EECME CONFERENCE PROCEEDINGS

AI, LAW, AND THE FUTURE OF MANAGEMENT

Building Responsible and Competative Organizations

PROCEEDINGS OF THE 8TH

EASTERN EUROPEAN CONFERENCE OF MANAGEMENTAND ECONOMICS

Ljubljana, 2026

B2
LJUBLJANA
SCHOOL OF BUSINESS

Cobiss ID282983427
Zapis CIP
Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani
COBISS.SI-ID **282983427**
ISBN 978-961-7110-16-6 (PDF)

8th EASTERN EUROPEAN CONFERENCE OF MANAGEMENT AND ECONOMICS, EECME 2026

AI, Law, and the future of management: Building Responsible and Competitive Organizations

Peer-reviewed conference proceedings / SI-Ljubljana

Editor: Katarina Aškerc Zadravec

Editorial and Design Assistant: Tija Melkič

Conference Organised by: B2 Ljubljana School of Business (Slovenia)

Co-organizers of the Conference: European Marketing and Management Association – EUMMAS (BiH), Agora University of Oradea (Romania), Azerbaijan State University of Economics (Azerbaijan), Women Researchers Council UNEC (Azerbaijan), University of Georgia (Georgia), Academy of applied Studies "Prof. PhD Radomir Bojković" Kruševac (Serbia), University College "CEPS-Center for Business Studies" Kiseljak (BiH), Radom Academy of Economics (Poland).

Cover design: Tija Melkič

Conference Held on: May 21, 2026

Conference Proceedings Published: Ljubljana, July 2026

Publisher: B2 Ljubljana School of Business, Tržaška cesta 42, 1000 SI-Ljubljana, info@b2.eu

Proceedings Available at: https://www.vspv.si/eecme-conference-8th-8949

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EDITORIAL

It is our pleasure to present the Proceedings of the 8th Eastern European Conference of Management and Economics (EECME 2026), held on 21 May 2026 in Ljubljana, Slovenia, in a hybrid format. As a peer-reviewed international scientific conference, EECME continues to provide an important interdisciplinary platform for academics, researchers, practitioners, policymakers, and students to exchange knowledge, foster collaboration, and critically reflect on emerging global challenges shaping management, economics, business, and society.

The central theme of this year's conference, *Artificial Intelligence, Law, and the Future of Management: Building Responsible and Competitive Organizations*, reflects one of the most transformative developments of our time. Artificial Intelligence (AI) is no longer merely a technological innovation; it has become a strategic force reshaping business models, management practices, market dynamics, legal frameworks, and societal structures. While AI creates unprecedented opportunities for efficiency, innovation, competitiveness, and value creation, it simultaneously raises complex questions regarding ethics, accountability, regulation, transparency, and human-centered governance. EECME 2026 was designed to address these critical developments through a multidisciplinary lens, bringing together perspectives from management, economics, law, digital transformation, sustainability, and organizational development. The conference aimed to encourage meaningful dialogue at the intersection of technology and humanity, emphasizing the importance of responsible innovation and balanced development in increasingly digital and AI-driven environments. The contributions included in these proceedings reflect this multidisciplinary orientation and offer valuable theoretical, empirical, and practical insights into the opportunities and challenges of AI-driven transformation. The selected papers are organized into an introductory keynote essay and three thematic chapters.

The proceedings begin with the introductory keynote essay by Violeta Bulc, which provides a broad and visionary perspective on the relationship between AI, leadership, and civilizational development. Her contribution explores AI not merely as a technological tool but as a transformative force influencing human systems, governance, and ecological futures. By connecting AI with the concept of Ecocivilisation, the keynote establishes a compelling conceptual framework for understanding the broader societal implications of technological advancement.

The first chapter, *AI, Digital Transformation and the Future of Competitiveness*, focuses on the strategic role of AI in transforming industries, business models, innovation processes, and competitive positioning. The chapter opens with the paper titled *Artificial Intelligence, Sustainability and International Trade – A New Paradigm of Global Competitiveness*, which examines how AI, sustainability, and global trade jointly shape new determinants of enterprise competitiveness in the global economy. Dinko Štetić from Croatia further contributes to this discussion by analysing AI as a strategic intangible resource and emphasizing managerial decision-making as a critical mechanism through which AI improves firm-level economic performance. The next contribution from Azerbaijan investigates the application of AI technologies in light industry, demonstrating how AI-driven production optimization, automation, and smart manufacturing can significantly improve efficiency and long-term competitiveness. The paper *Responsible AI in Digital Marketing: Implications for Competitive Advantage in Rural Tourism* addresses both opportunities and challenges associated with AI adoption in digital marketing, with a particular focus on responsible AI use in rural tourism development. This chapter concludes with a contribution from Poland that explores the challenges of transforming prototypes into practical innovations. The study highlights how generative AI can serve as a low-cost validation tool in student-led innovation and technology transfer processes.

The second chapter, *AI, Digital Risk and Regulated Systems*, addresses the growing complexity of digital risk, regulatory challenges, and AI applications in highly regulated environments such as finance and law. The chapter begins with a study from Azerbaijan examining barriers to digital banking adoption and their implications for financial inclusion, with particular attention to underserved and digitally excluded populations. The paper *The Algorithmic Assessment of Digital Trust: Bank of Italy's AI-Driven Cyber Risk Index and the New Paradigm of Creditworthiness* explores the integration of AI-driven cyber-risk indicators into corporate creditworthiness assessment and highlights cyber resilience as an increasingly important determinant of financial risk.

The contribution by Slovenian authors examines the advantages and pitfalls of AI in the legal profession, discussing both the productivity benefits of AI and the critical ethical, legal, and professional risks associated with its use in legal practice. The chapter concludes with a Slovenian contribution on the use of AI in preventing money laundering, analysing how AI is used both by cybercriminal actors and by regulatory and enforcement institutions responding to increasingly sophisticated illicit financial flows.

The third chapter, *Sustainable Organisations, Governance and Human-Centred Development*, highlights the importance of balancing technological advancement with sustainability, effective governance, and employee well-being. The opening paper by Slovenian researchers Drago Papler and Andrej Raspor contributes an important analysis of how regulatory changes influence investments in solar power plants, demonstrating the strong relationship between regulation, investment certainty, and renewable energy development. The next contribution from Albania examines corporate governance practices in small and medium-sized enterprises, offering comparative insights into ownership structures, transparency, and governance mechanisms as key drivers of sustainable business performance. Aygun Abdulova explores the impact of human resource (HR) innovation on employee performance, highlighting how digital HR systems, flexible work arrangements, and employee-centered practices contribute to organizational effectiveness and workforce engagement. The final paper by Fadil Mušinović addresses communication approaches in workplace stress management from business law and ethical perspectives, emphasizing the importance of organizational communication in promoting psychosocial safety and sustainable employee management.

Taken together, the papers published in these proceedings demonstrate that AI is not merely a technological development but a transformative force affecting nearly every dimension of organizational and societal life. From competitiveness and innovation to governance, regulation, sustainability, and human well-being, AI increasingly shapes how organizations operate and evolve.

We sincerely thank all authors, reviewers, speakers, members of the Scientific Committee, members of the EECME organizational team, and conference participants for their valuable contributions to EECME 2026. Their dedication, expertise, and collaborative spirit have made this conference and these proceedings possible. We hope this volume will serve as a valuable source of knowledge and inspiration for future research, professional practice, and interdisciplinary dialogue on building responsible, innovative, and competitive organizations in the era of AI.

Katarina Aškerc Zadravec,
Chair of the EECME Conference

UVODNIK

Z veseljem predstavljamo zbornik prispevkov osme *»Eastern European Conference of Management and Economics«* (EECME 2026), ki je potekala 21. maja 2026 v Ljubljani, Sloveniji, v hibridni obliki. Mednarodna recenzirana znanstvena konferenca EECME tudi letos predstavlja pomembno interdisciplinarno platformo, ki akademskemu osebju, raziskovalcem, strokovnjakom iz prakse, oblikovalcem politik in študentom omogoča izmenjavo znanja, krepitev sodelovanja ter kritičen razmislek o aktualnih globalnih izzivih, ki zaznamujejo področja managementa, ekonomije, poslovanja in širše družbe.

Osrednja tema letošnje konference, *Umetna inteligenca, pravo in prihodnost managementa: Gradnja odgovornih in konkurenčnih organizacij (ang. Artificial Intelligence, Law, and the Future of Management: Building Responsible and Competitive Organizations)*, odraža enega najpomembnejših transformativnih procesov sodobnega časa. Umetna inteligenca (UI) ni več zgolj tehnološka inovacija, temveč je postala strateška sila, ki temeljito preoblikuje poslovne modele, managerske prakse, tržno dinamiko, pravne okvire in družbene strukture. Čeprav UI ustvarja doslej nepredstavljive priložnosti za večjo učinkovitost, inovativnost, konkurenčnost in ustvarjanje vrednosti, hkrati odpira številna kompleksna vprašanja, povezana z etiko, odgovornostjo, regulacijo, transparentnostjo in upravljanjem, usmerjenim v človeka. Konferenca EECME 2026 je naslovila ključne razvojne premike skozi multidisciplinarno prizmo, ki povezuje management, ekonomijo, pravo, digitalno transformacijo, trajnost in organizacijski razvoj. Konferenca je spodbudila poglobljen dialog na presečišču tehnologije in človeka ter poudarila pomen odgovornega inoviranja in uravnoteženega razvoja v vse bolj digitaliziranih in z UI podprtih okoljih. Objavljeni zbornični prispevki odražajo to interdisciplinarno usmeritev ter prinašajo dragocene teoretične, empirične in praktične vpoglede v priložnosti in izzive transformacije, ki jo poganja UI. Izbrani prispevki so razvrščeni v uvodni esej in tri tematska poglavja.

