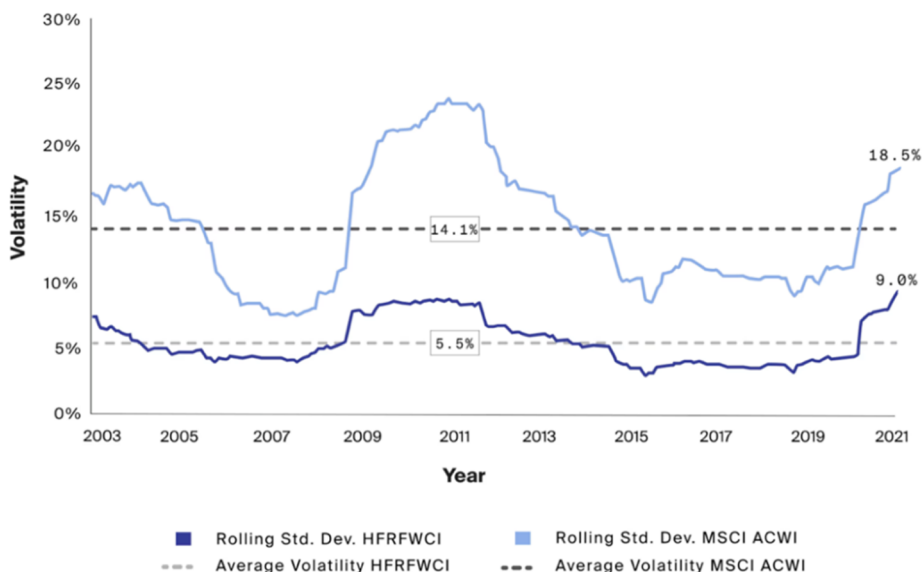
The pursuit of financial stability also necessitates a robust legal and regulatory framework. Effective regulation ensures that financial institutions operate within safe and sound parameters, minimizing the likelihood of excessive risk-taking or fraudulent activities (Al-Azzam, 2019). Regulatory frameworks encompass a range of measures, including capital adequacy requirements, liquidity requirements, and supervision of financial practices. These measures are designed to promote transparency, accountability, and risk management within the financial system (Sauert, 2014).

5.2. Impact of hedge funds

The volatility and Hedge Fund performance (see Figure 1: Hedge Fund Volatility vs Global Equities) focuses on the impact of market volatility on the performance of hedge funds. By incorporating a volatility index into the CAPM, the research aimed to determine how different hedge fund strategies perform under varying volatility conditions (Fieldhouse, 2024). The study highlighted the importance of considering volatility in investment decisions and suggested that certain strategies might be better suited for periods of heightened market fluctuations (Agarwal *et al.*, 2009b; De Freitas, 2022). Whereby the regulatory framework and retail participation, shows the regulation of hedge funds has evolved to balance investor protection with market growth. Research assessing the country's regulatory practices, especially concerning retail participation, indicates that the framework aligns well with international standards (Fieldhouse, 2024). The studies emphasize the need for a regulatory environment that safeguards investors while allowing access to the benefits of hedge fund investments.

Hedge funds both influence and react to market volatility in several ways. On one hand, they can help reduce overall market volatility by providing liquidity and stabilizing mispriced assets (Rudegeair, 2024). Market-neutral strategies, for example, can help balance supply and demand for securities, preventing excessive price swings. On the other hand, hedge funds with high leverage and speculative trading strategies can exacerbate volatility during market downturns (Fieldhouse, 2024). The liquidation of leveraged positions in times of stress can trigger a domino effect, leading to forced selling and increased market turbulence. The

2008 financial crisis highlighted how hedge funds, particularly those heavily exposed to structured credit products, contributed to market instability (Ferrara *et al.*, 2024). Furthermore, the relationship between hedge fund strategies and volatility is dynamic. Some funds thrive in high-volatility environments, such as trend-following strategies that capitalize on market momentum (Rudegeair, 2024). Others struggle during periods of extreme uncertainty, particularly those dependent on stable market conditions to generate returns.



Source: HFR, Bloomberg. As of 1/31/2022, Rolling 36 Months.

Figure 1. Hedge Fund Volatility vs. Global Equities

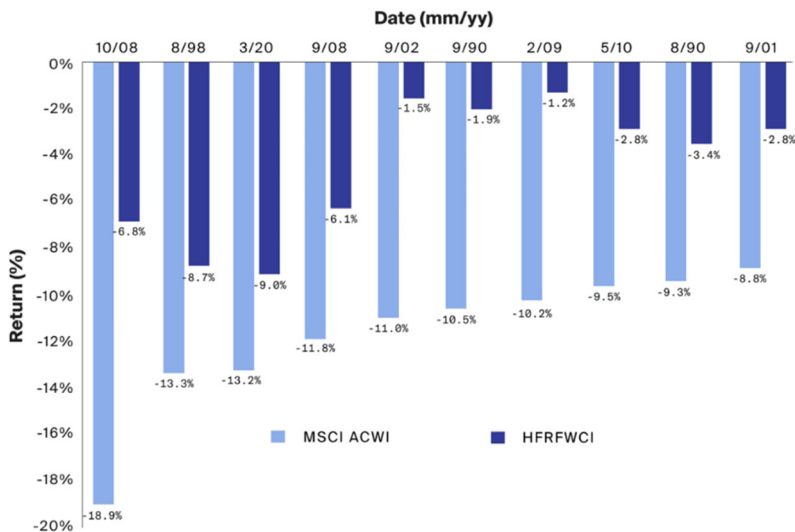
Table2. Performance Comparison in 2008

Asset Class	2008 Return	Drawdown	Recovery Time
S&P 500 (Equities)	-38.5%	~50% peak-to-trough	~5.5 years (recovered in 2013)
HFR Fund Weighted Composite Index (Hedge Funds)	-19.0%	~21% drawdown	~3-4 years (recovered by 2012-2013)
HFR Fund of Funds Index	-21.4%	~23% drawdown	~4 years

Source: Aragon (2024)

Table 2 shows that equities suffered severe losses due to the collapse of major financial institutions, a liquidity crunch, and a deep economic downturn. While hedge funds outperformed equities, still declining due to credit market disruptions, investor redemptions, and correlated asset sell-offs. Hence, hedge funds recovered faster than equities, as many strategies capitalized on market dislocations post-crisis. This implication has several arguments such as the hedging strategies using short positions to mitigate losses, particularly long/short equity and global macro funds. Combined with the lower net exposure, unlike the traditional equity classes, hedge funds reduced risk exposure and managed leverage actively, some HFs imposed redemption limits, preventing mass liquidations and forced selling.

In summary, the HF industry has undergone significant developments in performance, (see Figure 2: Hedge Fund Performance) regulation, and market dynamics. While challenges persist, ongoing research and evolving regulatory practices aim to enhance the industry's contribution to the broader financial market.



Source: HFR, Bloomberg. As of 1/31/2022.

**Figure 2. Hedge fund performance;
during the 10 worst months of the MSCI ACWI**

5.3. Difference to other asset classes

Other than with other asset classes, the strategies behind HFs include anything from leveraging to short-selling and span across a broad spectrum of asset classes. The flexibility of hedge funds is wider, since the investment in alternative strategies such as old and speculative things. Therefore, some

characteristics can be distinguished to show differences among the diverse private pooled investment vehicles, such as mutual funds, which need to be liquidated so that the money can be drawn out within a few or three days, which is not the case with hedge funds lock investors' money and restrict the withdrawal (Stowell and Stowell, 2024). Financial stability also intersects with other policy objectives, such as financial inclusion and economic equity (Jiao, 2013). Ensuring that the benefits of a stable financial system are broadly distributed across society, particularly to marginalized and underserved populations, is crucial for equitable economic development. Financial stability should not come at the expense of excluding segments of the population from access to financial services (Sauert, 2014). Policymakers must strike a balance between maintaining a stable financial system and promoting inclusive growth (Hellwig, 2014).

One major difference is the opportunity to exploit market inefficiencies using the combination of various investment strategies and instruments (Bloomberg, 2007). Thereby employing derivatives and executing short selling using financial engineering techniques. Hence, the growth of hedge funds is attributed to “two factors of the demographics of potential hedge fund investors and the attractive performance of hedge funds” (Edwards, 1999; 193). This leads to one of the reasons that HFs recover faster from crises (see Table 5: Historical Recovery Times).

Table 3. Historical recovery times

Crisis	Equities (S&P 500)	Bonds (U.S. Aggregate Bond Index)	Hedge Funds (HFRI Index)
Dot-Com Bubble (2000-2002)	~5 years (2007)	Bonds had minimal impact, continued growth	~3 years (2005)
Global Financial Crisis (2008-2009)	~5.5 years (2013)	Bonds had positive returns during crisis	~3-4 years (2012-2013)
COVID-19 Crash (2020)	~6 months	Bonds had a minor drop but recovered quickly	~3-6 months

Source: Aragon *et al.* (2024)

6. DISCUSSION

On the one hand, there are policymakers and academics, who acknowledge hedge funds' essential role in increasing profits and effectively diversifying risks in traditional portfolios (Çelik and Isaksson, 2014). Thereby, Alan Greenspan, the former chairman of the Federal Reserve System, mentioned that hedge funds “have become major contributors to the flexibility of the financial system” (Agarwal *et al.*, 2009). Thus, hedge funds not only provide an investment with potentially attractive returns but also offer an investment that has no correlation

with most traditional portfolios (Asness *et al.*, 2001). As seen in American economics, hedge funds have been used as financial means to support a stable interest rate beyond history (Mallaby, 2019, p. 213). Thus, hedge funds come with light regulatory oversight, and their participation in various markets has been proven fundamental. Achleitner *et al.* propose that the increasing provision of liquidity, made financial markets more efficient but resilient to financial shocks in past years, including the most recent financial crisis (Achleitner *et al.*, 2009).

Contrary, beginning with the first hedge fund of A. W. Jones uses leverage to have sustainable and substantial capacities for bigger trades, on the other side, being described as risky, especially in times of crisis when investors want their money back (Mallaby, 2019). A common concern following the near failure of Long-Term Capital Management (LTCM) in 1998 is that a single hedge fund creates a systemic risk to the worldwide financial system (Kruttli and Monion, 2013). Claiming that hedge funds are large enough to destabilize markets or even provoke financial crises. Such ongoing concern about the vulnerability paired with the tremendous development and opaque nature of hedge funds, emphasize their probable threat to financial stability (Erede, 2013) combined with its close relationships with other financial institutions such as prime brokers (Bussière *et al.*, 2015). One factor behind this is the illiquidity of assets which are used especially in event-driven hedge funds and in times of crises (Mallaby, 2019, p. 344). As stated by (Walden and Lajbcygier, 2023), there is a “lack of transparency within the hedge fund industry, especially when it comes to pricing, especially fees for the managers” (Walden and Lajbcygier, 2023, p. 154). This makes the process speculative and difficult for regulators and other market participants to assess the potential risks HFs pose to financial stability. The literature on systemic risk provides valuable insights into how interconnectedness and common exposures among financial institutions can propagate shocks throughout the financial system (Aramonte *et al.*, 2023). Studies such as those by (Adrian and Brunnermeier, 2008) and (Acharya *et al.*, 2010) highlight the systemic risk posed by institutions that are highly leveraged and interconnected, as is often the case with hedge funds. These risks are further magnified in times of market stress, when forced deleveraging and fire sales can precipitate sharp declines in asset prices, thereby exacerbating market turmoil (Aramonte *et al.*, 2023).

7. CONCLUSION

Hedge funds play a vital role in modern financial markets by enhancing liquidity, improving price efficiency, and providing diversification benefits to investors. Their ability to generate alpha through sophisticated strategies makes them an essential component of institutional portfolios. However, hedge fund volatility is highly dependent on the strategy employed, ranging from low-risk arbitrage approaches to high-risk leveraged trading. While hedge funds can act as stabilizers in financial markets, they can also contribute to volatility, especially

when leverage and liquidity risks are involved. Understanding these dynamics is crucial for investors seeking to optimize risk-adjusted returns in hedge fund investments.

The concept of financial stability is continually evolving, shaped by changes in financial markets, innovations in financial products and services, and lessons learned from financial crises (Anton and Afloarei Nucu, 2024). Emerging trends such as fintech, cryptocurrencies, and decentralized finance (DeFi) present both opportunities and challenges for financial stability (see Table 3). On the one hand, these innovations can enhance financial inclusion, reduce transaction costs, and increase efficiency (Imanov *et al.*, 2017). On the other hand, they can introduce new risks, such as cybersecurity threats, regulatory arbitrage, and operational risks (Aramonte *et al.*, 2023). Therefore, maintaining financial stability requires ongoing vigilance, adaptive regulatory approaches, and an openness to harnessing the benefits of innovation while managing associated risks.

So, hedge funds play a crucial role in capital allocation by directing capital toward underfunded or inefficient market segments. Strategies such as distressed asset investing and private credit funding provide liquidity to companies facing financial difficulties, contributing to the overall stability of financial systems (Bali and Weigert, 2018). Importantly, hedge funds act as risk managers by employing strategies designed to hedge against market downturns. For instance, global macro hedge funds use derivatives and short positions to protect portfolios from economic shocks, while tail-risk hedge funds specifically focus on mitigating extreme downside risks (Chattopadhyaya, 2011).

7.1. Differences in asset classes

Separated from other investment vehicles since hedge funds assist high-profile individuals and institutions to get the maximum return from the money they are investing while investment banking itself aids in raising capital for the investees from the investor (Stulz, 2007; Agarwal *et al.*, 2009a). Thereby hedge funds use “aggressive trading strategies designed to earn positive returns” (King and Maier, 2009) in all market environments, including short sales, leverage, program trading, arbitrage, and derivatives. Even though “little is known about these loosely regulated private investment pools, an unstudied reaction to 1998 is to regulate them” (Stulz, 2007). Other than that, alternative investment vehicles operate in other directions. The major difference is the investment horizon, as money in private equity funds is locked up for approximately ten years, whereas money in hedge funds is invested for about ten months. Also reflected in the incentive structure of the fund (Ubide, 2006), HF managers are paid regarding the financial cash flow generated over the term of the fund, whereby HF managers are referred to their periodic marking to market their portfolios (Managed Funds Association, 2003). Overall, it can be said that both investors have a distinct business model, however, when it comes to the reaction after a crisis, hedge funds

use diversification so that their recovery time is to be said four years, while equities take approximately six years to recover after a crisis (McKinsey Global Institute, 2009). The difference is the structure and the mindset behind the divergent systems, comparing investment bankers with hedge fund managers (Asness *et al.*, 2001). The hedge fund industry is unstable, acting like a start-up where managers are willing to stay up all night to make sure the investment is in order. Adding to the fact that most of the time the managers' money is also invested in their hedge fund (Jiao, 2013). Whereby, bankers act in a secure, stable environment with office hours, investing the money of others (comp. Mallaby, 2019).