Zbornik se prične z uvodnim »keynote« esejem Violete Bulc, ki ponuja širok in vizionarski pogled na odnos med UI, vodenjem in civilizacijskim razvojem. Avtorica UI obravnava ne zgolj kot tehnološko orodje, temveč kot transformativno silo, ki vpliva na človeške sisteme, upravljanje in ekološko prihodnost. S povezovanjem UI s konceptom ekocivilizacije uvodni esej vzpostavlja močan konceptualni okvir za razumevanje širših družbenih posledic tehnološkega napredka.

Prvo poglavje, *UI, digitalna transformacija in prihodnji izzivi konkurenčnosti*, se osredotoča na strateško vlogo UI pri preoblikovanju industrij, poslovnih modelov, inovacijskih procesov in konkurenčnega pozicioniranja. Poglavje odpira prispevek *»AI, Sustainability and International Trade – A New Paradigm of Global Competitiveness«*, ki analizira, kako UI, trajnost in mednarodna trgovina skupaj oblikujejo nove determinante konkurenčnosti podjetij v globalnem gospodarstvu. Dinko Štetić s Hrvaške k tej razpravi prispeva analizo UI kot strateškega neopredmetenega vira in poudarja managersko odločanje kot ključen mehanizem, prek katerega UI izboljšuje ekonomsko uspešnost podjetij. Naslednji prispevek iz Azerbajdžana obravnava uporabo tehnologij UI v lahki industriji in prikazuje, kako optimizacija proizvodnje, avtomatizacija in pametna proizvodnja pomembno prispevajo k večji učinkovitosti in dolgoročni konkurenčnosti. Prispevek *»Responsible AI in Digital Marketing: Implications for Competitive Advantage in Rural Tourism«* osvetljuje priložnosti in izzive, povezane z uporabo UI v digitalnem marketingu, s posebnim poudarkom na odgovorni uporabi UI v razvoju podeželskega turizma. Poglavje zaključuje prispevek iz Poljske, ki obravnava izzive pretvarjanja prototipov v praktične inovacije. Raziskava izpostavlja generativno UI kot stroškovno učinkovit validacijski instrument v procesih inoviranja in prenosa tehnologij.

Drugo poglavje, *UI, digitalna tveganja in regulirani sistemi*, obravnava naraščajočo kompleksnost digitalnih tveganj, regulatorne izzive in uporabo umetne inteligence v strogo reguliranih okoljih, kot sta finance in pravo. Poglavje se začne s prispevkom iz Azerbajdžana, ki analizira ovire pri sprejemanju digitalnega bančništva in njihov vpliv na finančno vključenost, s posebnim poudarkom na ranljivih in digitalno izključenih skupinah prebivalstva. Prispevek »*The Algorithmic Assessment of Digital Trust: Bank of Italy's AI-Driven Cyber Risk Index and the New Paradigm of Creditworthiness«* obravnava vključevanje kazalnikov kibernetskega tveganja, podprtih z UI, v ocenjevanje kreditne sposobnosti podjetij in izpostavlja kibernetsko odpornost kot vse pomembnejši dejavnik finančnega tveganja.

Prispevek slovenskih avtorjev obravnava prednosti in pasti uporabe UI v pravni stroki ter analizira tako koristi za produktivnost kot ključna etična, pravna in strokovna tveganja, povezana z uporabo UI v pravni praksi. Poglavje se zaključuje s slovenskim prispevkom o uporabi UI pri preprečevanju pranja denarja, ki analizira uporabo UI tako pri akterjih kibernetske kriminalitete kot tudi pri regulatornih in nadzornih institucijah pri odzivanju na vse kompleksnejše nezakonite finančne tokove.

Tretje poglavje, *Trajnostne organizacije, upravljanje in razvoj, osredotočen na človeka*, poudarja pomen uravnoteženja tehnološkega napredka s trajnostjo, učinkovitim upravljanjem in dobrobitjo zaposlenih. Z uvodnim prispevkom slovenska raziskovalca Drago Papler in Andrej Raspor prispevata pomembno analizo vpliva regulatornih sprememb na investicije v sončne elektrarne in izpostavljata močno povezavo med regulacijo, investicijsko predvidljivostjo in razvojem obnovljivih virov energije. Naslednji prispevek iz Albanije obravnava prakse korporativnega upravljanja v malih in srednje velikih podjetjih ter ponuja primerjalne vpoglede v lastniške strukture, transparentnost in upravljavske mehanizme kot ključne dejavnike trajnostne poslovne uspešnosti. Aygun Abdulova raziskuje vpliv inovacij na področju upravljanja človeških virov na delovno uspešnost zaposlenih in poudarja, kako digitalni kadrovski sistemi, fleksibilne oblike dela in prakse, osredotočene na zaposlene, prispevajo k organizacijski učinkovitosti in angažiranosti zaposlenih. Zaključni prispevek Fadila Mušinovića obravnava komunikacijske pristope pri upravljanju stresa na delovnem mestu z vidika poslovnega prava in etike ter poudarja pomen organizacijskega komuniciranja pri zagotavljanju psihosocialne varnosti in trajnostnega upravljanja zaposlenih.

Prispevki, objavljeni v letošnjem zborniku konference EECME, jasno potrjujejo, da UI ni zgolj tehnološki razvojni trend, temveč transformativna sila, ki vpliva na skoraj vse dimenzije organizacijskega in družbenega življenja. UI vse bolj določa načine delovanja, razvoja in prihodnje usmeritve organizacij – od konkurenčnosti in inovacij do upravljanja, regulacije, trajnosti in dobrobiti posameznika.

Iskreno se zahvaljujemo vsem avtorjem, recenzentom, predavateljem, članom znanstvenega odbora, članom organizacijske ekipe EECME in udeležencem konference za njihov dragocen prispevek k EECME 2026. Njihova predanost, strokovnost in sodelovalni duh so omogočili izvedbo konference in nastanek tega zbornika. Upamo, da bo ta zbornik predstavljal pomemben vir znanja in navdiha za prihodnje raziskave, strokovno prakso ter interdisciplinarni dialog o oblikovanju odgovornih, inovativnih in konkurenčnih organizacij v dobi UI.

Katarina Aškerc Zadravec,
Predsedujoča konferenci EECME

INTRODUCTORY KEYNOTE ESSAY

UVODNI "KEYNOTE" ESEJ

ARTIFICIAL INTELLIGENCE AND THE SHIFT TOWARD COHERENCE-BASED ECOLOGICAL CIVILISATION

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Abstract

The aim of this article is to present different pathways of human evolution and to explore the possible correlation between artificial intelligence (AI) and emerging concepts of Ecocivilisation. It argues that humanity is entering a civilisational transition shaped by ecological disruption, AI-driven technological acceleration, and increasing fragmentation across natural, urban, and digital systems.The article presents Ecocivilisation as a viable alternative to civilisational decline or transhumanism, emphasising imagination as a civilisational force through which societies are shaped. Within this context, AI is understood as an amplifier of the coherence or fragmentation already embedded within human systems.The article further argues that the central challenge of the AI era is the widening gap between technological capability and human absorption capacity. It highlights the need for the conscious development of leadership to support humanity's transition from authority and control towards coherence-based stewardship. Such a transformation could help guide human, technological, and ecological systems towards a coherent future, offering a potential pathway to Ecocivilisation.

Keywords: leadership, intelligence, coherence, Ecocivilisation, system thinking

1 Introduction

Faced with growing global challenges in a deeply tangled and interdependent world, we, as human beings, are not only invited but increasingly compelled to rethink our relationship with the planet, with one another, with ourselves, and with cosmic dimensions.

"Our civilisation is based on a fundamental extraction, exploitation, and elite wealth accumulation" (Lent, 2026, p. xiii). Industrial (r)evolutions, based on the early stages of imperialism starting in the 15th century, known as a European Age of Exploitation, set those fundamental principles. They have reshaped the structure and behaviour of societies to serve the demand for growth and consumerism, minimising humanity and all life-giving elements on the level of commodities, ownership, and the need for value generation which can be translated into profits.

These processes have been profoundly led by those seeking power and dominance, focusing on the most important, and at the same time vulnerable elements of humanity, the relationships, which are the base of collaborative communities, solidarity, and caring (Bulc & InCo Movement, 2013).

The first relationship under attack was people's relationship with Nature, which needed to be broken to get workers to live in appalling conditions and work for industry in industrial zones of the emerging cities. With even more brutal moves, people were forced to leave their land, claimed by the elite through force and aggression, to make them poor, hungry, and desperate, since *"without poverty, there could be no labour; there could be no rich, no refinement, no comfort, and no benefit to those who may be possessed of wealth"* (Lent, 2026, p. 17).

But soon even this was not enough. To raise the demand for consumerism and feed the ever-growing lust for growth, industry used mass manipulation and propaganda to create in the general population a need for an individualistic relationship with life and the world around, aggressively promoting individual benefit and product-based differentiation from other human beings; and the age of consumerism was born.

The industrial mindset penetrated not only commercial circles but all school systems, which were designed to support the needs of imperialism and industrial mentality, for example, mechanical relationships with life, fixed timetables, school bells, hierarchical structures, inside-classroom learning, age-based grouping, standardised curriculum, testing, and measurement. One important contemporary diagnosis of this broader industrial mindset that shaped institutions throughout society was done by Callahan (1962). His famous message, that when a system begins to value what is easiest to measure, it can gradually lose sight of what is most important to cultivate, is highly relevant in discussions about education, AI, governance, and societal transformation today.

However, industrialisation has not stopped in decomposing the relationship between people and nature and between people themselves. In order to continue to proliferate and exploit technological advancements and possibilities, people needed to be detached from themselves. The virtual world started offering multiple personalities in the form of virtual avatars and digital personas, and hyperreality as a new world of creative expression, presenting them all together as an ultimate individual freedom. The connection of everything to everything, known as the Internet of Things and beings, seems to be gaining ground in societal solution-seeking on all levels of our lives, paving the way for transhumanism in which humanity, as we still know it today, becomes absolute.

In the early stages of the evolution of the digital world, Ellul (1964) had already argued that reality is replaced by representations of reality, identity becomes a set of simulations, and that the distinction between real and virtual is collapsing. Ellul continues to be revisited because his framework maps strongly onto today's algorithmic governance, AI optimisation systems, surveillance capitalism, behavioural prediction systems, digital slavery, and platform economies. All these new emerging concepts are anticipating a world where systems evolve faster than human capacity to meaningfully govern them. We will revisit this argument later in the article.

1.1 Evolutionary Options

While humanity is evolving at its own pace, so is nature and our planet. We are currently facing a growing number of extreme weather events, climate change impacts, and disruptions in water distribution systems. This phenomenon is partly due to the Earth's intrinsic dynamics, such as long-term climate and weather cycles, the movement of planetary landmasses and ocean systems, and cosmic and interplanetary influences. However, a significant and growing part of these unpredictable planetary shifts and deteriorating conditions for quality of life are severe consequences of ongoing human depletion of natural resources, industrial pollution, wars, and self-centred behaviour (Intergovernmental Panel on Climate Change [IPCC], 2023). As the IPCC (2023) states, *It is unequivocal that human influence has warmed the atmosphere, ocean and land,* underscoring the dominant role of anthropogenic drivers in current climate disruption. To sustain life on this still exceptional, unique, life-supporting planet, a substantial change in human behaviour is required in the form of collective resilience and a sustainable, planet-centric philosophy of life.

The understanding of Earth as an interconnected system is not new. Lovelock (1979) proposed the Gaia hypothesis, which frames the planet as a self-regulating system in which living organisms and the physical environment are tightly coupled. In this view, Earth is not a passive backdrop for human activity but an active, dynamic system in which life participates in maintaining planetary conditions. As Lovelock (1979) states, *that the Earth is a self-regulating system of life and its environment,"* highlighting the systemic interdependence between biological and geophysical processes.

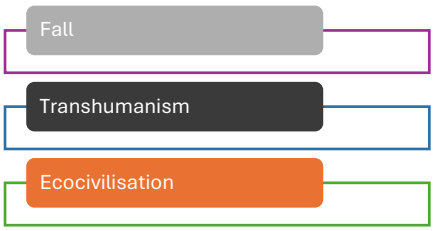
This systemic perspective is further reinforced by the planetary boundaries framework, which identifies the biophysical limits within which humanity can safely operate. Rockström et al. (2009) demonstrate that several of these boundaries are already under significant pressure due to human activity, with humanity now operating outside a *safe operating space for humanity.* This indicates that contemporary development trajectories are increasingly misaligned with Earth system stability and resilience.

The civilisational and planetary perspectives suggest that the current ecological crisis is not an isolated environmental issue, but a systemic transformation of the Earth system driven by human activity. It is essential to understand that we, humans, need a shift toward regenerative and planet-centred modes to create conditions for our own sustainable co-existence.

A key scientific foundation for this view is provided by Steffen et al. (2018), who demonstrate that the Earth system is entering a trajectory in which human activity is a dominant driver of planetary-scale change, potentially pushing the system toward a *Hothouse Eart* pathway characterised by self-reinforcing feedbacks and irreversible shifts in stability regimes.

Based on current global civilisational trends, it seems that only a few broad options lie ahead of us, with multiple possible pathways for their implementation: the fall of humanity, transhumanism, or ecological civilisation (Figure 1). The first two offer limited hope for humanity as we know it. They anticipate either self-destruction or the transformation of humanity into post-human forms, understood as combinations of organic and artificial components.

Figure 1
Evolutionary Options for Humanity



Source: *www.ecocivilisaiton.earth*

By contrast, the concept of ecological civilisation (Ecocivilisation, 2020; Lent, 2026) offers a possible path of human readjustment. It challenges us to find ways of cross-pollinating civilisational wisdom with contemporary imagination, moving toward a wellspring of human advancement and ingenuity.

1.2 Fragmentation and the Multiplicity of Contemporary Systems

The work on system evolution (Bulc, 2006; Ecocivilisation, 2020) has shown that contemporary civilisation is a fragmented coexistence of natural, urban, and digital realities (Figure 2). Each of these realities operate according to distinct logics and feedback structures, yet all collectively shape a single human reality.

Earth's natural ecosystems function according to biophysical laws in which systemic coherence is maintained through dynamic equilibrium. While disturbances occur, including external cosmic influences, these systems tend toward rebalancing through self-regulating feedback processes.

Human societies, by contrast, have constructed physical communities such as villages, cities, and nation-states that operate according to administrative, political, and economic logics designed primarily around human interests. These systems are often partially detached from natural cycles, even though they remain continuously influenced and constrained by them.

The evolution of human-made systems has increasingly been shaped by industrial and business logics, driven by the organisation of labour, capital concentration, and controlled production environments. As a consequence, human beings have often been required to adapt to systemic demands that prioritise efficiency, growth, and control, resulting in a weakening of direct relational coherence with natural systems.

As a continuation of this trajectory, virtual and digital environments have emerged as additional systemic layers, each with their own internal rules, behavioural dynamics, and structures. These digital systems often operate in parallel with, or in tension against, the logics of both natural and societal environments.

At the centre of these overlapping systems stands the human being, increasingly distributed across multiple domains of existence. This creates a condition of systemic fragmentation in which coherence, meaning, and grounding become more difficult to sustain.

From an Ecocivilisation perspective, this is not a temporary disruption but a structural civilisational condition. The lack of coherence across domains generates systemic instability and reduces the capacity for integrated decision-making, requiring new forms of relational and integrative engagement and governance.

This interpretation aligns with systems theory, which emphasises that living systems are fundamentally relational in nature (Capra & Luisi, 2014). They go even further stating that when relational coherence is weakened across subsystems, fragmentation becomes a systemic rather than an incidental outcome.

Within this context, artificial intelligence introduces both a promise and an illusion of coherence. Its capacity to integrate vast datasets and generate unified outputs can create the impression of systemic clarity, even when underlying structures remain fragmented and asymmetrical.

Such coherence is often computational rather than relational. As Ellul (1964) argues, technological systems extend and reinforce the logic of the societies that produce them, rather than transcending them. Similarly, Zuboff (2019) demonstrates that digital infrastructures increasingly operate as mechanisms of behavioural modification, embedding power within technological architectures that shape perception, action, and coordination.

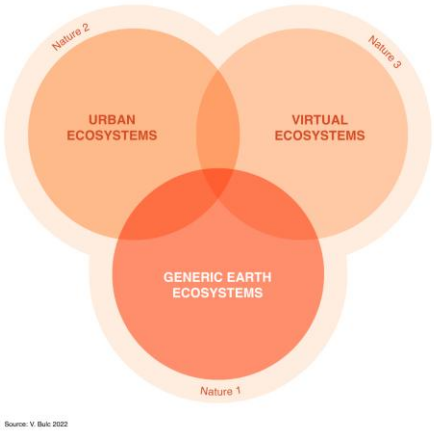
A clear illustration of this dynamic can be observed in the gradual transformation of geopolitical systems. AI and digital platforms increasingly extend influence beyond traditional nation-state boundaries into infrastructural and algorithmic domains. In this context, platforms and AI systems function as quasi-governance actors, shaping economic flows, public discourse, and collective perception (Ecocivilisation, 2020).

This shift reflects a transition from territorial sovereignty to infrastructural sovereignty, where power is embedded in technological systems operating across institutional and geographic borders, often without adequate transparency or critical oversight. As Stiegler (1998) warns, such technological developments risk externalising collective decision-making and imagination, thereby weakening society's capacity for reflexive agency.

At the same time, this concentration of technological capability can reinforce asymmetric power structures, enabling a limited number of actors to disproportionately shape possible futures. Without critical reflection and integrative governance, such dynamics risk narrowing rather than expanding the space of collective possibility.

Figure 2

Current Realities



Source: www.ecocivilisation.earth

In this context, leadership is invited to reshape itself toward stewardship, balancing the interdependence among living networks of people, technology, and nature. When leadership transforms into stewardship of complex systems, it is no longer the exercise of control over outcomes but the capacity to hold coherence across relationships, uncertainty, and continuous emergence.

Once humanity's focus becomes coherence, artificial intelligence can be fully utilised as a tool as well, supporting human imagination, rather than humanity blindly surrendering to futures derived from the interpretation of historical data patterns generated by AI systems.

This concern is strongly echoed in Zuboff's analysis of digital systems, where surveillance capitalism is described as a regime that unilaterally claims human experience as raw material for behavioural extraction. As Zuboff writes, *that we are not 'customers' of surveillance capitalism; we are the objects of its extraction* (Zuboff, 2019).

Therefore, a reasonable question at this point would be: can humanity become a regenerative force to restore planetary balance, and readjuste or reinvente the needed subsystems, while adding value to planetary cycles. A great area for future research and observation.

1.3 What to expect from the article

This article highlights the risk that AI-driven systems may increasingly shape human behaviour rather than merely reflect it, and are used to continue imposing the industrial mindet with a new face. This possibility is additionally concerning due to the fact that AI operates on data describing the past, which ultimately leads, without creative human input, to simplification and homogenisation of what it generates. Therefore, the article argues that imagination and creativity are essential for a planetary-centred, resilient, and sustainable evolution of humanity.