7.2. Further studies

Recent studies have delved into the intricate relationship between hedge fund volatility and financial stability, offering nuanced insights into how hedge fund activities can influence market dynamics. The ECB has examined the dual role of hedge funds in financial markets (Ferrara *et al.*, 2024). While hedge funds can enhance market efficiency and liquidity, their significant presence, especially in the euro area government bond markets, raises concerns about potential volatility amplification (European Central Bank, 2007).

The ECB's analysis indicates that although hedge funds contribute to market depth, their rapid withdrawal during periods of stress could exacerbate market volatility. This underscores the importance of monitoring hedge fund activities to maintain financial stability. The U.S. SEC has explored how hedge funds manage liquidity, particularly when holding illiquid assets. Findings suggest that hedge funds with lower-than-expected liquidity buffers may outperform benchmarks under normal conditions. However, during market crises, such as the one experienced in 2020, these funds are more susceptible to forced asset sales, which can trigger broader market disruptions. This highlights a policy trade-off: while lower liquidity buffers can enhance returns in stable markets, they may pose systemic risks during periods of financial stress (Aragon *et al.*, 2024).

Research from the Office of Financial Research delves into the risk-shifting behaviors of hedge funds, particularly following periods of underperformance. The study reveals that hedge funds may adjust their risk profiles by altering portfolio volatility, influenced by factors such as investor redemption terms, ownership concentration, and leverage. Understanding these behaviors is crucial, as they can have significant implications for market stability, especially if multiple funds engage in similar strategies simultaneously (Andrews and Gadgil, 2024).

A study published in the *Review of Finance* examines the relationship between hedge funds' idiosyncratic volatility and their future risk-adjusted returns. The research indicates that hedge funds exhibiting higher idiosyncratic volatility tend to achieve superior future risk-adjusted returns compared to their lower-volatility counterparts. This finding suggests that embracing certain levels of

idiosyncratic risk may be a deliberate strategy employed by hedge funds to enhance performance (Bali and Weigert, 2024).

The Bank of England has expressed concerns regarding the potential systemic risks posed by hedge funds, especially those engaging in substantial short positions against government bonds. Such positions, if unwound abruptly, could lead to significant market stress. The Bank emphasizes the need for vigilant monitoring of non-bank financial institutions, including hedge funds, to preempt and mitigate potential threats to financial stability (Arnold, 2024).

In summary, while hedge funds play a pivotal role in enhancing market efficiency and providing liquidity, their activities can also introduce elements of volatility and systemic risk. Ongoing research and regulatory oversight are essential to balance the benefits of hedge fund participation in financial markets with the imperative of maintaining overall financial stability.

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EUROPEAN INTEROPERABILITY REFERENCE ARCHITECTURE TEMPLATE FOR DATA INTEGRATION

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Abstract

EIRA (European Interoperability Reference Architecture) is a reference architecture meant to guide how to build interoperable solutions for European software (digital) services. The main tooling ecosystem is based on the ArchiMate environment. The defining sections of this reference architecture cover Architectural Building Blocks (ABBs), views, viewpoints, and a Data Space perspective.

A Solution Architecture Template (SAT) is a specification of EIRA applied to a particular interoperability problem. A SAT addresses the solution experts and architects of the domain proposal, providing guidance into the organizational, semantic, and technical matters.

The problem of Data Integration comes from the domain of Data Interoperability, which is a main concern of Interoperable Europe initiative of the European Commission. There is an SAT proposal in this area named SAT4OpenData that addresses the Open Data domain, more specifically, "to the practice of publishing (raw) data in a way that is accessible, reusable, machine-readable and licensed permissively".

In this paper, we will discuss the problem of Data Integration in the context of EIRA and how such a SAT proposal could be approached.

Keywords: *EIRA; public services; e-Government; software interoperability; application integration; SOA.*

JEL Classification: L86; C88; M15.

1. EIRA EUROPEAN INTEROPERABILITY REFERENCE ARCHITECTURE

EIRA is an architecture content metamodel “defining the most salient architectural building blocks (ABBs) needed to build interoperable e-Government systems” (European Union, 2020).

EIRA provides a common language to be used in the development lifecycles of the interoperable e-Government systems and extends the ArchiMate language as a modelling notation and uses SOA architectural style.

This architecture is meant to implement the European Interoperability Framework (EIF) and is part of the ISA² programme, Action 2016.32 (European Union, 2023a).

EIRA has four main characteristics (European Union, 2023b):

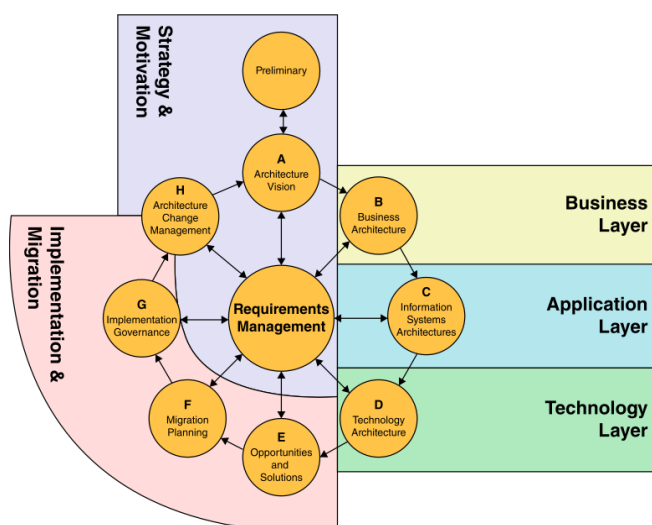
- 1) Common terminology to achieve coordination;
- 2) Reference architecture for delivering digital public services;
- 3) Technology – and product-neutral and a service-oriented architecture (SOA) style;
- 4) Alignment with EIF and TOGAF.

2. ARCHIMATE LANGUAGE

ArchiMate is an open and independent modelling language for Enterprise Architecture that “provides a uniform representation for diagrams that describe Enterprise Architectures and offers an integrated approach to describe and visualize the different architecture domains together with their underlying relations and dependencies” (Josey, 2019).

This architectural language is based on these underlying standards:

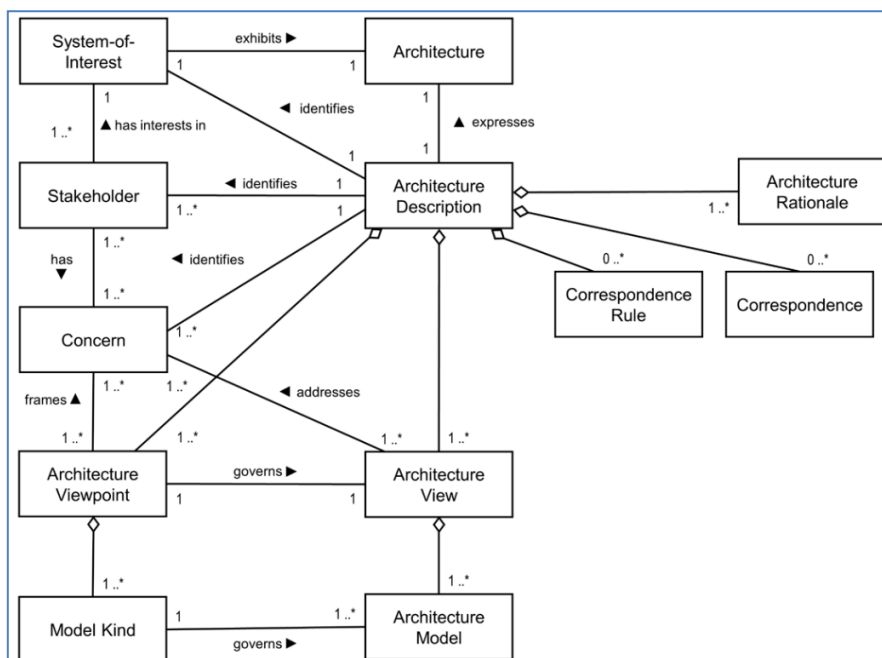
- TOGAF (The Open Group Architectural Framework),
- BPMN (Business Processing Modelling Notation),
- UML (Unified Modelling Language),
- BIZBOK Guide (Business Architecture Body of Knowledge Guide)
- BMM (Business Motivation Model).



Source: Open Group Library (2024)

Figure 1. ArchiMate alignment with TOGAF

The ArchiMate authors propose a conceptual model (see Figure 1) in line with TOGAF enterprise layers (business, application, technology) to build solid and sound enterprise software systems. Also, they propose two orthogonal layers, as Strategy & Motivation, and Implementation & Migration, to align the enterprise systems with the enterprise vision and with the planning and governance objectives of the enterprise (Priyadharshini, 2023).



Source: Open Group Library (2024)

Figure 2. ArchiMate alignment with TOGAF

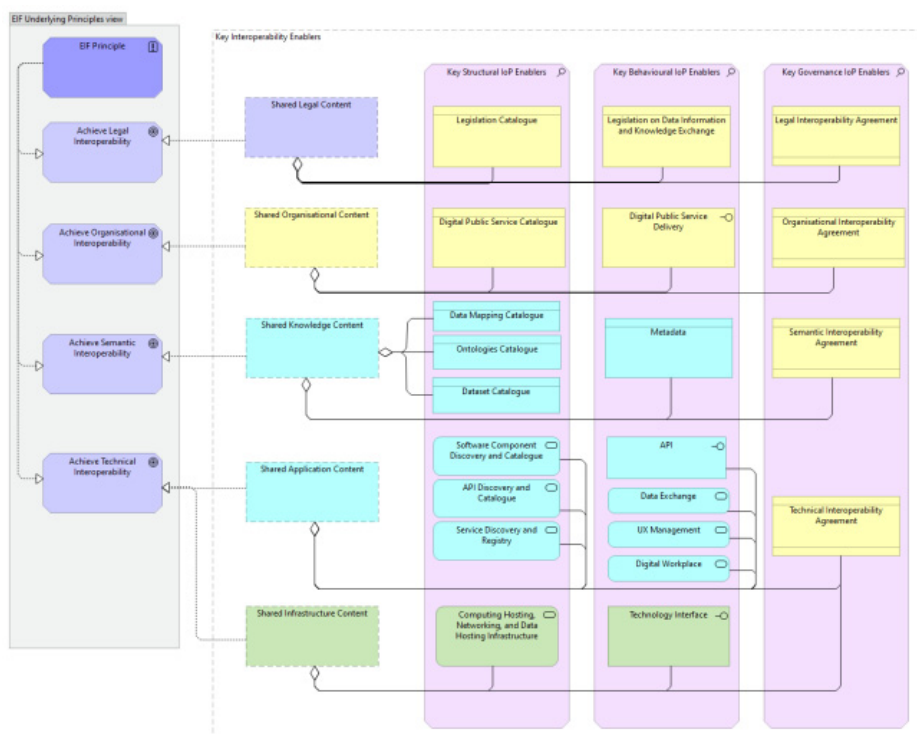
This way the ArchiMate conceptual model is engineered to align with TOGAF tenets so that architectural layers (see Figure 2) to support an architecture described with building blocks from architecture views, architecture viewpoints, and architecture models (application, and technology layers). Also, concepts like stakeholders, concerns, and architecture rationales are critical to align the architecture with the critical enterprise strategies and visions (the business layer).

3. EIRA EXTENSION OF THE ARCHIMATE: KEY CONCEPTS

EIRA (as of European Interoperability Reference Architecture) represents a standardization initiative at the EU level of decision to respond consistently to the public service integration problem. EIRA is founded on ArchiMate conceptual model and extends it in the business context of governmental software services.

The EIRA key (extended) concepts refer to (European Union, 2023b):

- *EIF interoperability level* and *EIF principles* cover the recommendations and principles to define the public services.
- EIRA views and EIRA viewpoints formalize EIF principles (as of ArchiMate graphical notations) and apply to specific stockholders' interests.
- *Architecture Building Block (ABB)* represents abstract and reusable components to be used in SBB concrete specifications.
- *Solution Building Block (SBB)* consists in the actual architectural solutions to business requirements.
- *Reference Architecture* make up an architectural solution using ABBs.
- *Solution Architecture* embodies an actual solution using the reference architecture.
- *Solution* implements the Solution Architecture with SBBs.



Source: The Open Group Library (2024)

Figure 3. EIRA architectural viewpoints

The EIRA specific architectural solution is based on several viewpoints (see Figure 3 that emphasize the viewpoints' relationships):

- Conceptual Model for Integrated Public Service Provisioning viewpoint,
- EIRA Ontology viewpoint,
- High-level viewpoint,
- Interoperability Governance viewpoint,
- Interoperability Privacy viewpoint,
- Interoperability Security viewpoint,
- Key Interoperability Enablers viewpoint,
- API viewpoint,
- Interoperable European Solution viewpoint.

Based on the viewpoints (pictured in Figure 3) EIRA define 5 architectural views extended from TOGAF principles of ArchiMate model:

- The Legal view,
- The Organizational view,
- The Semantic view,
- The Technical view (composed of an application and infrastructure part),
- The European Interoperability Framework underlying principles view.

4. OPEN DATA INITIATIVE

The EU defines “Open data” as ”data that anyone can access, use and share.” (European Union, 2024a).

Open data coming from public services (public data, public sector information- PSI or government data) should support the decision process of governments and businesses and are regulated by:

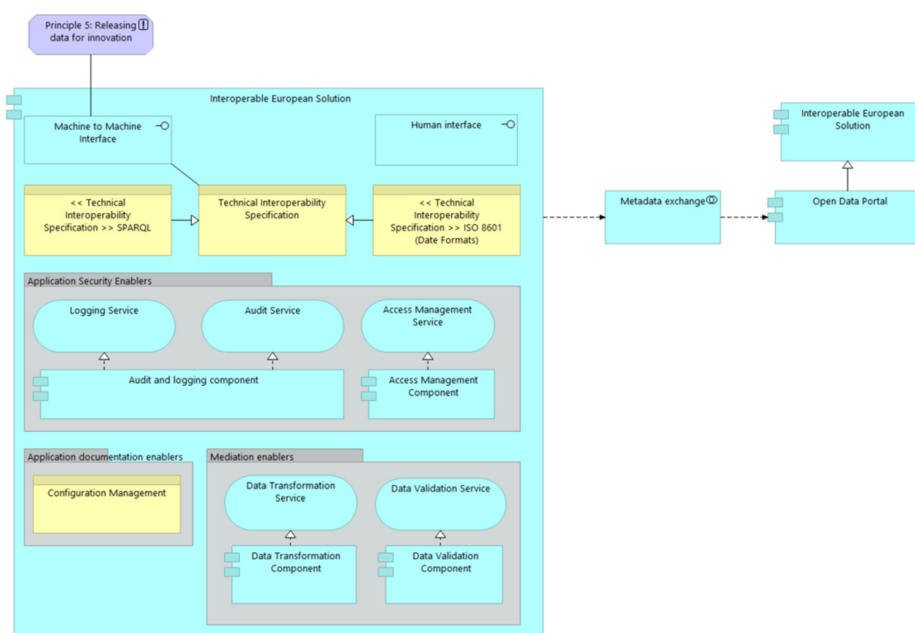
- Open Data EU directive: Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information.
- Open Transposition to Romanian Legislation: “Legea nr.179/2022 privind datele deschise și reutilizarea informațiilor din sectorul public”.