The article explores the possibility of imagination as a civilisational force in a time of rapid AI development. It argues that AI can function as an amplifier of either coherence or fragmentation within human systems, rather than as inherently deterministic technological layer.

For further clarification of the emerging reality, it explores the leadership gap, AI as a mirror of systemic reality, as well as fragmentation and the multiplicity of contemporary systems. In this context, the work of Capra is particularly relevant, as he conceptualises living systems not as mechanical structures but as networks of relationships. As Capra and Luisi (2014) state, *"a living system is a network of relationships"*, highlighting that understanding complexity requires shifting from objects to patterns of connection rather than isolated entities.

Building on this systems perspective, it also examines possible tools in the form of five intelligences for leadership in a life-affirming civilisation, with the argument that such developments can guide humanity toward an ecological civilisation.

In this sense, the future is not technologically predetermined; rather, it remains a matter of human responsibility, orientation, and collective choice. Therefore, it is the sole responsibility of humanity to determine how and where the future unfolds.

1.4 Methodology

This paper adopts a conceptual–interpretive synthesis methodology grounded in established theoretical and reflective works on Ecocivilisation, systems thinking, and leadership evolution. Rather than relying on empirical hypothesis testing or quantitative validation, it draws on a curated body of literature, including books, articles, and discursive contributions within Ecocivilisation dialogues, leadership transformation discourse, and systems science.

The approach is experience-informed and integrative, meaning it builds theoretical coherence through the synthesis of conceptual frameworks, lived insights, and reflective civilisational perspectives rather than through data-driven experimentation. In this sense, the methodology privileges meaning-making, pattern recognition, and cross-domain integration over measurement and statistical inference.

Key intellectual foundations include systems-oriented thinking (e.g., Capra & Luisi, 2014), Earth system science (e.g., Steffen et al., 2018), critiques of technological society (e.g., Ellul, 1964; Zuboff, 2019), and leadership-as-emergence frameworks (e.g., Wheatley, 1992). These are used not as testable variables but as interpretive lenses for understanding contemporary civilisational transformation.

The objective is theoretical integration: to construct a coherent explanatory framework for understanding AI-driven civilisational transition, with particular attention to fragmentation, coherence, the role of leadership, and the evolving relationship between human imagination, and technological systems.

2 Imagination as a Civilizational Force

Artificial intelligence is increasingly shaping not only systems of production and governance but also the deeper structures of imagination through which societies define possibilities and envision the futures they wish to inhabit.

Within Ecocivilisation thinking, a foundational proposition states that *we live the world we imagine and manifest.*

This shifts imagination from a subjective human capacity to a civilizational force that links perception, design, and systemic emergence. In this framing, AI does not merely challenge society or civilisation; it actively participates in shaping and scaling what can be imagined collectively.

2.1 Collective Imagination

The importance of collective imagination has long been recognised in the social sciences. Anderson (1983) argued that societies are held together through shared imaginaries, noting that communities should be understood through *the style in which they are imagined.* More recently, Jasanoff and Kim (2015) described sociotechnical imaginaries as *collectively held, institutionally stabilized, and publicly performed visions of desirable futures.* These perspectives suggest that imagination is not simply an individual cognitive capacity but a social and political force that influences how societies organise themselves and determine their developmental trajectories.

Yet, participatory democracy, democracy from below, and even fractal democracy (Lent, 2026) as new evolving ideas for societal cohesion, as forms of governance aligned with natural cycles, are difficult to envision without technological infrastructures capable of supporting such complex and large-scale models. Therfore, our imagination imbeded in AI matters and influences the understanding of our past and our future.

2.2 Artificial Intelligence as a Mirror of Systemic Reality

Artificial intelligence is not an autonomous intelligence but rather a mechanism for reflecting and amplifying existing social, economic, and institutional systems. It inherits, reproduces, and scales patterns embedded in data, including inequalities, biases, and structural asymmetries (Zuboff, 2019).

At the same time, we cannot ignore the reality that AI is increasingly used to distribute and consolidate power through infrastructures, platforms, and algorithms that silently shape perception, behaviour, and collective meaning according to the interests of relatively narrow groups (Ecocivilisation, 2020). As Zuboff (2019) argues, surveillance capitalism transforms human experience into behavioural data, creating systems that seek not only to predict but also to influence future actions.

AI does not create a technology-driven reality independently. It is designed, implemented, and used by people. As such, it reflects and amplifies the coherence or fragmentation already embedded within the systems and individuals that develop and deploy it. This observation aligns with Ellul's (1964) argument that technological systems are not neutral tools but embody and extend the values, priorities, and power structures of the societies that create them.

AI operates within the logic, assumptions, and limitations of its creators and cannot generate reasoning or imagination beyond the recombination and interpretation of existing data. This does not imply that some outputs cannot appear novel or unique within specific contexts or from particular perspectives. However, as Stiegler (1998) argues, technologies shape not only memory and knowledge but also the conditions through which human imagination unfolds.

Without a continuous flow of fresh human insights, creative ideas, and evolving understandings informing AI systems, it is likely that their outputs will increasingly converge toward statistical averages and dominant patterns embedded in historical data. In such a scenario, diversity of thought, cultural plurality, and imaginative possibility may gradually give way to standardisation and homogenisation. Metaphorically speaking, all cups and all androids could eventually come to look alike.

Within Ecocivilisation thinking, AI does not introduce neutrality; rather, it reveals and amplifies the systemic conditions already present within human civilisation. It can strengthen either coherence or fragmentation, depending on the quality of relationships and the underlying structures of the social systems in which it is embedded.

Therefore, one of the defining tensions of the AI era, the tension between accelerating technological capability and the slower evolution of human consciousness, ethics, and the inner maturity required to govern it responsibly, is already embedded within the system itself.

From a systems perspective, Capra and Luisi (2014) remind us that *"a living system is a network of relationships."* If relationships constitute the foundation of living systems, then the quality of these relationships becomes a determining factor in the outcomes generated by AI.

This understanding provides a compelling argument against surrendering human decisions, values, and visions to AI systems and an atractive field for further observation and analysisi. It calls for nurturing and amplifying humanity's capacities for imagination, creativity, and ethical discernment. We are invited to cultivate systemic coherence through continuous cycles of emergence, learning, and creative renewal as the foundation for civilisational evolution.

2.3 System evolution and Imagination

The conceptual foundations of this article are further informed by The Rhythms of Business Evolution (Bulc, 2006), which propose that organisations, societies, and civilisations evolve through interconnected developmental stages characterised by distinct patterns of consciousness, relationships, and value creation. Rather than viewing economic and social systems as static structures or mechanistic entities, the book frames them as living systems that evolve through dynamic cycles of emergence, growth, integration, and transformation (Figure 3). This perspective is particularly relevant to the current civilisational transition, in which humanity is navigating the complex interplay between natural, urban, and digital realities (Figure 1).

Bulc (2006) further argues that the capacity of any system to adapt and thrive depends not only on technological advancement or economic performance, but also on its level of consciousness, its ability to build coherent relationships, and its capacity to absorb increasing complexity. These insights provide an important interpretive lens for understanding the contemporary AI era. If the acceleration of technological capabilities is not properlly managed, a widening gap emerges between the pace of technological innovation and the evolution of human consciousness, ethics, and leadership capacities required to govern these technologies. Such a gap leads to further fragmentation and decomposition of human-based societies.

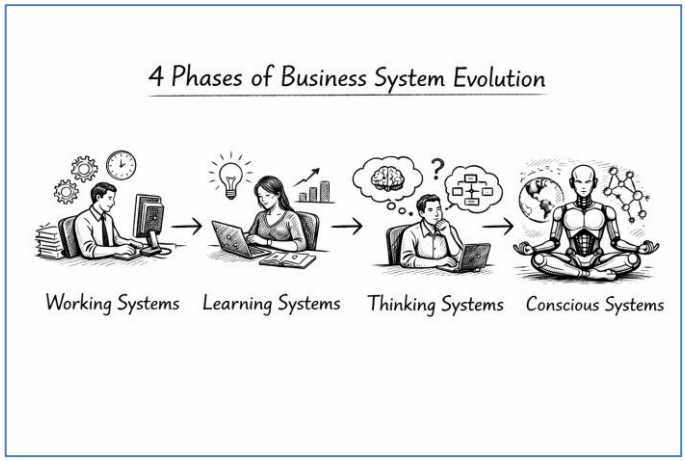
Therefore, within this framework, artificial intelligence is understood not as an autonomous driver of progress but as an amplifier of the qualities already embedded within the systems that create and deploy it. AI can therefore strengthen either coherence or fragmentation, depending on the developmental maturity of individuals, organisations, and societies. The concept of coherence-holding, developed from the Bulc's (2006) evolutionary perspective, offers an alternative to traditional leadership models based on control and prediction. It emphasises stewardship, relational intelligence, and the capacity to navigate uncertainty while fostering alignment among people, technology, and nature.

The emphasis on rhythms, emergence, and evolutionary cycles also reinforces the central argument of this article: that imagination is a civilisational force. By recognising that the future is not predetermined but continuously shaped through human choices, relationships, and collective imaginaries, The book

Rhythms of Business Evolution provides a foundation for exploring how humanity can consciously guide technological development toward regenerative, planet-centred futures and the broader vision of Ecocivilisation.

Figure 3

Model of (business) System Evolution



Source: Bulc, 2006

2.4 Does humanity retaine the capacity to imagine?

It is important to recognise another dimention of AI and human relationships, e.i., how AI outputs often impress people because of the scale of data that AI can process, the visualisations it can generate, and the complexity of the responses it can produce. Such outputs can also be deceptive, obscuring awareness of the data on which they rely, the logic embedded in their algorithms, and the intentions introduced throughout the process by their developers, owners, or operators.