5. SAT4OpenData

SAT means *Solution Architecture Template* and represents Solution Architecture tailored for a specific domain (within EU interest). This way, *SAT4OpenData* represents a SAT proposal for Open Data domain and its audience consists in architects, policy makers and public administrations. (European Union, 2024b). SAT4OpenData proposes several Interoperability Views:

- Legal View
 - Public Data Policies, Constraints
 - Legal Interoperability Specification.

- Organization View
 - Public Services, Providers and Consumers
- Semantic View
 - Representation, Data Model, Data Set, Descriptive Metadata
- Technical View - Application
 - Technical Interoperability Specs like SparQL
 - Data Transformation Services and Components
- Technical View – Infrastructure (pictured in Figure 4)
 - Data Publication Services
 - Metadata Management Services.



Source: EIRA 6.0.0 Specifications (European Union, 2024b)

Figure 4. Technical View – Application

6. DATA INTEGRATION

We consider SAT4OpenData a very welcome SAT initiative, but at the same time, we think that there are several data integration challenges that must be taken into consideration by this architecture, and this way it could be enhanced as the next level of Open Data Architecture.

There are several consistent Data Integration definitions in the literature:

“... a set of techniques that enable building systems geared for flexible sharing and integration of data across multiple autonomous data providers” (Doan *et al.*, 2012)

“... a set of procedures, techniques, and technologies used to design and build processes that extract, restructure, move, and load data in either operational or analytic data stores either in real time or in batch mode.” (Giordano, 2010)

“The practice associated with managing data that travels between applications, data stores, systems, and organizations is traditionally called data integration. (Reeve, 2013)

Taking into consideration the above definitions, one could summarize several data integration problems and challenges that must be addressed also in the context of EU Open Data initiatives:

- Format: heterogeneous data format/data models,
- Accessibility and autonomy: networking, access drivers, web-enabling
- Synchronous/Asynchronous Systems,
- Scope: Operational/Transactional (OLTP) vs. Analytical (OLAP.BI),
- Complexity: number of sources, data format (in)compatibilities,
- Source Data Query Language/Procedures (to extract data).

7. CONCLUSION: SAT4OPENDATA EXTENSION FOR DATA INTEGRATION

In this paper, we try to make an argument for an initiative that *SAT4OpenData* to further develop or extend the following interoperability extension views:

- Legal View: to describe the licenses required to combine data,
- Semantic View
 - Semantic Interoperability Spec to cover also the specific aspects of Data Integration,
 - Data Standard to describe the Data formats implied by the Data Integration operations,
- Technical View - Application
 - Technical Interoperability to produce the REST and/or GraphQL API Specifications for Interoperability,
 - Data Transformation Services and Components as Data Integration Services and Components,
- Technical View - Infrastructure
 - Digital Service Infrastructure to take into consideration the Infrastructure Data Integration and Consolidation Service Specs.

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THE IMPACT OF THE FINANCIAL AND PANDEMIC CRISES ON THE ROMANIAN BUSINESS ENVIRONMENT

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Abstract

Over time, the emergence of various types of crises (e.g., financial, geopolitical, pandemic, energy crisis) has significantly impacted the business environment in almost all countries. The influence of crises has been extensively studied in the academic literature both at the microeconomic and macroeconomic levels, from various perspectives; however, the complexity of the phenomenon still offers opportunities for further research. Studies in the literature have shown that crisis periods have influenced numerous domains such as the economy, accounting, banking and financial system, politics, and the labour market. This paper aims to analyse the influence of the major crises from the past 20 years on the business environment in Romania. In this regard, we considered the most representative crises for Romania the economic crisis of 2007–2008 and the crisis generated by the COVID-19 pandemic during the period 2020–2022. In order to achieve the purpose of the paper, we conducted an exploratory study to investigate the trends generated by periods of crisis on how economic uncertainty, imposed restrictions, and legislative changes have influenced business decisions regarding establishment, continuation, suspension, or business closure. We used statistical data provided by the National Trade Register Office regarding the registration of legal entities, active registered professionals, business suspensions, dissolutions, removals from the registry, and insolvency proceedings. The statistical data available and analysed in this paper cover the period 2009–2024. The results of the study highlighted that the COVID-19 pandemic did not have a significant impact on the number of registrations of entities, suspensions, removals, and insolvencies in Romania during the period 2008–2024. However, the economic crisis of 2007–2010 had a major influence both on the number of temporary activity suspensions and on the number of insolvencies and even business closure.

Keywords: *economic crisis; COVID-19; business environment; firm dynamics; accounting.*

JEL Classification: G01; M10; M21; M41.

1. INTRODUCTION

In recent decades, economic and pandemic crises have caused significant transformations in the global business environment, having a direct impact on the Romanian economy. The purpose of this article is to analyze how the economic crises of the last 16 years, particularly the financial crisis of 2008 and the COVID-19 pandemic, have influenced the structure and functioning of businesses in Romania from an accounting and economic perspective. The current study is based on statistical data provided by the National Trade Register Office, which reflects the evolution of the number of legal entities and authorized individuals during the period 2008 – 2024.

Our analysis fits into a broader theoretical context, inspired by the international literature that has studied changes in SME financing during periods of crisis, based on works by authors such as Berger *et al.* (1998) and Robb and Robinson (2014). Small enterprises have usually faced difficulties in obtaining external capital due to a lack of informational transparency, which has forced them to rely on their own resources or informational support. However, recent studies indicate a trend towards more active use of the tools available within the conventional financial industry. Our article analyzes whether and to what extent companies in Romania have managed to maintain their operations while the system is unstable.

To support this point of view, our analysis is based on official statistical data provided by the National Trade Register Office. These data track the evolution of the registration of legal entities and authorized natural persons, as well as the dynamics of removals during the period 2008–2024. The obtained information provides a clear picture of how the financial crisis and the one generated by the COVID-19 pandemic have affected businesses in Romania, highlighting the capacity for adaptation and entrepreneurial resilience, as well as moments of economic setback. Therefore, our analysis contributes to understanding the effects of these external events on the country's economic structure. It also provides a solid foundation for the development of public policies tailored to real circumstances.

The article also responds to the calls of authors such as Buckley (2002), Doh (2015), or Buckley *et al.* (2017), who have highlighted the importance of economic research focusing on how institutional and political differences affect international companies (Ghemawat, 2001, 2007; Henisz, 2002). We examine the real changes that have occurred in the Romanian business environment following the recent crises. We do this using the source from the National Trade Register Office. At the same time, studies on the national economies of countries have demonstrated that microenterprises should become essential components of economic recovery strategies (North and Smallbone, 2006; Siemens, 2012; Corp, 2014). In Romania, microenterprises that dominate the SME landscape have been

the most exposed to crises. They face issues related to capital, access to credit, and a lack of digital infrastructure, especially in underdeveloped regions.

In conclusion, this article provides a clear perspective on how economic crises have contributed to the situation of the registration of legal entities and authorized natural persons, as well as the evolution of the number of removals during the same period in Romania, placing particular emphasis on national statistical data and relevant comparisons from international literature.

2. LITERATURE REVIEW

In order to analyze the impact and methods of crisis reduction, it is essential to define it. Booth (1993) defines a crisis as a situation faced by an individual, a group, or an organization that cannot be managed using ordinary procedures. Periodic threat, gradual threat, and sudden threat are the three types of crisis according to Booth (1993). Since the COVID-19 pandemic developed rapidly and affected entire economic sectors, not just individual organizations, it can clearly be considered a "sudden threat."

Economic crises represent periods of significant decline in economic activity, characterized by significant changes in the perception of future prospects that are preceded or followed by speculative episodes (Ribstein, 2003). There is no clear, unanimously recognized definition of the concept of "economic crisis," as it is rather recognized by its effects.

Reinhart and Rogoff (2009) propose a classification of microeconomic crises into seven types, four of which are defined based on quantitative criteria and three based on specific events:

- the first three types refer to crises related to the loss of currency purchasing power (inflation, currency crashes, developments);
- the next two types are crises determined by the decline in asset values (stock market crashes and banking crises);
- the last types of crises are those generated by the state's inability to pay its debts (external debts or internal debts).

Kindleberger (1996) proposes a clear but interdependent direction between financial and economic crises, highlighting that a major financial turmoil is relevant only when it influences macroeconomic indicators. According to his vision, large-scale financial crises manifest at the peak of economic cycles, which can lead to a systematic recession with international effects, surpassing the simple logic of cyclical fluctuations.

The analysis of the relationship between the economic crisis and faulty accounting necessitates a new conceptual framework: it is not enough to look for obvious symptoms of poor accounting post-crisis; it is essential to understand the evolutionary dynamics of accounting practice. Inspired by evolutionary biology, this approach proposes a transition from explanations of accounting decisions to pre-selection models through individual choices influenced by the economic

environment. In this context, the hypothesis emerges that the evolution of accounting occurs in leaps during periods of crisis, followed by phases of relative stability, according to punctuated equilibrium theory (Waymire and Basu, 2011). At the same time, an analysis of evolutionary accounting requires the identification of relevant hierarchical levels, from specific accounting treatments to general principles and regulatory bodies.

Deficient accounting is viewed as a contributing factor in the formation and burst of speculative bubbles and in the emergence of financial scandals. This connection is reflected in the history of capital market regulations in the US and UK (Littleton, 1933; Baskin and Miranti, 1997; Ribstein, 2003). The development of accounting has historically been shaped by waves of economic bankruptcies (Littleton, 1933). One relevant example, prompted by the crisis caused by the American Civil War, was the introduction of minimum capital requirements for US banks and the federal government during the 1860s (White, 2014). Crises caused by sovereign defaults or currency depreciation have indirect links to corporate accounting and financial reporting. However, speculative bubbles and banking crises involve direct and substantial accounting implications (Waymire and Basu, 2011).

Although numerous studies have addressed the subject of crises, authors stress the need for more rigorous reflection on historical lessons, avoiding generalizations and simplistic analogies. The objective of this approach is to provide new perspectives for policymakers, practitioners, and researchers seeking to understand the complexity of the financial system through a historical lens. Naming the 2008 financial crisis inevitably involves subjective judgments about its nature and duration, judgments that may prove premature (Kobrak *et al.*, 2014). Historical analysis shows that the actors involved in modern events often lack the clarity to fully comprehend their significance and consequences, being heavily influenced by immediate contexts.

Financial crises occur more frequently than most people realize and generate significant losses. In the last quarter-century, there have been an average of three to four systemic banking crises annually. While not all resulted in visible costs, most had real economic impacts (Cecchetti *et al.*, 2009).

Smithers (2009) argues that central banks fueled speculative bubbles in asset markets through misguided liquidity policies and prolonged low interest rates, contributing to the financial crisis. Interest rates directly affect asset prices, which in turn impact the real economy. Vogel (2010) adds that excess bank credit, when not absorbed by the real economy, is diverted toward risky investments in financial and real estate assets. Thus, monetary policies such as manipulating the federal funds rate play a role in the formation of speculative bubbles.

The COVID-19 crisis brought a more severe and complex economic shock than the 2008 recession. According to Tooze (2020), while the 2008 economic crisis was driven primarily by financial sector imbalances, the COVID-19

pandemic simultaneously impacted all sectors – production, consumption, and international trade. The deliberate shutdown of essential economic sectors led to a much deeper contraction, posing widespread risks to labor markets and global financial stability.

Unlike the 2008 financial crisis, where unconventional monetary policies were central to stabilizing the banking system, the COVID-19 pandemic required a combination of these policies with aggressive fiscal measures to support household income and prevent business collapse. In this context, expanding social safety nets and accelerating health infrastructure investment were critical (Tooze, 2020).

Most countries implemented lockdowns to curb the spread of COVID-19, quickly leading to a financial recession stemming from the public health crisis (Madeira *et al.*, 2020). The tourism industry was especially hard-hit, and the restaurant sector was among the most severely affected (Muller, 2020).

One of the main economic concerns was the forced shutdown of businesses across the US and other countries due to “stay-at-home” orders designed to curb the virus’s spread (Walmsley, Rose and Wei, 2021). These closures, combined with plummeting demand and health concerns, resulted in widespread business disruptions. In the US, the number of active business owners dropped from 15 million in February 2020 to 11.7 million in April, partially recovering by June, when the net loss still amounted to 1.2 million entrepreneurs (Fairlie, 2020). This economic disruption significantly impacted business revenues and heightened the risk of permanent closures.

Under normal circumstances, market exit by firms promotes productivity growth by replacing low-productivity businesses with more efficient ones. However, during the COVID-19 pandemic, this process was distorted by infection outbreaks and lockdowns rather than genuine productivity levels, leading to the failure of high-performing firms and the survival of less efficient ones (Dörr *et al.*, 2022). Moreover, business closures result in the loss of intangible capital (such as brand value and know-how) and costly reallocation of physical capital (Cooper *et al.*, 2007).

Firm closures also eliminate the possibility for employees to be rehired by former employers, increasing the risk of long-term unemployment, particularly in already weakened labor markets (Davis and Wachter, 2011). For business owners, market exit implies not only job loss but also the destruction of personal wealth. On a local scale, mass business closures can alter the economic structure of communities (Crane *et al.*, 2022). Simultaneously, the pandemic accelerated the digitalization of work and remote learning – trends that persisted even after restrictions eased (Feng *et al.*, 2020).

Companies turned to electronic invoicing and payment via online accounting software, which simplified operations and eliminated the need for face-to-face meetings to keep businesses running (Hertati *et al.*, 2020). At the same time,

developing a clear budget plan became vital for assessing performance and formulating strategies for economic adaptation (Jefferson *et al.*, 2011).

In the early phase of the COVID-19 pandemic, small and medium-sized enterprises (SMEs) were more likely to close permanently than large companies. Though many later recovered significantly, market concentration remained higher than pre-pandemic levels (Fairlie *et al.*, 2023).

SMEs played a vital role in sustaining the economy during the 1998 and 2008 economic crises, primarily because most lacked access to external financing, making them less vulnerable. However, during the COVID-19 pandemic, this sector proved to be extremely vulnerable. In the US, nearly all small business owners felt the impact of the pandemic, with most reporting substantial declines in sales (Gostic, 2020; Hertati *et al.*, 2020).

To overcome challenges, technological solutions such as automated accounting and sales via social networks became increasingly important (Deming, 2005; Hertati, 2019; Li *et al.*, 2020). Amid worsening economic conditions, strict and automated accounting facilitated sound financial decision-making, including cost reduction measures. Capital structure decisions were shaped by risk factors, tax implications, financial flexibility, and market conditions. However, due to the global economic shock caused by the pandemic, many micro and small businesses failed to grow, leading to significant declines in liquidity, profitability, and financial stability (Hertati, 2015; Wieland, 2017).

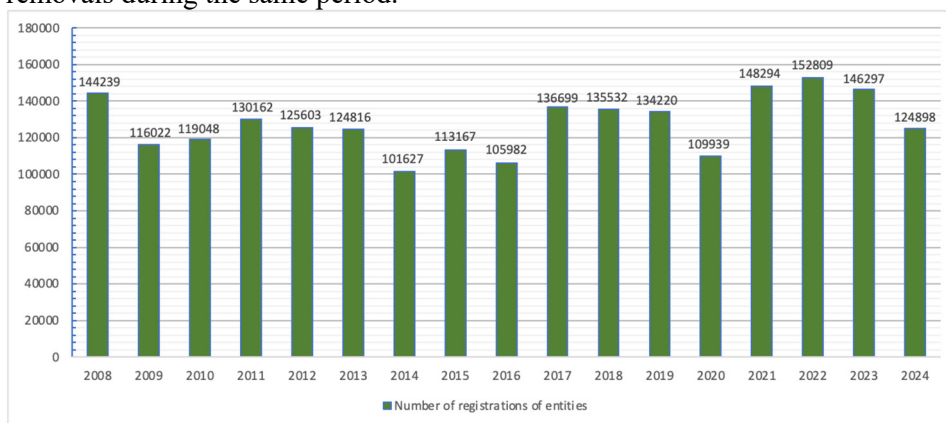
The severe economic impact undermined SMEs' revenue streams, with many businesses failing due to lack of capital before they could recoup their investments or stabilize operations (McCloskey *et al.*, 2014; Hartati, 2016; Hartati *et al.*, 2020; Lin *et al.*, 2020; Long *et al.*, 2020). In this context, capital market development emerged as a tool to enhance transparency, attract investments, and reduce unemployment. This was influenced by internal business factors such as size, profitability, and risk exposure (Smith *et al.*, 2004; Renn, 2008; Seale *et al.*, 2011).

During the COVID-19 crisis, managing SMEs became an exceptionally demanding task. Many sectors were paralyzed, contributing to a global economic slowdown. To survive, entrepreneurs had to quickly identify alternative solutions while minimizing direct interactions to reduce health risks. Effective cash flow management proved essential, as its absence could lead to insolvency (Hartati *et al.*, 2020; Kwok *et al.*, 2020).

The impact of the COVID-19 pandemic on the global economy and society was profound, and implementing a recovery strategy was essential to surviving in the new normal. Nevertheless, there is limited understanding of the challenges and processes through which small businesses respond during and after the COVID-19 crisis (Hossain *et al.*, 2023).

3. ANALYSIS OF ROMANIAN COMPANIES AFFECTED BY CRISES

Since 2001, the National Trade Register Office has periodically published reports that reflect the situation of companies in Romania. These reports provide access to aggregated data and useful analyses regarding the dynamics of the business environment in Romania. Additionally, the National Trade Register Office (NTRO) of Romania publishes monthly, quarterly, and annual statistics on business registrations, removals, activity suspensions, insolvencies, and dissolutions, detailed by counties, activity sectors (CAEN), and legal forms, providing useful information about the dynamics of the business environment. To observe the influence of crises on the business environment in Romania over the past 16 years, we analyzed the statistics provided by NTRO to date regarding the registration of legal and natural persons, as well as the evolution of the number of removals during the same period.



Source: own processing based on data from NTRO

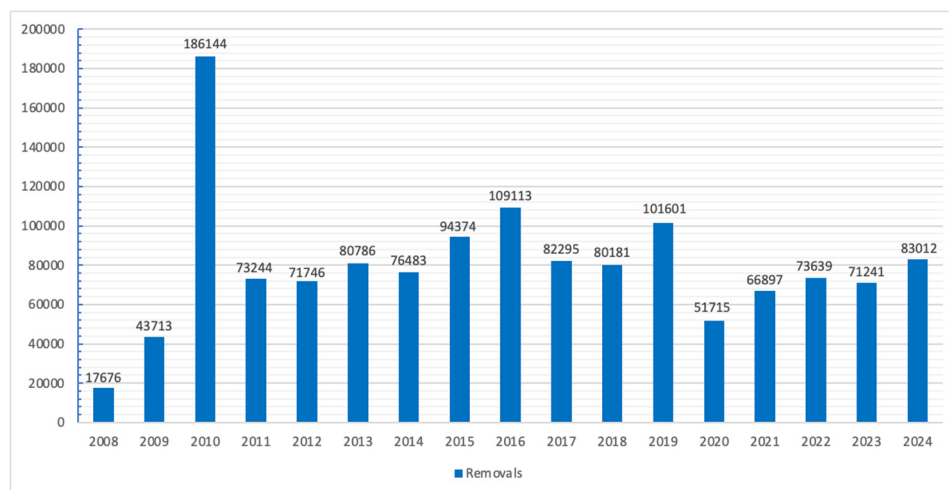
Figure 1. Annual number of registrations for individuals and legal entities in Romania during the period 2008–2024

Figure 1 presents the evolution of the annual registration numbers at NTRO for individuals and legal entities during the period from 2008 to 2024, a timeframe that begins with the financial crisis and ends with the health crisis generated by the Covid-19 pandemic. From the presented data, it can be noted that the number of registrations does not seem to be influenced by the mentioned crises, remaining somewhat constant. It can be observed, however, that during the crises, the number of registrations was even higher than in other years (2008, 2021, 2022). The exception is the year 2020, being the first year when the Covid-19 pandemic made its presence felt in Romania. This situation could be explained by the fact that in 2020, the toughest population protection measures were taken, which affected many sectors of the economy. The sectors that recorded the greatest decline in the number of registrations in 2020 were agriculture, forestry, and

fishing (-49.90% compared to the previous year) and cultural and recreational activities (-49.73% compared to the previous year). In 2021, the number of registrations increased considerably (by approximately 35%). The sectors with the highest increase in the number of registrations in 2021 were agriculture, forestry, and fishing (with 262.41%), and the production and supply of electricity and thermal energy, gas, hot water, and air conditioning (with 218.28%).

In order to supplement the previous analysis, through (Figure 2) we have presented the evolution of the number of removals in Romania during the period 2008-2024. Thus, it can be observed that in 2010, the number of removals increased by 326% compared to the previous year. This situation can be explained by the fact that in 2010 the effects of the economic crisis were felt the most. The financial crisis of 2007-2010 was considered the most severe since the Great Depression of 1929–1933, known as "The Great Depression" (Eichengreen, 2010). This caused the closure of numerous businesses worldwide. Starting from 2011, the number of removals decreased significantly (61%), indicating that the economy began to recover slightly.

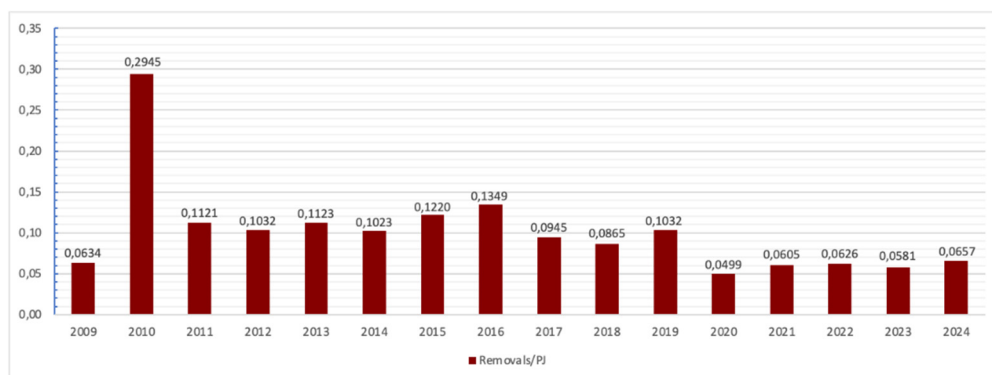
A paradoxical aspect can be observed in the year 2020, when the number of removals decreased by 49% compared to the previous year, even though it was the year with the most severe Covid-19 measures that affected numerous businesses. At the same time, however, we noted through Figure 1 that the number of registrations of individuals and legal entities was significantly lower in 2020 than in 2017, 2018, 2019, 2021, or 2022.



Source: own processing based on data from NTRO

Figure 2. Number of removals of legal entities in Romania during the period 2008–2024

To make our analysis more conclusive, we have presented the situation regarding the evolution of the number of removals relative to the total number of active legal entities in Romania during the period 2008-2024 through (Figure 3). It is noteworthy that the number of removals in 2010 relative to the total number of active legal entities is 29.45%. On the other hand, there is no observed influence of the health crisis generated by the Covid-19 pandemic on the number of removals reported to the number of active legal entities. On the contrary, statistics show that this ratio was lower than before.

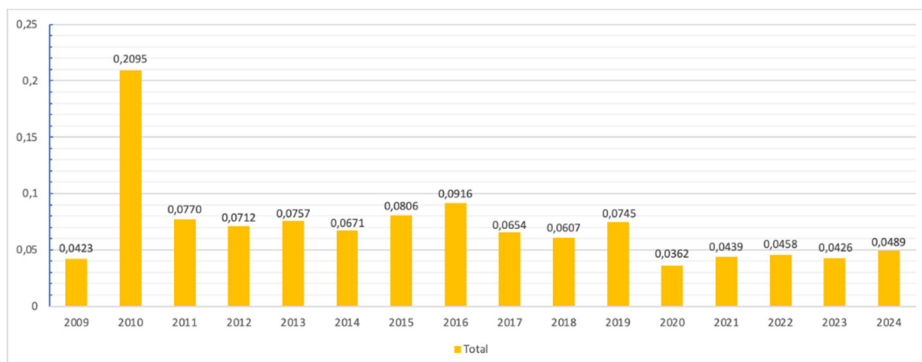


Source: own processing based on data from NTRO

Figure 3. Number of removals per number of active legal entities during the period 2008-2024 in Romania

Figure 4 presents a situation regarding the evolution of the number of removals relative to the total number of active natural and legal persons in Romania during the period 2008-2024. We conducted this analysis because the statistics on removals provided by NTRO also include individuals. Thus, the results validate the previous analysis presented through Figure 3. It can be observed that in 2010, the share of removals in the total number of active individuals and legal entities is 21%, the highest in all years. The lowest percentage is found in 2020, right at the onset of the pandemic. Even though the year 2020 saw a 5% decline in Romania's economy, the number of insolvencies and removals seems to have been unaffected.

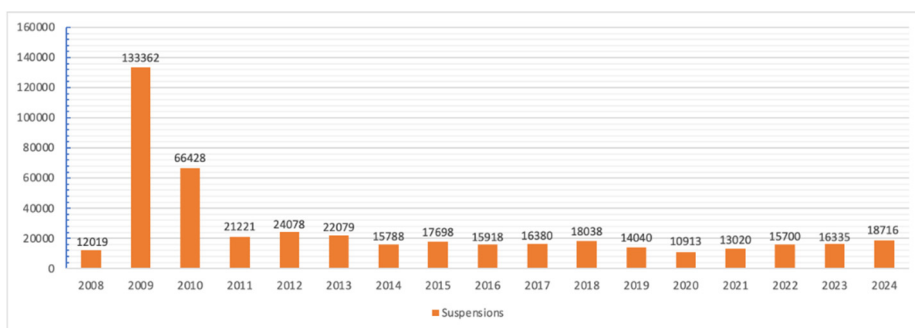
According to Article 237 of Law no. 31/1990 on companies, an entity may opt for a temporary suspension of activity, but not exceeding a duration of 3 years from the moment of registration of the mentions in the trade register. If the entity's activity is not resumed after this period, the court may pronounce the dissolution of the company at the request of any interested party, including at the request of the NTRO.



Source: own processing based on data from NTRO

Figure 4. Number of removals per total number of active legal and individuals during the period 2008-2024

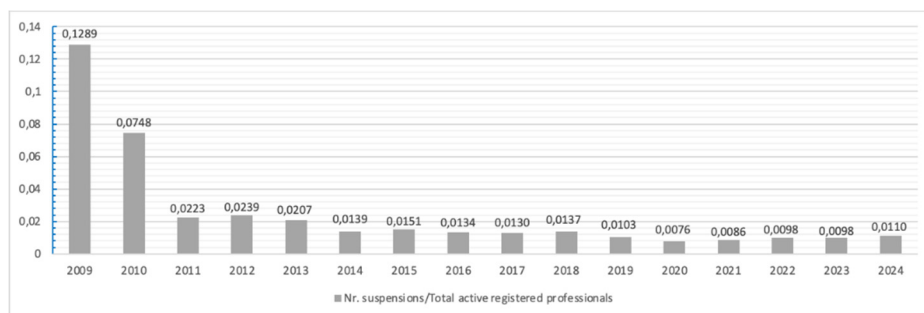
Figure 5 presents the evolution of the number of temporary activity suspensions in Romania during the period 2008-2024 to analyze whether the crisis periods had any influence in this regard. Thus, it can be observed that in the years 2009 and 2010, the highest number of temporary activity suspensions was recorded, a situation that can be explained by the fact that these are the years when the economic crisis was most acutely felt. Starting from 2011, the trend is relatively constant. The Covid-19 pandemic did not significantly influence the number of activity suspensions compared to the economic crisis.



Source: own processing based on data from NTRO

Figure 5. Number of company activity suspensions during the period 2008-2024

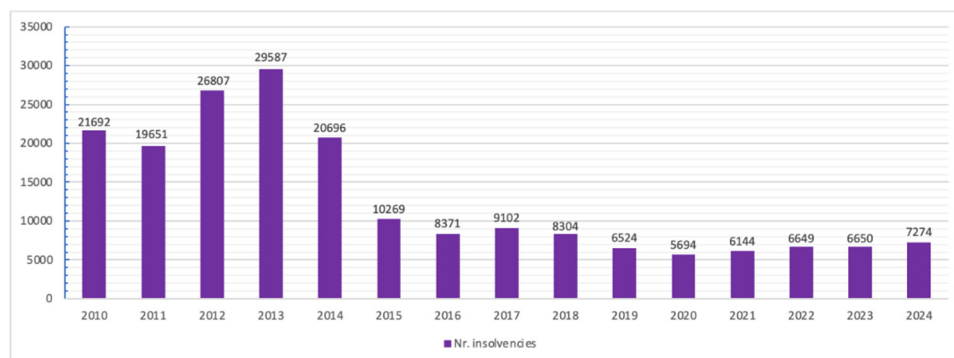
By comparing the number of suspensions each year to the number of active professionals, it can be observed through (Figure 6) a year-on-year decrease in this indicator. The financial crisis from 2007 to 2010 significantly influenced the suspension of activities, but the Covid-19 pandemic did not have the same impact.