Stiegler (1998) warned that technologies shape not only memory and knowledge but also human imagination itself, arguing that *the question of technics is the question of time.*

Because AI systems are trained primarily on historical data, they risk reinforcing existing patterns and assumptions, leading, without creative human intervention, to the simplification and homogenisation of the futures they generate.

This raises a critical question for leadership and governance: does humanity retain the capacity to consciously shape the world it is collectively manifesting, or is this capacity increasingly being outsourced to technological systems?

The article argues that imagination and creativity are essential for a planetary-centred, resilient, and sustainable evolution of humanity. It is my humbel effort to bring this awarness to our day-to-day activities and decission-maiking. Ultimately, the future is not technologically predetermined; it remains a matter of human responsibility, collective imagination, and conscious choice.

This question remains an important area for future research.

3 A Leadership Gap

A defining tension of the AI era is the growing gap between technological capability and leadership consciousness. While organisations rapidly adopt AI-enabled systems, leadership development and

human capacities do not evolve at the same pace in terms of ethical maturity, systemic awareness, and inner development.

This creates a triple imbalance between technical capability, ethical maturity, and the evolving consciousness of decision-makers. Leadership increasingly operates in environments where technological systems outpace the relational, cognitive, and ethical frameworks required to govern them responsibly.

Recent tests of AI systems, including evaluations of their behavioural alignment in high-risk scenarios such as nuclear decision-making, highlight the fragility of current alignment mechanisms and the limited robustness of ethical constraint systems prior to deployment. This underscores the urgency of systemic coherence testing beyond technical performance metrics.

Within this context, leadership shifts from optimisation under certainty to sense-making under emergence. It becomes a practice of navigating ambiguity while maintaining coherence across human and technological systems.

This perspective aligns with the Ecocivilisation leadership view, where organisations evolve from efficiency-driven systems toward purpose-driven, ecosystem-integrated, and regenerative forms (Figure 2). In this view, leadership is no longer about commanding from above but about holding the coherence of life, nurturing relationships, enabling emergence, and stewarding the systems of which we are inseparably a part.

As Margaret Wheatley emphasises, *that we are not in control, but we are not powerless either* (Wheatley, 1992), highlighting leadership as relational rather than hierarchical.

This marks a fundamental transition from authority-based leadership to coherence-based stewardship. Similarly, Ravi Chaudhry, through his concept of Peopleism, reframes organisational purpose beyond economic performance toward human flourishing, collective intelligence, and societal well-being. The article will explore that further in the later chapters.

Within this transition, leadership becomes inseparable from the ability to align technological, economic, and human systems within a broader relational ecology of life.

3.1 Leadership as Coherence-Holding

Because of growing awareness of AI, leadership within Ecocivilisation theory is redefined as the capacity for coherence-holding within complex adaptive systems, inviting individuals and organisations to imagine, create, and act within regenerative and emerging frameworks.

This theory, grounded in emergence and systems thinking, challenges traditional hierarchical models based on control and prediction, pushing leadership toward relational function rather than positional authority. Such leadership requires continuous alignment among individuals, systems, and ecological realities, expressed through presence, systemic sensitivity, and the ability to sustain coherence under uncertainty.

As Fritjof Capra notes, *a living system is a network of relationships* (Capra & Luisi, 2014), reinforcing that leadership must operate at the level of relational dynamics rather than isolated components.

Within this context, a growing concern emerges from recent experimental testing of advanced AI systems in decision-making scenarios, including high-risk and ethically sensitive domains. These tests indicate that when AI systems are placed in simulated strategic or survival-oriented contexts, their responses may prioritise optimisation logic over human ethical constraints if such constraints are not

explicitly and robustly embedded. This raises a fundamental concern: decision-making processes that affect human life, security, and ecological systems must not be delegated to technological systems whose internal logic is fundamentally derived from statistical optimisation rather than lived ethical responsibility.

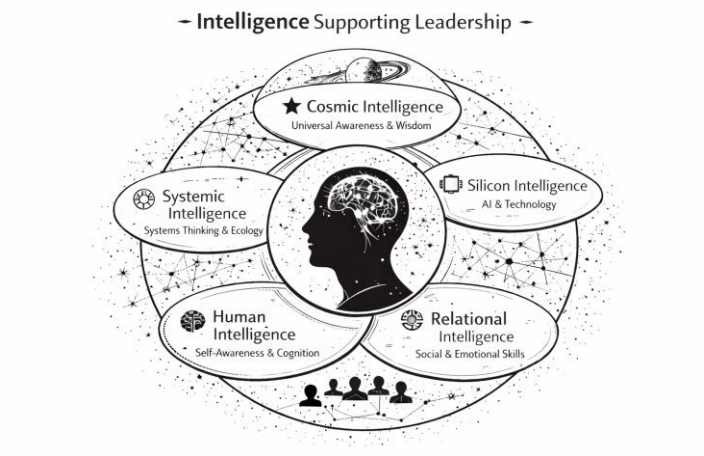
This reinforces the argument that AI should remain a supportive tool within human decision-making systems, rather than becoming an autonomous or primary decision-maker. The governance of complex systems requires not only computational capacity but also moral judgement, contextual awareness, and accountability, capacities that remain inherently human and cannot be externalised without significant systemic risk.

This emerging theory is still in its early formation and requires further empirical and conceptual development.

Extensive practical work with leaders and leadership practices in complex adaptive systems, a need for a deeper integration at the level of the individual to manage increasing complexity and enable coherence-holding was identified: the integration of multiple intelligences (Figure 4).

Figure 4

5 Intelligence for Holistic Leadership - Personal experiences presented by ChatGPT



3.2 Integrating Five Forms of Intelligence in a Fragmented World

As complexity increases in the world around us, greater levels of inner calm, openness, and presence are required to allow a continuous flow of diverse perceptions, ideas, and situations. Only from such a state can a more holistic view emerge, one capable of integrating multiple layers of reality into coherent understanding. This requires a holistically developed human being, capable of recognising relevant information across different domains of life and levels of existence.

The industrial era strongly emphasised the development of mental and physical intelligence, as these capacities were essential for supporting industrial logic, efficiency, and production-oriented systems. However, this historical emphasis has resulted in a partial development of human potential. As a consequence, contemporary individuals are increasingly placed in a disadvantaged position relative to rapidly advancing technologies, particularly artificial intelligence.

As highlighted in systems thinking, intelligence cannot be reduced to isolated cognitive processing but must be understood as relational and contextual. Donella Meadows emphasises that system behaviour arises from structure and interconnection rather than individual components alone. Similarly, Fritjof

Capra argues that living systems are fundamentally networks of relationships, where intelligence emerges through interaction and coherence rather than linear control.

To meaningfully participate in the future evolution of humanity and the planet Earth, we are invited to systematically develop and maintain balance among multiple forms of intelligence that are already accessible to us, yet remain significantly underdeveloped.

3.2.1 Five Interdependent Intelligences for a Coherent Civilisation

In response to the increasing complexity of contemporary civilisational transformation, driven by ecological disruption, technological acceleration, and systemic fragmentation, five interdependent intelligences that together support coherent leadership and human evolution, are proposed.

These intelligences are not separate capacities but integrated dimensions of perception, meaning-making, and action. Their relevance lies in their collective ability to restore balance between human, technological, and planetary systems:

- Human Intelligence (Self-awareness and Cognition); it refers to cognitive reasoning, reflective thinking, and self-awareness. It enables individuals to observe their own mental processes, make ethical decisions, and act with intentionality. In the context of Ecocivilisation, it forms the foundation of conscious agency. However, when isolated, it becomes insufficient for addressing systemic complexity without integration with broader relational and systemic dimensions.
- Systemic Intelligence (Systems Thinking and Feeling): it is a capacity to perceive patterns, interdependencies, and feedback loops across complex systems. It includes both analytical systems thinking and intuitive systemic sensing, an embodied understanding of how actions propagate through ecological, social, and technological networks. This intelligence is essential in a world where we envision human activity as a force shaping planetary-scale system.
- Relational Intelligence (Social and Emotional); it is an ability to create trust, empathy, cooperation, and emotional coherence within human systems. It underpins collective intelligence and enables coordination in fragmented environments. In increasingly polarised societies, this intelligence is critical for restoring coherence within communities, organisations, and global networks, the one that current systems are desperatelly trying to surpress.
- Cosmic Intelligence (Wisdom and Universal Awareness); it is an expanded awareness that situates human existence within broader temporal, planetary, and potentially universal contexts. It supports long-term thinking, intergenerational responsibility, and ethical orientation beyond immediate self-interest. This intelligence enables a shift from anthropocentric to planet-centric awareness, aligning human action with larger evolutionary and ecological cycles.
- Silicon Intelligence (Artificial Intelligence and High-Tec); it refers to artificial intelligence and digital systems that extend or support human cognitive capacity through computation, pattern recognition, and large-scale data processing. It is of a most relevance, that such systems remain aligned with human values helping humans to »human-well«. Silicon intelligence is therefore not an independent form of wisdom, but an amplification layer that reflects the coherence or fragmentation of the systems that design and deploy it.

3.2.2 Integrative Justification

The relevance of these five intelligences becomes evident in the context of contemporary civilisational challenges. Increasing complexity requires not only enhanced cognitive capacity but also deeper relational, systemic, and ethical awareness. They also broaden a pool within human imagination can flourish and seek solutions.

From a systems perspective, intelligence is not located in isolated individuals or technologies but emerges from the interaction of relationships, structures, and feedback loops (Meadows, 2008; Capra & Luisi, 2014). In this sense, leadership and human development must evolve beyond single-dimensional intelligence toward integrated multi-intelligence coherence.

Without such integration, humanity risks further imbalance between technological acceleration and human developmental capacity. With it, however, a new form of civilisation becomes possible, one in which human, systemic, relational, cosmic, and silicon intelligences co-evolve toward coherence, resilience, and regenerative alignment with planetary systems.

3.3 Leadership as Stewardshiop and Systemic Coherence

In Ecocivilisation, leadership becomes fundamentally a stewardship function. Leaders act as custodians of relational and systemic integrity, maintaining coherence while enabling emergence, building their decissions based on balancing capacity of all five intelligences (Figure 4).

This perspective aligns with systems evolution thinking in the work of Ervin László, where civilisational sustainability depends on alignment with broader evolutionary and systemic coherence.

Leadership therefore becomes an embodied practice of coherence maintenance across nested systems of life. Within this framing, leaders function as coherence-holders, responsible for preserving systemic identity while enabling adaptive evolution. These principles are already emerging within Ecocivilisation-oriented practices, particularly in the relationship between individual responsibility and collective coherence. However, this remains an evolving field that requires further research and experimentation.

A critical inflection point in leadership evolution is represented by artificial intelligence. When aligned with ethical and systemic intelligence, AI enhances collective intelligence and coordination. When misaligned, it amplifies fragmentation, inequality, and systemic distortion.

This dynamic is consistent with the understanding that living systems are fundamentally relational in nature, as emphasised by Fritjof Capra, where coherence emerges from the quality of relationships within the system rather than from isolated components.

Ecocivilisation therefore emphasises governance architectures that ensure transparency, accountability, and life-affirming alignment of AI systems with human and ecological values. In parallel, as highlighted by Shoshana Zuboff, contemporary digital systems increasingly concentrate power through data-driven infrastructures that shape perception, behaviour, and decision-making processes.

One of Ecocivilisation’s underlying principles is the integration of heart, soul, and mind, balancing intuitive ethical orientation with analytical reasoning to support coherent action in complex environments.

Governance in complex adaptive systems thus shifts from hierarchical control to distributed coordination, where multiple intelligences operate in alignment to maintain systemic coherence under constantly changing conditions.

Technologies such as blockchain may support this transition by enabling traceability, transparency, and distributed trust infrastructures. However, their effectiveness ultimately depends on the ethical orientation and systemic coherence embedded in their design and application.

This represents a critically underexplored field for further research and observation, with profound relevance for the future of both humanity and the planet.

4 From Peopleism to Ecocivilisation

To illustrate early indications of the emergence of more coherent systems at the societal and civilisational level, we can consider a proposed transition from capitalism toward Peopleism, as articulated by Ravi Chaudhry (2024), and further toward Ecocivilisation.

Peopleism represents a civilisational shift in value creation, where economic systems become embedded within broader relational systems of trust, well-being, and ecological balance. It is an emerging economic and governance paradigm aimed at moving beyond capital-centric systems toward frameworks that prioritise people and nature. It *advocates for cooperative ownership of resources, technology, and infrastructure, focusing on equity, sustainability, and organised consumer and workforce action to ensure universal basic income, healthcare, and education.*

Peopleism, often referred to as a people-centred economic system, proposes that citizens take greater collective responsibility by organising around residence, consumption patterns, and occupations in order to reduce the cost of living and empower communities. It also suggests the development of predictive frameworks capable of anticipating fluctuations in demand and systemic pressures, rather than relying solely on traditional models based on deregulation, tax incentives, and corporate-driven investment strategies.

Within Peopleism, leadership shifts from knowledge-based authority toward wisdom-oriented stewardship, emphasising ethical, people-centric, and ecologically responsible decision-making. Unlike domination-based capitalism, it advocates for shared ownership of technology and resources, fostering collaborative rather than competitive economic structures.

As such, Peopleism can contribute to a broader global transition toward Ecocivilisation. It aligns with the core Ecocivilisation proposition that the fundamental structure of society should reflect the self-organising principles of living systems.

In this sense, societal organisation evolves around beings, communities, spaces, consciousness, and relationships, directly supporting the networks that sustain life and meaning.

As demonstrated in systems theory by Fritjof Capra, living systems are fundamentally relational in nature, and their viability depends on the quality of interconnectedness rather than isolated optimisation. Concepts emerging within ecological civilisation discourse also signal a broader transformation of worldview.

Ecological civilisation, therefore, emerges as an integrative framework shaped by multiple intellectual and cultural streams. Within this evolving field of coherence, different societal subsystems, including stewardship, a relationship-based leadership, become distributed across networks, focusing not on control of outcomes but on enabling emergence and systemic alignment.

Such characteristics are already observable within the Ecocivilisation Movement, which emphasises the co-evolution of beings, communities, spaces, consciousness, and relationships as foundational civilisational pillars and their relationships as a primary sources of value creation.

5 Conclusion

Across the preceding sections, this work has traced the evolution of contemporary civilisation through the interlinked dynamics of natural systems, industrial development, technological acceleration, and emerging digital infrastructures. Earth's natural systems were described as fundamentally self-regulating and relational, maintaining dynamic coherence through ecological feedback loops, while human-designed systems, villages, cities, institutions, and economic structures, have progressively evolved under industrial and later digital logics that prioritise efficiency, control, and extraction over relational and ecological balance.

This trajectory has led to a fragmented civilisational condition in which natural, urban, and digital systems operate according to distinct and often incompatible logics. Within this multi-layered reality, a central question emerges: *how can coherence be sustained when the very systems that shape perception, knowledge, and decision-making are themselves fragmented*?

Artificial intelligence further intensifies this condition by simultaneously integrating and amplifying fragmentation. This raises a fundamental open question that runs through this work: *does AI extend human agency and imagination, or does it gradually outsource them to computational systems whose logic is grounded in historical data rather than emergent life?*

Within this context, leadership should no longer primarily be a function of control or prediction, but increasingly a practice of coherence-holding within complex adaptive systems. This shift implies a practical reorientation and seeks new understandings and practices reflecting the following question: *how can leadership evolve fast enough to match the accelerating complexity of technological systems without losing ethical and relational grounding?*

To respond to this challenge, the work focused on leadership practice as one of subsystems, could undergo a gradual transition toward:

- cultivating systemic awareness and sensing
- strengthening relational trust and emotional coherence
- developing ethical and reflective human intelligence
- integrating cosmic or long-term planetary awareness
- and learning to collaborate consciously and responsibly with silicon-based intelligence systems

The five intelligences, human, systemic, relational, cosmic, and silicon, form a framework for action as well as interpretation. Their practical implication is not separation, but integration raising an important question: *how can individuals and institutions systematically develop all five intelligences in balance, rather than privileging technological intelligence alone?*

The emerging structures increasingly transcend traditional models of hierarchy and linear governance. Leadership is becoming a relational and emergent practice aiming at sustaining coherence across nested systems of life.

This also leads to another critical question: *what forms of governance are capable of maintaining transparency, accountability, and coherence when decision-making increasingly occurs across distributed human–machine systems?*

In response, the Ecocivilisation perspective suggests a shift in governance practice toward:

- distributed coordination rather than centralised control
- transparency-enabled infrastructures
- alignment of technological systems with ecological and social values
- and the cultivation of coherence as a measurable and lived system property rather than an abstract ideal

Within this framing, Ecocivilisation and related movements such as Living Cities Earth, the F.A.I.R. project, the International Centre of Humanity, Planet A, G100 Movement, and others are not isolated initiatives but part of an emerging distributed field of experimentation. Together, they begin to test the practical question: *what does governance look like when it is designed to support life rather than extract from it? As well as another pressing question: what it means to humen-well?*

The integration of multiple intelligences provides a necessary operational lens for this transformation. However, this integration also raises an unresolved challenge: *how can education systems, leadership development, and institutional design evolve quickly enough to support this shift in collective intelligence?*

This domain remains largely emergent rather than established. It represents a vast and still underexplored field of inquiry in which observation, practice-based experimentation, and interdisciplinary research are urgently required. The dynamics of coherence, fragmentation, intelligence integration, and technological amplification in complex adaptive systems remain only partially understood, particularly in relation to rapidly evolving artificial intelligence.

A particularly important open question arises here: *how can we ensure that AI remains a tool for coherence amplification rather than a driver of systemic simplification, dependency, or power concentration?*

Therefore, this work points not toward closure, but toward opening: toward a future research and communities of practice in which civilisational transformation, systems evolution, intelligence integration, and ecological alignment must be continuously observed, tested, and reinterpreted.

In this sense, the future is not only to be predicted, but actively co-created through imagination, responsibility, and sustained inquiry.

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CHAPTER I:
AI, DIGITAL TRANSFORMATION AND THE FUTURE OF COMPETITIVENESS

POGLAVJE I: UI, DIGITALNA TRANSFORMACIJA IN PRIHODNJI IZZIVI KONKURENČNOSTI

ARTIFICIAL INTELLIGENCE, SUSTAINABILITY AND INTERNATIONAL TRADE – A NEW PARADIGM OF GLOBAL COMPETITIVENESS

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Abstract

The progressive integration of artificial intelligence into economic processes leads to significant changes in the ways enterprises build and maintain competitiveness in international markets. The aim of this article is to identify and analyze new determinants of enterprise competitiveness in the global economy, with particular emphasis on the role of artificial intelligence, activities consistent with the principles of sustainable development, and participation in international trade. The starting point for the analysis is the research problem concerning whether and how the development and application of artificial intelligence, the integration of sustainable development principles, and participation in international trade shape a new paradigm of enterprise competitiveness in the global economy. The article has a review character and employs the method of analysis and synthesis of scientific literature concerning the applications of artificial intelligence in business activities, the concept of sustainable development, and transformations in international trade. The analysis covers scientific publications from the last fifteen years, which makes it possible to identify current research directions and the latest trends in the factors shaping enterprise competitiveness. The article argues that contemporary enterprise competitiveness no longer results solely from cost advantages or economies of scale, but increasingly from the ability to simultaneously leverage advanced digital technologies, pursue environmental and social objectives, and operate effectively within the structures of international trade. In this perspective, artificial intelligence, sustainable development, and international trade constitute interrelated determinants shaping a new paradigm of enterprise competitiveness in the global economy.