Source: own processing based on data from NTRO

Figure 6. Number of activity suspensions relative to the number of active professionals during the period 2009–2024

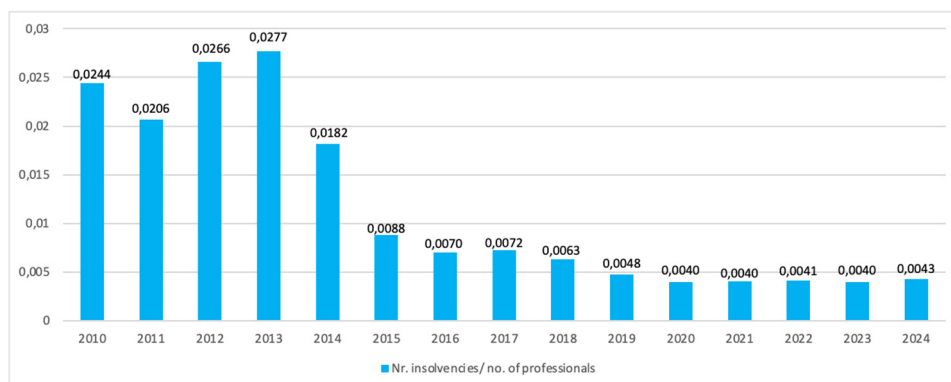
The situation regarding the number of insolvencies in Romania from 2010 to 2024 is presented through (Figure7). Just like in the case of the situation with activity suspensions and removals, the economic crisis caused the most such situations. Moreover, in the four years following the end of the financial crisis, the effects are even more visible. The period 2010-2014 recorded the highest number of insolvencies. According to statistics, the Covid-19 pandemic did not have an impact on the number of insolvencies, as their number remained relatively constant. Moreover, in 2020, the lowest number of insolvencies was recorded.



Source: own processing based on data from NTRO

Figure 7. Number of insolvencies in Romania during the period 2010-2024

Reporting the number of insolvencies to the number of active professionals, the results are presented through (Figure 8). The situation is similar to that presented in Figure 7. In practice, an influence of the economic crisis on this indicator is noted, while the crisis generated by the Covid-19 pandemic does not have the same impact.



Source: own processing based on data from NTRO

Figure 8. Number of insolvencies per number of active professionals in Romania during the period 2010-2024

The main conclusion of the study conducted on the number of registrations, suspensions, cancellations, and insolvencies in Romania during the period 2008-2024 is that the COVID-19 pandemic did not have a significant impact on the business environment. The economic crisis from 2007 to 2010, however, had a very significant influence on both the number of temporary activity suspensions and the number of insolvencies and even removals.

4. CONCLUSIONS

The study analyzed the evolution of the business environment in Romania from 2008 to 2024, examining the number of registrations, temporary suspensions of activity, removals, and insolvencies, concluding that the COVID-19 pandemic did not have a significant impact on the evaluated indicators regarding entrepreneurial dynamics. Although the COVID-19 pandemic began in Romania in 2020, characterized by an approximate 5% decrease in GDP, the effects on the number of removals, suspensions, and insolvencies were surprisingly small, according to data provided by the National Trade Register Office (NTRO). For example, the number of removals decreased by 50.90% compared to the previous year, 2019, and the number of insolvencies reached the lowest value in the examined period. The pandemic did not cause significant increases in activity suspensions; instead, their number remained relatively constant compared to previous years.

In contrast, the financial crisis from 2007 to 2010 had an immediate and significant effect on the business environment, manifested by dramatic increases in negative indicators. Therefore, the number of removals increased by 425.83% in 2010 compared to the previous year, and the proportion of removals relative to the total number of active legal entities reached the highest level of 20.45% during

the analyzed period. This trend is also confirmed by the situation of insolvencies; the period 2010 – 2014 recorded the most insolvency cases, when the effects of the crisis increased in the medium term, even after the recession was officially over.

The results of the analysis show that there is a significant difference in how the two crises affected the business environment in Romania. The global economic recession from 2007 to 2010 had structural and profound consequences, which were reflected in significant increases in the number of removals, suspensions, and insolvencies. In contrast, the health crisis generated by the COVID-19 pandemic did not cause comparable deterioration of the analyzed indicators. This situation can be, at least partially, explained by the government support policies that were implemented during the pandemic, as well as by the increased adaptability of the entrepreneurial environment to economic changes.

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VARIOUS ASPECTS REGARDING THE CONCRETE APPLICATION OF THE EU LEGISLATION IN COMERCIAL ACTIVITY

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Abstract

Establishing a more competitive business environment, which will develop in the internal market, is an essential objective, which has been pursued through the entire legislation on commercial companies, developed at the level of the European Union. Therefore, in the first part of the paper, the legal regulations in the field will be commented on in detail, which only cover certain aspects, such as: the mergers, the divisions and the conversions; the transfers of registered office of the companies. The effectiveness of these normative legal acts is determined by their concrete application, with all the challenges that have existed in practice. In this regard, in the second part of this presentation, the most relevant decisions on the matter, pronounced by the Court of Justice of Luxembourg, will be presented and analyzed, with all their consequences.

The article is of real importance, on the one hand, for companies carrying out commercial activities and which are obliged to comply with the existing Union legal order. On the other hand, the Member States of the Union must transpose, properly and without delay, all secondary Union legislation in the field and comply with the content of the judgments of the Court of Justice, which relate to the interpretation of the provisions of primary Union legislation.

Keywords: *commercial activity; legislation; case law; European Union.*

JEL Classification: N44.

1. INTRODUCTORY CONSIDERATIONS

The present analysis is a continuation of another study (Verga, 2024) and concerns some of the key legal regulations of the secondary legislation in the field of company law at the level of the European Union (EU), considering essential aspects relating to mergers, divisions and conversions of the companies, on the one hand, and, on the other hand, to the transfers of registered office.

In the institutional framework of EU, the role of the Court of Justice of the European Union (CJEU) was from the very beginning of the member states cooperation, both specific and evolving towards the present status (Tofan and Verga, 2023). The article examines, through the significant decisions commented on, how the case law of the CJEU has made an important contribution to the

effective application and interpretation of legal provisions in the field under our attention. The content of the Court decisions regarding the interpretation of the provisions of the Union Treaties in force is binding for all subjects of Union law.

2. THE LEGAL FRAMEWORK IN FORCE

The legal framework governing companies within EU has developed gradually over decades, shaped by the need to facilitate the functioning of the internal market and ensure the freedom of establishment across Member States. While primary legislation, notably the Treaty on the Functioning of the European Union (EU, 2012) and the Charter of Fundamental Rights of the EU (European Convention, 2012) lays the foundations, the concrete rules enabling corporate mobility and restructuring are found in secondary legislation.

Article 26 TFEU defines the internal market, while Article 49 establishes the principle of freedom of establishment, further operationalized through directives under Article 50. Article 54 provides a definition of companies, and Article 16 of the Charter enshrines the freedom to conduct business. These provisions form the constitutional basis upon which directives regulating mergers, divisions, conversions, and cross-border operations have been adopted.

Over time, the EU has enacted a series of directives, gradually expanding and refining the rules to ensure both corporate flexibility and stakeholder protection. The following sections trace this evolution chronologically, analyzing how the directives addressed challenges in company law, from the earliest sectoral rules in the 1970s to the modern “Mobility Directive” and recent digitalization initiatives.

2.1. Early directives on mergers and divisions

The Third Council Directive 78/855/EEC (1978) - The EU’s first significant step was the Third Council Directive of 9 October 1978 on mergers of public limited liability companies (Council of the European Communities, 1978). The directive sought to protect shareholders, employees, creditors, and third parties during corporate mergers. It defined procedures for different forms of mergers: mergers by acquisition, mergers through the creation of a new company, and acquisitions where a company already held at least 90% of another’s shares.

Key obligations included detailed reporting, mandatory publication of merger plans, and safeguards against nullity by specifying limited grounds for invalidation. The directive aimed to balance corporate flexibility with legal certainty, enabling restructuring while protecting stakeholder rights.

The Sixth Council Directive 82/891/EEC (1982) - Given the parallels between mergers and divisions, a specific framework for divisions soon followed. The Sixth Council Directive of 17 December 1982 (Council of the European Communities, 1982) regulated two forms of division: by absorption and by the creation of new companies. It required prior publication of draft division terms,

general meeting approval, explanatory reports, and expert opinions where necessary.

The directive clarified the effects of divisions: transfer of all assets and liabilities to successor companies, automatic conversion of shareholders' rights, and dissolution of the divided entity. Safeguards included protection for employees, creditor guarantees, and provisions for judicial or administrative review of legality. Like mergers, divisions could only be declared null under strictly defined conditions, reinforcing certainty.

Together, the 1978 and 1982 directives laid the foundation for cross-border corporate mobility, though initially confined to purely domestic transactions.

2.2. Expansion to cross-border restructuring

Directive 2005/56/EC on Cross-Border Mergers - The next major milestone was Directive 2005/56/EC (EU, 2005) which for the first time established a framework for cross-border mergers of limited liability companies. Recognizing the need to enable companies from different Member States to merge, the directive permitted three forms: merger by absorption, merger through the creation of a new company, and absorption of a wholly owned subsidiary.

The directive imposed conditions ensuring compatibility with national laws, compliance with domestic merger procedures, and the right of Member States to oppose mergers for public interest reasons. Safeguards mirrored those of earlier directives: publication of merger plans, management reports on economic and legal consequences, expert reports for shareholders, and general meeting approval. It also mandated legality checks by competent national authorities, followed by registration of the resulting company. Crucially, it extended protections for shareholders, creditors, and employees to the cross-border context, addressing the risks of mobility across legal systems. Its implementation was reviewed in Directive 2009/109/EC (Council of the EU, 2009a), which sought to simplify reporting and reduce administrative burdens by allowing online publication of merger documents.

Tax Harmonization: Directive 2009/133/EC - Corporate restructuring inevitably raised tax questions. Council Directive 2009/133/EC (Council of the EU, 2009b) established a common tax system for mergers, divisions, partial divisions, transfers of assets, and exchanges of shares between companies from different Member States. Its objective was to eliminate fiscal obstacles to cross-border reorganizations by ensuring tax neutrality.

The directive stipulated that capital gains would be taxed only upon realization, not when restructuring, and shareholders would not incur immediate tax liabilities when receiving shares. It also allowed provisions and reserves to be carried forward and regulated subsequent taxation of gains. This framework ensured that taxation would not undermine the economic rationale for cross-border operations.

2.3. Consolidation and simplification

Directive 2011/35/EU (EU, 2011) replaced the original 1978 directive on mergers, aiming to unify and modernize the rules on domestic mergers of public limited liability companies. It largely replicated the established framework but sought to simplify and harmonize implementation across Member States.

The drive for consolidation culminated in Directive (EU) 2017/1132 (EU, 2017), which brought together several prior directives into a single legislative act. It covered company establishment, operations, conversions, mergers, and divisions. While it did not substantially alter existing rules, it provided a coherent framework, enhancing clarity and accessibility of EU company law.

2.4. The Mobility Directive and modern developments

Directive (EU) 2019/2121 (EU, 2019b) - The so-called Mobility Directive marked a transformative step by addressing gaps left by earlier legislation. It introduced rules for cross-border conversions and divisions, areas previously characterized by legal uncertainty and fragmentation. Companies could now transfer their registered office and legal form to another Member State without liquidation, retaining legal personality. The directive provided detailed procedures for conversions and divisions, mirroring those for mergers: preparation of project terms, reports, general meeting approval, and legality checks. It harmonized rules for full and partial cross-border divisions, whether by absorption or by creating new companies. Critically, it strengthened stakeholder protections. Employees gained clearer consultation rights, creditors received stronger safeguards, and minority shareholders were offered fair exit mechanisms. It also introduced rigorous legality checks to prevent abuse, such as operations intended to evade tax or labor laws. Competent authorities were required to assess not only formal compliance but also the good faith of transactions.

Another innovation was the emphasis on digitalization. The directive mandated the use of electronic registers, online platforms, and the Business Registers Interconnection System (BRIS) to streamline cross-border operations and ensure secure information exchange. Member States were required to transpose the directive by January 2023. In Romania, this was achieved through Law No. 222/2023 (Romanian Parliament, 2023), which amended national company and trade register legislation.

2.5. Digitalization: Directive 2019/1151 and Directive 2025/25

Parallel to the Mobility Directive, Directive 2019/1151 (EU, 2019a) advanced the digitalization of company law, enabling online company formation, branch registration, and document filing. It required data to be stored in machine-readable formats to facilitate electronic exchange. Building on this, Directive (EU) 2025/25 (EU, 2025) further enhanced digital tools, aiming to remove administrative barriers and harmonize electronic procedures across Member

States. Although not limited to restructurings, its provisions significantly impact how mergers, divisions, and conversions are processed, emphasizing transparency and accessibility.

The evolution of EU company law demonstrates a steady expansion from domestic regulation of mergers to a comprehensive framework for cross-border mobility. Early directives focused on legal certainty and stakeholder protection within national contexts. Later instruments extended these principles to cross-border mergers, divisions, and conversions, while addressing tax neutrality and administrative efficiency. The Mobility Directive represents a culmination of these efforts, harmonizing procedures across Member States and embedding digital tools into corporate restructuring. At the same time, the EU has increasingly balanced corporate flexibility with protection against abuse, reflecting broader concerns with tax avoidance, social dumping, and creditor rights.

From the 1970s to the present, EU legislation on company restructuring has evolved into a sophisticated, multi-layered framework. Rooted in the TFEU's provisions on the internal market and freedom of establishment, the directives collectively facilitate corporate mobility, remove barriers to the single market, and protect stakeholders.

The trajectory reveals three phases: initial harmonization of domestic mergers and divisions; expansion to cross-border mergers and tax coordination; and finally, comprehensive regulation of conversions, divisions, and digitalized procedures. As corporate structures grow increasingly international, and as digitalization reshapes corporate governance, the EU's legislative framework continues to adapt. The challenge remains to strike a balance between fostering mobility and safeguarding fairness, transparency, and trust. The reforms of 2019 and 2025 suggest a future of greater integration, harmonization, and technological modernization, ensuring that EU company law keeps pace with economic and social realities of a dynamic internal market.