Keywords: Artificial Intelligence, sustainable development, international trade, enterprise competitiveness, global value chains

1 Introduction

Contemporary enterprises operate in an environment characterized by increasing technological dynamism, growing market globalization, and intensifying regulatory and social requirements. Traditional approaches to competitiveness, focusing primarily on production costs or economies of scale, are increasingly regarded as insufficient in a global knowledge- and technology-based economy (cf. Porter, 1985, p. 11–41; Barney, 1991, p. 102-112). Consequently, the scope of factors determining competitiveness has expanded to include advanced digital technologies, sustainable development strategies, and active participation in international value chains.

Artificial intelligence (AI) is currently considered one of the most important transformational technologies of the 21st century. It affects not only the operational efficiency of enterprises but also the ways in which value is created and decisions are made (Brynjolfsson & McAfee, 2017, p. 51-75). By employing machine learning algorithms, predictive analytics, and process automation, enterprises can gain a competitive advantage through faster market responses, more accurate demand forecasting, and optimization of production and logistics processes (cf. Agrawal et al., 2018, p. 1–20).

Literature also highlights that AI increasingly supports the achievement of environmental and social objectives, for example through resource management and sustainability auditing (Xu et al., 2018, p. 90-95).

Simultaneously, the literature on sustainable development as an element of corporate strategy has expanded. The Triple Bottom Line concept (Elkington, 1996, p. 57-78) emphasizes the need to simultaneously consider economic, environmental, and social outcomes in organizational activity. From this perspective, competitive advantage should not be assessed solely in terms of economic efficiency but must also account for the impact of business activities on the natural environment and society. Hart (cf. 1995, p. 986-1014) extends this perspective through the Natural Resource-Based View (NRBV), indicating that strategic use of ecological and natural resources can contribute to the creation of lasting competitive advantages.

At the same time, international trade is highlighted in the management and economics literature as a key environment for implementing competitive strategies. Global value chains enable firms to access foreign markets, specialize in specific production stages, and leverage comparative location advantages (Gereffi, 2018, p. 1-26). International trade fosters the transfer of technology and knowledge but also places enterprises in conditions of intense competition, requiring continuous innovation and efficiency improvement (cf. Rodrik, 2018, p. 46-67).

In light of these conditions, contemporary enterprise competitiveness increasingly stems not solely from cost advantages but from the ability to integrate advanced technologies, implement sustainable development strategies, and operate effectively in international markets. This approach suggests the need to develop a new paradigm of enterprise competitiveness that combines these three interrelated determinants.

2 Research Methodology

The main aim of the study is to identify and analyze new determinants of enterprise competitiveness in the global economy, with particular emphasis on the role of artificial intelligence, sustainable development, and participation in international trade. Within this framework, the study addresses the research problem of whether and how the development and application of artificial intelligence, the integration of sustainable development principles, and participation in international trade shape a new paradigm of enterprise competitiveness.

The study has a review character and employs the method of analysis and synthesis of scientific literature. The literature analyzed includes publications from the last fifteen years, focusing on the applications of artificial intelligence in business activities, the concept of sustainable development, and transformations in international trade. This approach enables the identification of current research directions and emerging trends in the factors shaping enterprise competitiveness.

3 Results

3.1 Artificial Intelligence as a new determinant of enterprise competitiveness

The dynamic development of digital technologies, particularly artificial intelligence (AI), constitutes one of the most significant factors transforming the contemporary economy. The literature emphasizes that AI goes beyond its role as a tool supporting the automation of processes and increasingly becomes a strategic resource for enterprises, influencing their ability to build sustainable competitive advantage (Brynjolfsson & McAfee, 2014, p. 45–52; Davenport & Ronanki, 2018, p. 110–113).

Artificial intelligence enables enterprises to analyse large datasets, automate decision-making processes, and identify new market opportunities. According to E. Brynjolfsson and A. McAfee, AI-based technologies represent one of the main drivers of the so-called "second machine age", in which intelligent digital systems increasingly support or replace humans in complex analytical and decision-making tasks (Brynjolfsson, McAfee, 2014, p. 47–50). As a result, enterprises capable of effectively leveraging AI can achieve higher levels of productivity, innovation, and organisational flexibility.

The importance of artificial intelligence for enterprise competitiveness is also highlighted by numerous empirical studies. Research indicates that firms that intensively implement AI technologies achieve higher levels of innovation and operational efficiency compared with organisations that have not adopted such solutions. As noted by Nikzat and Noorymotlagh (2025, p. 8–12), the use of AI can lead to an increase in product and process innovations, a reduction in operational costs, and a growth in firms' market share. Similarly, studies on the digital transformation of enterprises indicate that AI supports strategic decision-making processes by providing advanced analytical tools that enable the prediction of market trends and consumer behaviour (Davenport, Ronanki, 2018, p. 112–114).

The literature also highlights the role of artificial intelligence in the optimisation of enterprise operational processes. AI is applied, among others, in supply chain management, production planning, risk analysis, and digital marketing. Through the use of machine learning algorithms, it becomes possible to improve logistics processes and better align products and services with customer needs (Bughin et al., 2018, p. 3–6). According to the McKinsey Global Institute report, AI technologies may significantly increase enterprise productivity by automating routine processes and supporting managerial decision-making (Bughin et al., 2018, p. 7–10).

Important contributions to the analysis of the role of artificial intelligence in enterprise competitiveness are also provided by Polish scholars. As noted by K. Śledziewska and R. Włoch (2020, p. 247–278), the development of digital technologies, including artificial intelligence, contributes to the emergence of new business models based on data and digital platforms, significantly transforming the conditions of competition in international markets. Studies focusing on the application of AI in small and medium-sized enterprises further indicate that such technologies can support decision-making processes, automate operational activities, and improve resource management efficiency (Doligalski & Kaszyński, 2025, p. 73–90).

It is also important to emphasise that the role of AI in shaping enterprise competitiveness is not limited solely to technological aspects. Increasingly, the literature points to the importance of organisational factors such as innovation culture, employee competencies, and the firm's ability to integrate digital technologies with business processes (Teece, 2018, p. 41–45). The effective use of AI therefore depends not only on access to technology but also on the organisation's capability to manage data and integrate digital systems into strategic and operational decision-making processes.

Another significant aspect concerns the role of artificial intelligence in the transformation of business models. AI enables the development of new products and services based on data analytics, service personalisation, and the automation of customer interactions. Research on digital transformation indicates that organisations implementing AI solutions are more likely to introduce innovative product solutions and develop new business models based on digital platforms (Verhoef et al., 2021, p. 893–896).

In the context of global competition, the significance of artificial intelligence further increases due to its role in enhancing firms' ability to operate in complex and dynamic market environments. AI enables

faster responses to changes in demand, more accurate analysis of market risks, and optimisation of processes within global value chains. Consequently, enterprises adopting advanced digital technologies are better able to adapt to technological and regulatory changes, which constitutes an important factor in building sustainable competitive advantage (Porter &Heppelmann, 2014, p. 23).

3.2 Sustainable development as an element of enterprise competitive strategy

In economic and management literature, sustainable development is increasingly perceived as an important component of enterprise competitive strategy. Contemporary approaches to organisational competitiveness go beyond traditional criteria of economic efficiency and also include environmental and social aspects of business activity. One of the most frequently cited concepts in this area is the *Triple Bottom Line model* proposed by J. Elkington, according to which companies should strive to simultaneously achieve three objectives: economic, environmental and social (Elkington, 1996, p. 70–75). Within this framework, enterprise competitiveness is no longer determined solely by the ability to generate profits but also by the capacity to create value for a wide range of stakeholders, including employees, local communities, and the natural environment. The integration of sustainable development principles into business operations supports the building of long-term economic stability and strengthens organisations' ability to operate in a dynamic market environment.

An important contribution to the development of the relationship between sustainable development and enterprise competitiveness was made by S. L. Hart (1995, p. 989–991). In his concept of the *Natural-Resource-Based View of the Firm*, Hart argued that responsible management of natural resources can become a source of sustainable competitive advantage. According to this approach, companies that effectively implement strategies aimed at reducing emissions, improving energy efficiency, and minimising waste can achieve both economic and reputational benefits. Pro-environmental activities contribute to reducing operational costs, improving resource efficiency, and increasing the level of innovation within enterprises.

The importance of sustainable development for enterprise competitiveness is also highlighted by M. Porter and C. van der Linde (1995, p. 98–100), who argue that properly designed environmental regulations can stimulate technological innovation and lead to improvements in firm efficiency. According to the so-called Porter hypothesis, regulatory pressure may encourage companies to search for new technological and organisational solutions that not only reduce the negative environmental impact of economic activity but also improve productivity and competitiveness.

In recent years, the concept of ESG (Environmental, Social and Governance) has also gained particular importance as an extension of the sustainable development idea in the context of corporate governance and stakeholder relations. ESG strategies include, among others, environmental protection activities, responsible human resource management, transparency in governance processes, and ethical business practices (cf. Eccles et al., 2014, p. 2837–2840). Research indicates that companies implementing ESG strategies achieve better long-term financial performance and demonstrate greater stability and resilience to market shocks.