3. THE RELEVANT JURISPRUDENCE OF THE CJEU ON THE MATTER

The CJEU has consistently included in the content of the freedom of establishment the right of companies to transfer their registered office or to reorganize through cross-border operations (mergers, divisions, transformations), without losing their legal personality, if they obey the legislation of the Member State of destination. This view has been essential in removing legal and administrative obstacles in the Member States to corporate mobility.

3.1. Judgment of the Court of 9 March 1999. *Centros Ltd v Erhvervs- og Selskabsstyrelsen* - Case C-212/97 (CJEU, 1999)

Centros Ltd was a company incorporated in the United Kingdom, with its registered office in the United Kingdom, but which did not carry on any business in that Member State. Its share capital was very small (GBP 100), since the British legal framework at that time did not require a significant minimum share capital for limited liability companies. The associates of that company were two Danish nationals, Mr and Mrs Bryde, resident in Denmark, who wished to set up a company in the United Kingdom to avoid the much stricter Danish minimum share capital requirements for limited liability companies (at that time DKK 200,000). In this regard, the two partners applied to the Danish Trade and Companies Agency (Erhvervs- og Selskabsstyrelsen) to register a branch of *Centros* in Denmark. The Danish authorities refused to register this because the company sought to establish its head office in Denmark, thereby circumventing the Danish legislation on minimum share capital. The Trade Agency also justified its refusal by the need to protect creditors and prevent fraudulent insolvencies.

The Danish Court (Højesteret) referred a preliminary question to the CJEU, seeking the interpretation of the articles of the EC Treaty (now TFEU) on freedom of establishment (Articles 52, 56 and 58 at the time, now Articles 49 and 54 TFEU), to determine whether Denmark's refusal to register the *Centros* branch was compatible with Community law.

The Court held that “it is contrary to Articles 52 and 58 of the EC Treaty for a Member State to refuse to register a branch of a company formed in accordance with the law of another Member State in which it has its registered office but in which it conducts no business where the branch is intended to enable the company in question to carry on its entire business in the State in which that branch is to be created, while avoiding the need to form a company there, thus evading application of the rules governing the formation of companies which, in that State, are more restrictive as regards the paying up of a minimum share capital. That interpretation does not, however, prevent the authorities of the Member State concerned from adopting any appropriate measure for preventing or penalizing fraud, either in relation to the company itself, if need be in cooperation with the Member State in which it was formed, or in relation to its members, where it has been established that they are in fact attempting, by means of the formation of a company, to evade their obligations towards private or public creditors established in the territory of the Member State concerned”.

This judgment also established that the practice of refusing, in certain circumstances, to register a branch of a company established in another Member State has the effect of making it impossible to exercise the right of establishment conferred by Articles 52 and 58 of the Treaty and constitutes an obstacle to the exercise of the freedoms guaranteed by those provisions. The Court determined four conditions regarding national measures likely to make it difficult or less

attractive to exercise the fundamental freedoms guaranteed by the treaty: they must be applied in a non-discriminatory manner, be justified by imperative reasons of general interest, be adequate to guarantee the achievement of the objective pursued and not exceed what is necessary for its achievement.

This case highlighted the priority of the incorporation theory over the real seat doctrine or the main seat of the activity. Incorporation theory refers to the fact that the legal status of a company is determined by the law of the state in which it was registered, regardless of where it carries out most of its activities. This theory allowed companies to be established in states with the most favorable legislation in the field, thus facilitating corporate mobility.

3.2. Judgment of the Court of 5 November 2002. *Überseering BV v Nordic Construction Company Baumanagement GmbH (NCC)* Case C-208/00 (CJEU, 2002)

Überseering BV represented a company established in the Netherlands, according to domestic legislation in the field, which concluded a contract with *Nordic Construction Company Baumanagement GmbH (NCC)*, a German company. Immediately thereafter, all the shares in *Überseering BV* were acquired by two German nationals, which resulted in the transfer of the real and effective place of management of *Überseering BV* from the Netherlands to Germany, while the statutory registered office remained in the Netherlands. The German legal framework enshrines the "real seat theory" (or principal place of business). *Überseering BV* then brought legal action against *NCC* in Germany for non-performance of contractual obligations. The German courts refused to recognize the legal personality of *Überseering BV* in Germany, and therefore its capacity to bring legal actions, because by moving its real seat to Germany, the company lost its legal capacity in German territory, as it did not re-incorporate as a German company.

The German Supreme Court (*Bundesgerichtshof*) referred a question to the CJEU for a preliminary ruling and asked for the interpretation of Articles 43 EC and 48 EC (now Articles 49 and 54 TFEU) of the EC Treaty (now TFEU), in order to determine whether the refusal of a Member State (Germany) to recognize the legal personality and capacity to bring legal proceedings of a company legally established in another Member State (the Netherlands), on the grounds that it had moved its real seat to the territory of the first State, is compatible with the freedom of establishment. The Court ruled that this refusal constitutes a restriction on the freedom of establishment, even where the company subsequently transferred its real place of management to the host Member State.

The Luxembourg Court has substantiated the "seat theory" (or country of registration), arguing that the Member State in which a company has been legally incorporated and registered determines the law applicable to the legal status of that company. This law must be recognized by all other Member States.

Companies can therefore freely pursue their specific activities in any Member State without losing their legal personality, if they have been legally incorporated in their State of origin.

The recognition of the legal personality of the company in the host Member State, as defined by the law of the state of incorporation, does not prevent the host state from applying certain provisions of its law in relation to the activities carried out in its territory, provided that these provisions are justified by an imperative public interest and are proportionate.

3.3. Judgment of the Court of 30 September 2003. *Kamer van Koophandel en Fabrieken voor Amsterdam v Inspire Art Ltd* Case C-167/01 (CJEU, 2002)

Inspire Art Ltd was a company incorporated in the United Kingdom under the laws of England and Wales with a minimum share capital. This company, which did not carry on any significant activities in the United Kingdom, was set up by a Dutch national to carry on commercial activities in an art studio in the Netherlands. The Dutch legislation at that time contained a legal regulation imposing certain additional requirements on companies incorporated abroad but carrying on the majority or all their activities in the Netherlands. These requirements concerned, for example, the obligation to indicate in the company name that it was a foreign company and to comply with the Dutch rules on minimum share capital and directors' liability, even though the company was registered in another Member State.

The Dutch Court (Kantongerecht te Amsterdam) referred a preliminary question to the CJEU on the interpretation of Articles 43 EC, 46 EC and 48 EC (now Articles 49 and 54 TFEU), in order to determine whether Dutch national legislation, which imposed additional requirements on a company legally established in another Member State but which carried out its main activity in the Netherlands, was compatible with the freedom of establishment. In this regard, the Court ruled that “it is contrary to Articles 43 EC and 48 EC for national legislation such as the *Wet op de Formeel Buitenlandse Vennootschappen* to impose on the exercise of freedom of secondary establishment in that State by a company formed in accordance with the law of another Member State certain conditions provided for in domestic company law in respect of company formation relating to minimum capital and directors' liability. The reasons for which the company was formed in that other Member State, and the fact that it carries on its activities exclusively or almost exclusively in the Member State of establishment, do not deprive it of the right to invoke the freedom of establishment guaranteed by the EC Treaty, save where the existence of an abuse is established on a case-by-case basis”.

The European Court reaffirmed that the protection of creditors is an imperative reason of general interest, which can justify restrictions on the freedom

of establishment. However, it reiterated that national measures must be proportionate and non-discriminatory. It also reconfirmed the recognition of the legal personality of a company legally established in another Member State.

This decision determined the Member States to amend their national legislation, so that it is consistent with the content of the freedom of establishment and the mutual recognition of the legal personality of companies.

3.4. Judgment of the Court (Grand Chamber) of 13 December 2005. SEVIC Systems AG Case C-411/03 (CJEU, 2005)

Two companies (German and Luxembourg) wanted to merge by cross-border acquisition, in which case Sevic Systems AG (the German company) would have been the acquiring company and Imprema GmbH (the Luxembourg company) the acquired company. At that time, the German legal framework allowed mergers by acquisition, but only between companies governed by German law. The competent German authority refused to register the merger because national law did not provide for such a cross-border merger, but only for a purely German internal merger.

The German Federal Court (Bundesgerichtshof) has referred a question to the CJEU for a preliminary ruling, seeking the interpretation of Articles 43 EC and 48 EC (now Articles 49 and 54 TFEU) of the EC Treaty, in order to determine whether the prohibition of a cross-border merger by acquisition, imposed by the law of a Member State (Germany), on the ground that one of the companies involved is governed by the law of another Member State, is compatible with the freedom of establishment. The Court held that the refusal of a Member State to authorize a cross-border merger by acquisition constitutes a restriction on the freedom of establishment (now Article 49 TFEU). That restriction does not allow companies to carry out restructuring operations (in this case mergers) which they would be permitted to carry out if they were both established in the same Member State. The Court admitted that such a restriction can only be justified by imperative reasons of general interest and only if it is proportionate to the objective pursued. In the analyzed case, it was found that Germany did not bring arguments to justify the total prohibition of cross-border mergers, in compliance with the criteria established by the CJEU jurisprudence in the field.

Through this decision, the Court recognized, for the first time, that the freedom of establishment also includes the right of companies to carry out cross-border mergers, although there was no adequate Union framework in the field at that time. The decision commented on above is of particular significance, as it led to the drafting of Directive 2005/56/EC on cross-border mergers of commercial companies, thus strengthening the mobility of companies, which are free to carry out various cross-border operations within the single market.

3.5. Judgment of the Court (Grand Chamber) of 12 September 2006.

Cadbury Schweppes plc and Cadbury Schweppes Overseas Ltd v Commissioners of Inland Revenue Case C-196/04 (CJEU, 2006)

Cadbury Schweppes plc and Cadbury Schweppes Overseas Ltd (both UK companies, part of the Cadbury group) established two subsidiaries (CSTS and CSTI) in Ireland, a country with a much more favorable tax regime at the time than the UK. The subsidiaries were set up primarily to handle intra-group financing and other financial activities, taking advantage of the lower corporate tax rates in Ireland. UK Controlled Foreign Company (CFC) legislation allowed UK tax authorities to include the profits of certain foreign subsidiaries in the tax base of the UK parent company, if the subsidiaries were in low-tax jurisdictions and met certain conditions. The aim of this legislation was to prevent UK companies from shifting profits to tax havens or low-tax jurisdictions to avoid UK taxation.

The UK tax authorities applied CFC legislation to the profits of Cadbury Schweppes' Irish subsidiaries, arguing that they were set up to benefit from a more advantageous tax regime. Cadbury Schweppes contested this decision, arguing that the measure infringed the freedom of establishment guaranteed by EU law.

The British national court (Special Commissioners of Income Tax, London) has referred a preliminary question to the CJEU, requesting the interpretation of Articles 43 EC and 48 EC (now Articles 49 and 54 TFEU) on freedom of establishment. The European court was asked to answer the question whether national legislation (such as the British legislation on CFCs) is compatible with freedom of establishment when it allows the inclusion of the profits of a foreign subsidiary, located in another Member State, in the tax base of the parent company, on the grounds that the subsidiary was established in a low-tax jurisdiction.

Since the United Kingdom imposed an additional tax burden on a parent company on the profits of its subsidiaries in other Member States, the Court confirmed that the United Kingdom's CFC legislation constituted a restriction on the freedom of establishment (Article 49 TFEU). The British legal framework in this area discouraged companies from setting up subsidiaries in other Member States to take advantage of a more favorable tax regime. The Court found that the need to combat tax evasion and avoidance can be an imperative reason of general interest, which imposes such a restriction. This justification is valid to prevent abusive behavior, which would cause damage to the national tax system.

The CJEU emphasized that a restriction of the freedom of establishment, justified by combating tax evasion, can only be applied in the case of "wholly artificial arrangements". An arrangement is considered wholly artificial if it does not reflect economic reality but has as its sole purpose the obtaining of a tax advantage. To determine whether an arrangement is wholly artificial, the national court must analyze objective elements, such as the existence of physical establishments in the host Member State; the existence of real staff carrying out

economic activities; the existence of adequate equipment and assets; the real capacity of the subsidiary to carry out economic activities in the host Member State. In the same sense, the European court appreciated that the simple fact that a company establishes a subsidiary in another member state to benefit from a less onerous tax regime does not constitute an abuse of law or an artificial arrangement. Freedom of establishment includes the right to choose the most advantageous location from an economic and tax point of view, as long as there is an effective economic activity, staff, establishments.

The decision led the EU member states to amend their CFC legislation, in accordance with the requirements of CJEU jurisprudence, having as a reference the concept of "wholly artificial arrangement". The judgment under review also significantly reduced the discriminatory application of CFC legislation in Member States (Hadjipanayi, 2018). Thus, any tax restriction imposed by national legislation on subsidiaries in other Member States must respect the principle of proportionality and only apply to cases where abuse has been proven.

3.6. Judgment of the Court (Grand Chamber) of 16 December 2008.

CARTESIO Oktató és Szolgáltató bt Case C-210/06 (CJEU, 2008)

Cartesio Oktató és Szolgáltatói bt. was a company established in Hungary which decided to transfer its actual place of management from Hungary to Austria, without changing the applicable legislation and, therefore, without changing its legal status as a Hungarian company. The Hungarian Commercial Register refused to approve that transfer, since Hungarian law provided that a Hungarian company must maintain its actual place of management in Hungary. In the case of the transfer of the real seat to another state, the respective company had to be deregistered, which thus ceased to exist.

By submitting a preliminary question, the Court of Appeal of Szeged (Szegedi Ítéltábla) asked the CJEU to determine whether Articles 43 EC and 48 EC (currently 49 and 54 TFEU) preclude national legislation which prohibits a company established under its law from transferring its real seat to another Member State, without changing its nationality and, implicitly, without ceasing to be governed by the law of the Member State of registration.

The Court pointed out that, in the absence of complete harmonization of company law at European level, the Treaty does not require a Member State to allow a company formed in accordance with its law to transfer its effective place of management to another Member State, while maintaining its nationality and the applicable law, thus reaffirming the principle established in the Daily Mail Case (Case 81/87). This decision also stated that a Member State, as the State of registration, has the power to determine not only the conditions for the establishment of a company on its territory, but also the conditions necessary for that company to maintain its connection with its legal system and, implicitly, the conditions under which it ceases to exist under its law.

In the *Centros*, *Überseering*, *Inspire Art Cases* analysed above, the Court required the host State to recognise the legal personality of a company registered in another Member State. In the *Cartesio Case*, the State of origin is not obliged to accept that a company registered under its national law may transfer its real seat to another Member State and retain its legal status, that is to say, the quality of a Hungarian company, as long as its legislation does not provide for such a possibility (Marek, 2009).

In the legal literature (Korom and Metzinger, 2009) it has been stated that “the pro-freedom of establishment attitude of the Court witnessed in recent years seems to have yielded to a more conservative approach, upholding the distinctions between outbound v inbound and primary v secondary freedom of establishment”. This case thus reflected the urgent need for a Union legislative act on cross-border conversions (transfer of the registered office and/or the applicable law), to complete the European legislative framework on the mobility of companies. This judgment confirmed that a company formed under the law of a Member State may, in principle, transfer its registered office to another Member State, without being obliged to dissolve and re-establish itself. However, the Court emphasized the fact that the Member State of registration can condition the maintenance of legal personality on compliance with certain requirements of its national law.

3.7. Judgment of the Court (Grand Chamber) of 25 October 2017. Polbud - Wykonawstwo sp. z o.o. Case C-106/16 (CJEU, 2017)

Polbud - Wykonawstwo sp. z o.o., a limited liability company established in Poland, decided to transfer its registered office from Poland to Luxembourg, where it intended to operate as a "Société Anonyme" (SA). Polbud intended to continue its legal existence in Poland, not to dissolve the company and to change its registration from one Member State to another, but to be governed by Luxembourg law. Polbud also wished to maintain part of its activity in Poland, as a branch. The Polish Commercial Register refused to remove Polbud from Poland, without it having first entered liquidation, on the grounds that national law provided that the transfer of the registered office abroad had the effect of ceasing the legal existence of the company in Poland, i.e. liquidation.

The Polish Supreme Court (Sąd Najwyższy) referred three preliminary questions to the CJEU, two of which are relevant to our study. The first raised the issue of whether Articles 49 and 54 TFEU (on freedom of establishment) “preclude the application, by the Member State in which a (private limited liability) company was initially incorporated, of provisions of national law which make removal from the commercial register conditional on that company being wound up after liquidation has been carried out, if that company has been reincorporated in another Member State pursuant to a shareholders’ decision to continue the legal personality acquired in the State of initial incorporation”.

The European Court answered affirmatively to this question and appreciated that Articles 49 and 54 TFEU must be interpreted as precluding legislation of a Member State which provides that the transfer of the registered office of a company incorporated under the law of one Member State to the territory of another Member State, for the purposes of its conversion into a company incorporated under the law of the latter Member State, in accordance with the conditions imposed by the legislation of that Member State, is subject to the liquidation of the first company.

The second question addressed to the Court raised the question if "Articles 49 and 54 TFEU must be interpreted as meaning that restrictions on freedom of establishment cover a situation in which - for the purpose of its conversion to a company of another Member State – a company transfers its registered office to that other Member State without changing its main head office, which remains in the State of initial incorporation). The Court clarified that freedom of establishment also applies where a company changes only the place of its registered office and, by implication, the law applicable to its statutes, even if it does not simultaneously transfer its principal place of business or initially carry out significant activity in the new Member State. In this way, the point of view expressed by the ruling in the Centros Case was reaffirmed.

The judgment handed down is of major importance, because the Court established that the freedom of establishment allows not only the establishment of branches (Centros) or the transfer of the actual headquarters (Überseering), but also the full transfer of the statutory registered office (with a change in the applicable law), without the need to liquidate the company of origin.

On 25 April 2018, the European Commission proposed new company law rules to enable companies to make best of business opportunities in the EU's Single Market and to ensure that cross-border conversions, mergers and divisions are accompanied by adequate safeguards against abuse (Van Gelder, 2018).

This decision had a direct influence on the adoption of *Directive (EU) 2019/2121* (which amended *Directive EU 2017/1132*), which introduced a new legal framework for cross-border conversions, including the transfer of the registered office.

Therefore, by interpreting the freedom of establishment broadly and by emphasizing the need to eliminate barriers to cross-border restructurings, the Court has directly and significantly influenced the adoption and amendment of EU directives.

In the same time, the CJEU focuses on the protection of the private interests of companies by allowing them to choose a favorable legal order. Economic interests of the Member States are of lesser importance under the Court's approach (Fillers, 2020).

4. CONCLUSIONS

Consequently, within the framework of the freedom of establishment enshrined in the TFEU (art. 49-55) a series of normative legal acts have been developed in secondary legislation, which are important in terms of mergers, fusions, conversions and transfers of registered office. These have created a uniform legislative framework at the level of the Member States of the Union, with precise procedures, which provide more clarity, predictability, legal certainty and remove the various legal and administrative obstacles that previously existed in national legislation.

The Union normative acts regarding the mergers, the mergers and the conversions analyzed in the paper aimed to facilitate the restructuring of companies from different member states and to ensure the protection of all interested parties (shareholders, creditors, employees). The legislation in this area has undergone changes over time, as detailed in this study, changes that have considered the needs of the single market, which is in constant evolution.

The combined efforts of the EU and the Member States have thus led to the development of a consolidated legal framework on the issues examined in the field of commercial companies, essential to ensure a competitive business environment, which is in continuous transformation. This legislation facilitates the implementation of various cross-border operations, gives stability to companies in the Member States of the EU, allows them to adapt to existing and future needs and take advantage of cross-border opportunities. Directive 2019/2121 added an essential mechanism to prevent abuses, thus ensuring that the freedom of establishment is not used for illicit purposes.

At the same time, the CJEU rulings have obliged Member States to align themselves with the lines of action determined by specific case law in the field and provide precise guidelines for companies, so that they can carry out their activity as efficiently as possible, by highlighting the importance of one of the basic principles of the Union, the freedom of establishment. In this regard, the judgments in the Centros cases (C-212/97), Überseering (C-208/00) and Inspire Art (C-167/01) established the mutual recognition of the legal personality of companies registered in other Member States, even if the legal rules of registration in the State of origin were more permissive. The aim was thus to prevent the imposition of unjustified restrictions by the host Member States. The freedom of establishment was thus strengthened. However, if the latter implies the right to enter and operate in another Member State, as in the Cartesio judgment, it does not oblige the State of origin to allow a company to transfer its real seat, while maintaining its nationality. However, the Luxembourg Court ruled, in the Polbud judgment, that the State of origin cannot prevent a company from transferring its registered office to another Member State, without there being an obligation to dissolve in the State of origin. In this way, increased mobility of companies was facilitated.

Finally, both the relevant secondary EU legislation in the field and the Luxembourg case law have made an essential contribution to maintaining a functioning single market, a major objective of the EU, the achievement of which is facilitated, in a significant way, by the harmonization, consolidation and effective application of the legal framework regarding mergers, conversions and transfers of registered office.

However, in the specialized literature (Gerner-Beuerle and Schillig, 2010) it was found that the case *la/2019w* of the European Court of Justice after *Cartesio*, rather than providing for a coherent system of European company law, leads to arbitrary distinctions and significantly impedes the free movement of companies.

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NE BIS IN IDEM PRINCIPLE. A NEVER-ENDING SAGA IN EU LAW AND NATIONAL LAW

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Abstract:

Ne bis in idem is one of the most important principles in EU law. Also, it has a constitutional role in all EU member states. Because of the economic growth of the economies of the member states, the number of parallel tax and criminal procedures has increased. Because of that, the national courts of law are often confronted with a situation where the results of the two procedures are in conflict. In fact, it can be said that even the high courts, like national constitutional courts, European Court of Justice or European Court for Human Rights.

In this complicated context, I believe it is of outmost importance to make deep research that must engulf the roots of the principle and its reflection in the case law. Also, I would like to propose some solutions regarding the role of the principle in the EU members which are ruled by the principle of the rule of law.

In the end, the purpose of the article is to draw conclusions related to the impact of the principle in complex of EU human rights system and how a modern approach of the principle can benefit to privates, member states and EU by guaranteeing the fairness of the tax and criminal procedures in the process of the application of EU and member states taxation rules.

Keywords: *ne bis in idem; taxation; rule of law; constitutional.*

JEL Classification: K2.

1. INTRODUCTION

Ne bis in idem principle is one of the most important principles in the family of European law principles. Initially, it was applicable only to the traditional criminal law cases. The idea behind the principle was that no one should be given two penalties for the same offence (Conway, 2003). If the criminal area covered only traditional domains and did not interfere with other law areas, the application of the principle did not generate many discussions.

Because of the extension of business law principles of traditional criminal law principles interfered with the domain (Lotito Fedele, 2020). Tax law is part of business law and is under heavy scrutiny from the state authorities. Being watched by state authorities, decisions and indecision of taxpayers were being applied

sanctions, both administrative and criminal. There were many examples when the same state of fact was analyzed by both administrative and criminal procedures and the European courts were asked many times to deliver their opinion.

The first famous example when the European courts were asked to analyze the application of both administrative and criminal sanctions related to the same state of fact is the case *Engel vs. Netherlands* (ECHR, 1976). The European Court of Human Rights was asked to analyze the compatibility between the two types of sanctions (Baker, 2021). From the start, the Court of Strasbourg underlined that there is no restriction on applying both administrative and criminal sanctions to the same state of fact. But the court issued a warning: state authorities must pay attention that administrative sanctions do not transform in criminal sanctions. The famous Engel criteria test was born: the scope of the sanction; the amount of the sanction; the qualification of the sanction in the national law.

Engel case is a landmark decision because it was for the first time the application of the *ne bis in idem* principle was explained in relation to both administrative and criminal procedures. Furthermore, it is important to underline that prior to the entry into force of the European Charter of Fundamental Rights, the European Union had no competence in the fundamental rights area. It is important to notice that the case law of European Union Court of Justice prior to the entry into force of the Charter did not focus on this topic.

Everything changed after the entry into force of the Charter and the Court of Justice of the European Union became interested in interpreting the *ne bis in idem* principle in cases that have both administrative and criminal impact. Especially, art. 325 from the Treaty of the Functioning of the European Union says that the European Union and the member states have the obligation to protect the budgetary resources of the European Union, even by using criminal methods.

The first *ne bis in idem* case that was analyzed by the European Union Court of Justice, is *Fransson* (CJEU, 2013). This is a Swedish case origin that has roots in a tax law problem that was related to problems of VAT payment (Lock, 2019). Mr. Fransson was accused by the Swedish tax authorities that he was behind a fraudulent scheme to avoid paying VAT. In parallel, a criminal procedure was opened against him.

The Swedish court of law wanted to find if the criminal procedures can go on in the context when Mr. Fransson was issued an administrative tax decision that obliged him to pay the amount of VAT, default interest and tax penalties. In its reasoning, the Court of Justice of the European Union referred to the Engel criteria test and agreed fully to the theoretical explanations made by the European Court of Human Rights in the *Engel* case.

The Court explained that the tax amounts to which Mr. Fransson was forced to pay cannot be considered a criminal sanction. The supreme court of the European Union argued that the amount of VAT and the default interest do not have a criminal aspect because their role is to cover the damage suffered by the

national budget which was deprived by a legitimate right. The role of tax penalties is to force the taxpayer to comply with tax regulations in the future. The role of the criminal sanctions is to sanction the person who disobeyed a clear tax rule.

It can be said that Fransson case opened the area for a width discussion about the role of the *ne bis in idem* principle in the complicated tax vortex of the European Union and the member states cooperation under the auspices of art. 325 from the Treaty of the Functioning of the European Union. In this context, it can be said that the role of the *ne bis in idem* in the European taxation landscape is of utmost importance. The role of the present paper is to select the most important cases delivered by the European Union Court of Justice and to extract the teachings made that came out.

2. DUAL PROD (EUCJ, C-412/21) CASE. PARALLEL TAX AND CRIMINAL PROCEDURES

One of the most important questions that arises in modern taxation problems is what to do when the same state of fact is examined from two sides in parallel: tax approach and criminal approach. The problem was analyzed in some cases of the European Court of Human Rights. The first case is *Lungu and others vs. Romania* (ECHR, 2014). In this case, the Mr. Lungu was accused of tax evasion by the Romanian authorities. In the tax procedure, Suceava Court of Appeal decided that the amount of damage produced by Mr. Lungu is 60 euros.

In the criminal procedure, the same Suceava Court of Appeal decided to ignore the result of the tax procedure and decided that the amount of damage is 30,000 euros. Accordingly, the criminal sanctions were higher because they are in direct connection with the amount of the damaged produced by the taxpayer.

As can be noticed, the same court of law applied to different sanctions related to the same state of fact. The problem was presented before the court of Strasbourg from the point of view of *ne bis in idem* principle. The European court ruled that two parallel procedures are possible, but the results cannot be different. That means that the result from the procedure that ends first is automatically opposable in the second procedure and cannot be ignored.

In conclusion, Romania was condemned because of breaching the *ne bis in idem* principle because the criminal procedure ignored the amount of damage from the tax procedure and should have determined the sanctions is straight relation with outcome of the tax procedures. A few years later, the court of Strasbourg was faced with the same problem from Norway in *A and B vs. Norway* (ECHR, 2016) case and the conclusions of the court were the same (Neagu, 2019).

We can keep in mind that two parallel procedures are possible, but state authorities must pay attention in handling such topics not to harm fundamental rights of taxpayers (Groussot *et al.*, 2011). In Dual Prod case, the hot topic was brought to the attention of the European Union Court of Justice. According to the Romanian tax legislation, when an excise duty warehouse is charged with criminal

accusation related to breaching the obligation that arises from the quality of an excise duty warehouse, automatically it's excise duty warehouse will be suspended if the criminal procedure is pending.

The problem is that the Romanian legislation has no provision related to the length of the criminal procedure. Dual Prod is a Romanian excise duty warehouse authorized to produce ethylic alcohol and to trade alcohol beverages. In 2018, a criminal procedure was launched against it. In 2020, it was officially indicted to breach obligations specific to excise duty warehouses, but the accusations were never presented before a criminal law judge.

In this context, the Romanian tax authorities decided to suspend for an indefinite time its excise duty warehouse authorization, suspension that set to last until the conclusion of the criminal procedure. Satu Mare Tribunal, a Romanian court of law decide to suspend the procedure and to submit a preliminary question before the European Union Court of Justice, according to art. 267 of the Treaty of the Functioning of the European Union.

The Court of Luxembourg joined the opinion of the Court of Strasbourg previously presented but decided to criticize the Romanian legislation. It has been ruled that the Romanian legislation is incompatible with the *ne bis in idem* principle because it is not acceptable to apply a tax sanction that depends on the indefinite time length of a criminal procedure. In conclusion, it is important to underline that no sanction cannot be applied in advance of one of the procedures.

3. ECOSERV (EUCJ, C-570/24) CASE. *RES JUDICATA* AND *NE BIS IN IDEM* PRINCIPLE

Another Romanian origin case is tackling the problem of the *ne bis in idem* principle in connection with the *res judicata* principle. Ecoserv is a Romanian excise duty warehouse. Its former manager was convicted by a Romanian criminal court of law for abusing company's property, especially for selling the company's alcohol products without paying excise duties and VAT. The criminal indictment decided that only the former manager is to be held responsible for the breach and the damage will be recovered by the Romanian tax authorities only from the budget of the former manager (CJEU, 2024).

The Romanian tax authorities issued a decision before the end of the criminal procedure and decided that only the company is to be held responsible to pay excise duties and VAT. Cluj Court of Appeal is entitled to decide whether to annul or to uphold the tax administrative decision. Because of the decision delivered by Cluj Court of Appel – Criminal Chamber, Cluj Court of Appeal – Tax Chamber decided to open a preliminary procedure.

The Romanian court wants to find if the European law, especially *ne bis in idem* principle, opposes to an interpretation according to which it is possible to ignore the criminal decision taken by a court of law and to uphold the

administrative tax decision. At the time of writing the present article, the European Union Court of Justice has not delivered a decision yet.

Nonetheless, an opinion should be expressed because also the principle of *res judicata* it is applicable. In the *Lucchini* case, the European Union Court of Justice declared that the principle of *res judicata* cannot be breached in the process of applying the EU law and is mandatory to be considered (Cappai and Colangelo, 2023).

Although, the Romanian tax authorities have the obligation to protect the financial interests of the EU financial resources, according to art. 325 of the TFUE and of the member states, our opinion is that still the principle of *res judicata* has priority. Because the criminal procedure ended first, its result should automatically be reflected in the tax procedure (Turmo, 2021).

What is important to underline is that the decision delivered in the criminal procedure decided who is responsible for the damaged represented by unpaid excises duties and VAT in the person of the former manager and the Romanian tax authorities are tasked to put that decision into force. If the European Union Court of Justice would reject the above proposed point of view, our opinion is that will open the Pandora box by targeting directly the principles of *res judicata* as part of the wider principle of the legal certainty. Furthermore, even the foundation of the *ne bis in idem* principle will be shaken because that will mean that the result of the first terminated procedure is no longer opposable in the second procedure.

As can be noticed, the principle of *ne bis in idem* is the origin of complex and important debates over its application and its effects on taxation (Ardizzone, 2023). The reality proves that member states want to put into practice art. 325 of the Treaty of the functioning of the European Union and that is an objective that should be praised. But, as can be noticed from the above-mentioned cases, it is of utmost importance to comply with all standards of fundamental rights of taxpayers (Radvan and Schweigl, 2016).

4. CONCLUSIONS

From our perspective, it is important to underline that the European Union needs to improve its legislative instruments to approach correctly the balance between protecting taxpayer fundamental rights and protecting the financial interests of the European Union. The Member States' competencies should be limited only to put into practice European legislation, not to make legislation.

Furthermore, future European legislation should approach in a comprehensive manner the parallelism of procedures with the aim of providing a logical interference between tax and criminal procedures. Otherwise, a situation like the one from Dual Prod case will happen again. Nonetheless, member states courts of law should be instructed to use extensively the preliminary procedures according to art. 267 of the Treaty of the Functioning of the European Union. The

preliminary procedure will provide an important tool for the correct application of the *ne bis in idem* principle.

In the end, it should be mentioned that the *ne bis in idem* principle cannot be applied singular, but in full cooperation with other principles as part of the European Union law family principles. Only in this manner will the fundamental rights of the taxpayers be fully and correctly protected.

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THE ART OF MANAGEMENT LEADING THE MIX PROCESSES OF INTERNAL COMMUNICATION

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Abstract

Internal communication has become a formal discipline in modern organizations also due to its proven impact on performance. Today, in the era of digitation and deepening the use of AI tools in organizations, communication is becoming more available and more tailored to organizational audiences. As a result, the scope of communication and internal communication expand. Accordingly, organizations manage a mix of communication channels and tools and refine the definition of the line manager's role with internal communication.

At the same time, the expansion of internal communication can lead to overload and loss of focus, as well as challenge the management ability of leading internal communication. This article presents the findings from a qualitative study that constitutes the first stage of a PhD-level research entitled: "The Relationship between Internal Communication and the Strength of Employees' Engagement in Companies". This current study examines the internal communication processes based on data collected through interviews with 7 managers and 7 employees. The study has identified three core themes within internal communication processes: communication skills of line managers, corporate communication, managing multiple communication tools and channels.

Each theme illustrates a combination of key categories, i.e., knowledge and idea sharing, direct person-to-person communication. The study highlights the significant role of communication led by line managers, as 56.5% of interviewees used theme referring to their line manager when describing how they received the internal communication.

This article highlights the pivotal role of line managers' managerial communication skills in the delivery of internal communication and, expands knowledge about the required skills.

Keywords: *managing internal communication; communication led by line managers; managerial communication skills, digital communication channel.*

JEL Classification: M10; M12; M14; D83.

1. INTRODUCTION

In the digital age we live in, information is constantly being exchanged, including business issues, along with thoughts, emotions, and more (Pocztowski,

2018). The exchange of information is part of everyday business and is also becoming central and significant in the role of managers (Griffin, 2002).

According to Griffin (2002), managers communicate through a variety of channels and tools, including: meetings, correspondence, hallway conversations, work instructions, and more. These allow for both the transmission of messages and listening to information from employees (within the framework of dialogue).

Studies show that managers value communication as a means of conveying clear information (Ziek and Anderson, 2015). Organizational communication plays a critical role in the success of organizations because it influences managers' ability to connect employees to the organization and achieve its goals (Welch and Jackson, 2007).

This article presents part of the qualitative research, which constitutes the first stage of the methodology research for PhD level that deals with: "The relationship between internal communication led by line managers and the strength of employees' engagement in organizations". This current study deals with the categories that detail the communication skills of managers as they emerged in this qualitative study. Understanding that can help building a strategy for leveraging employees' engagement.

2. LITERATURE REVIEW

2.1. Managers as communication leaders

Communication led by managers helps motivate employees, and this motivation is important in motivating them to achieve organizational goals (Timm and Peterson, 2000). Managers who connect employees to the broader organizational picture and vision create inspiration that motivates employees (Mishra *et al.*, 2014). However, the ability of managers to lead communication also depends on the manager's communication skills, communication style, and ability to listen and integrate different communication channels that are tailored to employees (Men *et al.*, 2020).

The issue is also reinforced in research that reviews the development of the manager's role and the presentation of his role as a communication leader that promotes employee engagement (Pugh and Dietz, 2008).

Comparison of managers' communication approaches (De Vries *et al.*, 2010), showed that managers who are capable of conveying information are also more likely to communicate with their employees, compared to managers who are more executive and task-oriented. As a communication leaders managers use diversity of communication tool i.e., newsletters, speeches, meeting (Patel and Das, 2021). Patel and Das, (2021) assert that when managers used an open and transparent dialog the level of employees' engagement promoted.

2.2. Employees' engagement

In a large study of employees in the UK (Engage for Success, 2025), it is found that the higher level of engagement, the more employees find satisfaction and intrinsic meaning in their work, and not just as a source of income. This contributes positively to their overall well-being and their motivation to act in favor of the organization's goals.

Digital communication interfaces, the use of advanced communication technologies, and also sharing information through 'cloud technologies' help managers lead continuous communication. This ability depends on the managers' abilities and their accessibility to technology (Kobis, 2015). Subsequently, the organization and managers need to adapt the communication channel to their abilities and for the benefit of an optimal interface with employees - for transferring information and collecting information from employees (Chalupa and Harris, 1998).

The importance of employee engagement has also increased in light of the positive relationship found between the level of engagement and reducing employee burnout at work (Schaufeli *et al.*, 2008) and, in addition, in light of the relationship found between engagement and the level of employee productivity (Gruman and Saks, 2011). Furthermore, a broad positive effect of the level of employee engagement to the organization has also been found on the person's good civic behavior (Lee *et al.*, 2014). It is interesting to note further that, current definitions of organizational engagement refer to an employee who is engaged as an employee with high energy and enthusiasm to perform their tasks and work towards achieving the organization's goals (Chanana and Sangeeta, 2021).

2.3. Factors influencing the level of engagement

The literature points to a number of factors that influence the level of engagement. Researches pointed that internal communication has an important influence on employees' engagement (Karanges *et al.*, 2014). Welch (2011) pointed that internal communication can connect employees to the organization's values and involving them in organizational goals. Moreover Verčič and Vokić, (2017) assert that communication has an important role in leveraging employees' engagement.

From a deeper study of the world of internal communications, it emerges that the communication component led by line managers has a significant impact on employee engagement (Engage for Success, 2025). Further, it appears that the communication that a direct manager conveys has a significant impact on the engagement of his employees, and not only because of the role of managers as connectors between the organization and employees (Pugh and Dietz, 2008).

2.4. The use of qualitative research methodology

This current article presents findings from the first part of a qualitative study, that constitutes the first phase of a mixed methods doctoral research project. This study examines the question what processes and steps involved in internal communication.

This phase was conducted using a qualitative research method designed to allow for the exploration of information and the collection of data that will contribute to understanding the field and preparing for the quantitative research phase. (DiCicco-Bloom and Crabtree, 2006). The research tool was an in-depth interview conducted based on a semi-structured interview outline (Creswell, 2009); the interviews were conducted using a digital interface in accordance with ethical guidelines (Creswell, 2009).

2.5. The research population

The population of this qualitative study includes 7 managers and 7 employees in business organizations with 150 employees or more. Half of them are women and half are men of a variety of ages, from the sectors of banking, finance, advanced industry and high-tech.

3. THE SAMPLING METHOD

The sample was a 'convenience sample'. The population was chosen from accessible target audience (Creswell, 2009). The interviews that conducted based on semi-structured interview guide, that was formulated according to the outline designed by Brinkman and Kavala (2015).

The interview guide was validated according to Cresswell (2009) method led by qualitative expert's opinion, as well as doing a pilot with 2 interviewers (see Table 1).

Table 1. The research design

Analysis method	The population of the research	The research design	The aim
Content analysis	7 Line Managers 7 Employees	Semi-structured interviews	To find what processes are involved in internal communication in organization

Source: the author

1. 4. HYPOTHESES

The hypotheses for the study were formulated based on an analysis of previous studies, and based on experience. This article focuses on one hypothesis dealing with managing processes that are involved in internal communication.

Hypothesis: Processes related to communication led by managers will receive a high weight among all the processes involved in internal communication.

5. THE ANALYSIS METHOD

The content collected in the interviews was analyzed and categorized into central themes (Shkedi, 2003). Within each theme, categories were defined that reflected recurring statements that corresponded to the category and reflected similar content.

6. ETHICAL ASPECTS

In this qualitative study, an emphasis was placed on the ethics of conducting the research. In this framework, the objectives of the study were presented to the participants, the possibility of withdrawing from the study at any time was given, the information was kept anonymous, and each participant expressed their explicit consent to participate.

7. FINDINGS

The content analysis that emerged in this study presented 3 central themes that represent processes that are involved in internal communication in organizations:

- Communication skills of line managers
- Corporate communication
- Managing multiple communication tools and channels

The hypothesis confirmed - The communication process led by line managers is the process that has been repeated more times than the other communication processes involved in communication that takes place in organizations. In addition, the theme dealing with communication skills of managers was defined as a central process in internal communication.

The theme: communication skills of managers, includes 4 categories of issues, as presented in Table 2.

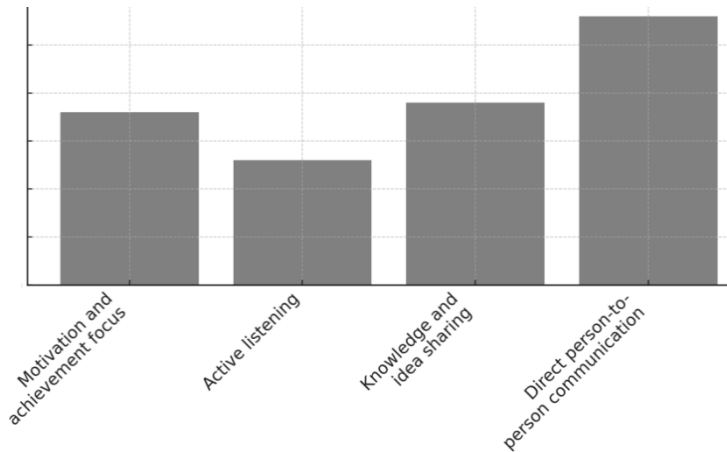
Table 2. The theme: Communication skills of line managers and the related categories

The theme	The Categories	Quate as an evidence
communication skills of line managers	Motivation and achievement focus	<i>"It is important for me to receive encouragement and ongoing guidance from my manager" (P: Employee.7, 10.2024).</i>
	Active listening	<i>"I maintain a routine of listening to employees' opinions on the issue at hand." (P: Manager.2, 10.2024).</i>
	Knowledge and idea sharing	<i>"My manager shares knowledge" (P: Employee.1, 10.2024).</i>
	Direct person-to-person communication	<i>"My manager makes sure to hold face-to-face meetings for both sharing and listening" (p: Employee 3, 10.10.24)</i>

Source: the author

8. LINE MANAGERS LED MIX PROCESSES OF INTERNAL COMMUNICATION

One of the themes that emerged from the content analysis in this study is communication skills of managers, referring to a mix of 4 categories of managerial skills: Communication that motivate and achievement focus, Active listening, Knowledge and idea sharing, and Direct person-to-person communication. Within the overarching theme of communication skills of managers, the leading category identified was direct person-to-person communication, as presented in Figure 1.



Source: the author

Figure 1. The strength's level of the categories within the theme: communication skills of managers

Figure 1 presents that in the theme: communication skills of line managers, the category: 'direct person to person communication' led by line managers', emerge as the frequent process that emerge relate to communication skills of line managers.

9. DISCUSSION AND CONCLUSIONS

This article relates to a part of qualitative research stage, which is a part of mix method research. This part based on interviews with 7 managers and 7 employees dealing with the processes that are involved in internal communication in organizations.

The finding presente 3 central themes that represent processes that are involved in internal communication in organizations: Communication skills of line managers, corporate communication, managing multiple communication tools and channels

From the finding, both employees and managers identified the process -direct person-to-person communication as the most common process involved in internal communication in general and, as the process that most often mentioned as related to the communication skills of managers.

This research phase motivates further future research regarding the skills required for managers as communication leaders.

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Safe Use of Artificial Intelligence on EU Market

This volume is the result of the research carried out within the Jean Monnet Centre of Excellence European Financial Resilience and Regulation and reunites a selection of papers presented at the International Conference “European Financial Resilience and Regulation – EUFIRE 2025”, organized at “Alexandru Ioan Cuza” University of Iasi, in May 2025. The event offers for the participants the opportunity to present their research on the safe use of the AI on the EU market and globally, and it reunited an impressive number of researchers, academics, and practitioners. Through its interdisciplinary contents, the volume approaches different aspects of the financial, business, and public administration regulatory framework in the European Union, especially focusing on its dynamics, recent developments, deficiencies and means of reinforcement, given the current global challenges.

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