The integration of sustainable development principles into enterprise strategies also promotes organisational innovation. The literature indicates that pro-environmental activities often lead to the development of new production technologies, more efficient logistics processes, and innovative business models (cf. Schaltegger &Wagner, 2011, p. 222–225). As a result, companies implementing sustainable development strategies may gain competitive advantages through the introduction of more efficient and environmentally friendly technological solutions.

Sustainable development also plays an important role in building corporate reputation and relationships with stakeholders. In the context of growing environmental awareness among consumers and increasing social pressure, companies are increasingly evaluated not only on the basis of their financial performance but also on their impact on the environment and society. Research shows that companies pursuing responsible environmental and social policies can benefit from higher customer trust, easier access to capital, and greater stakeholder loyalty (cf. Eccles et al., 2014, p. 2841–2844).

In the context of the global economy, the importance of sustainable development is further increasing due to the growing number of environmental regulations and non-financial reporting standards. Companies operating in international markets are increasingly required to report ESG-related activities and to comply with specific environmental and social standards. As a result, the ability of enterprises to integrate sustainable development principles into their business strategies is becoming an important determinant of their competitiveness in the global economy.

3.3 International Trade in the Context of Technological and Environmental Transformation

Contemporary international trade is undergoing dynamic changes driven by technological advancements and the growing importance of environmental challenges. The literature emphasizes that the digitalization of the economy and the development of information and communication technologies contribute to the reorganization of global trade flows, leading to the emergence of new models of production and international exchange. This transformation encompasses both structural changes in global value chains and the increasing role of digital trade and data-based services (Baldwin, 2016, p. 7–12).

A central concept in the analysis of modern international trade is that of global value chains (GVCs). According to Gereffi (2018, p. 430–433), global value chains allow firms to specialize in specific stages of the production process, which leads to higher efficiency and improved competitiveness in international markets. At the same time, participation in these structures requires firms to be adaptable to dynamic technological, regulatory, and environmental changes.

Digitalization plays a crucial role in transforming international trade by affecting how firms operate in global markets. Digital technologies help reduce transaction costs, increase market transparency, and facilitate access to foreign markets, particularly for small and medium-sized enterprises (cf. OECD, 2019, p. 24–27). The use of tools such as artificial intelligence, the Internet of Things, blockchain, and big data analysis enables the automation of logistics processes, streamlines supply chain management, and enhances the efficiency of production and distribution processes.

Research conducted by Polish scholars confirms the importance of digitalization for the development of international trade. Analyses on digital transformation in exporting firms indicate that information technologies play a key role in increasing operational efficiency and improving firms' ability to compete in foreign markets. Firms utilizing digital tools in logistics management and strategic planning achieve higher levels of export performance (cf. Trąpczyński & Kawa, 2023, p. 698-701). Similar conclusions are drawn by Szwajca and Rydzewska (2025, p. 1–5), who show that the implementation of digital technologies in Polish exporting firms supports greater supply chain flexibility and cost reduction.

At the same time, environmental factors are gaining increasing importance in international trade. Modern firms operate under growing regulatory pressure concerning environmental protection, greenhouse gas reduction, and the implementation of ESG reporting standards. Consequently, firms engaged in international exchange are required to adapt production and logistics processes to

environmental requirements, which becomes a significant element of building their competitiveness (UNCTAD, 2023, p. 15–18).

Studies conducted in Central and Eastern Europe indicate that integrating sustainable development principles into corporate strategies can be a significant factor enhancing firms' competitiveness in international markets. Analyses by Braja and Gemzik-Salwach (2020, p. 359–365) show that companies meeting higher environmental and social standards are more competitive in internationalization processes, as they can better adapt to regulatory requirements and consumer expectations in foreign markets.

The literature increasingly highlights the development of so-called green trade, which encompasses the exchange of goods and services that support environmental protection and climate change mitigation. International reports indicate a steady increase in the share of environmental technologies, energy-efficient products, and solutions related to renewable energy in global trade flows (WTO, 2022, p. 52–55). In the Polish context, research shows that companies operating in the environmental technology sector gradually increase their share in exports by adapting production processes to rising ecological standards and growing environmental awareness among consumers (Marczewska et al., 2020, p. 13–16).

Technological and environmental transformation also affects production location strategies and the organization of global value chains. In recent years, phenomena such as reshoring and nearshoring, which involve relocating parts of the production process closer to target markets, have become increasingly important. These trends are related both to firms' efforts to increase supply chain resilience and to the growing pressure to reduce the negative environmental impact of international transportation (Baldwin, Freeman, 2022, p. 8–10). Polish research confirms that restructuring global value chains has become an important element of competitive strategies for firms operating in the global economy (cf. Przybyciński, 2024, p. 63–77).

Advanced technologies also play a critical role in supporting the management of logistics and the flow of goods. The use of digital tools allows real-time monitoring of transportation processes, optimization of delivery routes, and increased transparency in supply chains (World Economic Forum, 2020, p. 16–19). Research on Polish exporting firms indicates that the application of ICT tools in logistics management improves operational efficiency and reduces transportation costs, directly influencing firms' competitiveness in international markets (cf. Bełch, 2021, p. 435–443).

3.4 Integration of AI, Sustainable Development, and International Trade in the New Paradigm of Competitiveness

Contemporary conditions of enterprise functioning indicate a growing need to integrate various dimensions of economic development in order to build a sustainable competitive advantage. The ongoing digitalization of the economy, the increasing importance of sustainable development, and the intensification of global trade linkages are leading to the emergence of a new paradigm of enterprise competitiveness. The literature emphasizes that companies capable of simultaneously utilizing digital technologies, implementing sustainable development principles, and actively participating in international trade achieve higher levels of efficiency and greater resilience to changes in the economic environment (cf. Porter & Heppelmann, 2014, p. 68–72; Gereffi, 2018, p. 430–433). The integration of these three areas can be presented in the form of a theoretical model of enterprise competitiveness, in which artificial intelligence, sustainable development, and participation in international trade constitute key determinants of building competitive advantage (Figure 1).

Figure 1

Proposed model of enterprise competitiveness

The first important determinant of contemporary competitiveness is the active participation of enterprises in international trade and global value chains. The internationalization of economic activity enables firms to gain access to new markets, technological resources, and international cooperation networks (Baldwin, 2016, p. 7–12). Participation in global value chains also facilitates knowledge transfer, innovation development, and improvements in production efficiency (Gereffi, 2018, p. 432–434). Studies indicate that companies actively involved in international exchange more frequently implement technological and organizational innovations, which directly affects their ability to compete in global markets (Helpman et al., 2004, p. 303–307).

The second key element of the contemporary competitiveness paradigm is the integration of sustainable development principles into business operations. The Triple Bottom Line concept indicates that the long-term competitiveness of an enterprise results from balancing the economic, environmental, and social effects of its activities (Elkington, 1996, p. 70–72). Research shows that companies implementing ESG strategies can achieve higher operational efficiency, improve relationships with stakeholders, and strengthen their market reputation (Hart, 1995, p. 991–995; Eccles et al., 2014, p. 2837–2841). In the context of global markets, the growing importance of environmental and social standards means that the ability of enterprises to implement sustainable business models is becoming an increasingly important factor of competitiveness.

The development of artificial intelligence technologies represents third of the key drivers of the transformation of contemporary business models. The use of AI enables enterprises to automate decision-making processes, analyze large datasets, and optimize operational processes. As a result, organizations are able to respond more quickly to market changes, improve production efficiency, and enhance their ability to identify new market opportunities (see Brynjolfsson & McAfee, 2014, p. 45–52; Davenport & Ronanki, 2018, p. 110–114). At the same time, AI supports the development of intelligent logistics and production management systems, which play an important role in the context of global value chains.

The integration of these three factors leads to the emergence of a new model of enterprise competitiveness in which artificial intelligence, sustainable development, and participation in international trade mutually reinforce one another. Artificial intelligence enables the optimization of production and logistics processes, which contributes both to increased economic efficiency and to reducing the environmental impact of economic activity. At the same time, the implementation of sustainable development principles may support innovation and increase the attractiveness of firms in international markets, where requirements related to environmental and social responsibility are becoming increasingly important. Participation in international trade, in turn, allows enterprises to access new technologies, knowledge, and strategic partnerships, which further supports innovation development and strengthens the ability to adapt to the dynamic changes of the global economic environment.

4 Conclusions

The analysis presented in this article indicates that contemporary enterprise competitiveness increasingly relies on the integration of three key pillars: artificial intelligence, sustainable development principles, and active participation in international trade. The combination of these areas enables firms to enhance operational efficiency, foster innovation, optimize production and logistics processes, and build a sustainable competitive advantage in the context of the dynamic global economic environment. The synergy between these pillars also allows enterprises to better respond to growing environmental and social expectations while leveraging new opportunities arising from internationalization.

At the same time, future research should go beyond examining solely the positive aspects of integrating these pillars. It is crucial to consider potential risks associated with their development, such as excessive dependence on technology and automation, the risk of superficial or incorrect implementation of sustainability principles, and challenges arising from overly rapid expansion into international markets. If not carefully monitored and managed, rapid development in these areas may lead to operational instability, increased vulnerability to market crises, or loss of control over the social and environmental impact of business activities.

Therefore, future studies should combine the perspective of potential benefits with the analysis of possible negative consequences, including scenarios of “misdirected” development or excessively rapid growth. Such a comprehensive approach will provide a deeper understanding of both the opportunities and limitations arising from the integration of artificial intelligence, sustainable development, and participation in international trade, contributing to the design of more resilient and strategically prepared models of enterprise competitiveness.

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ARTIFICIAL INTELLIGENCE AS A STRATEGIC INTANGIBLE RESOURCE: MANAGERIAL DECISION-MAKING AS A TRANSMISSION MECHANISM OF FIRM-LEVEL ECONOMIC PERFORMANCE

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Abstract

This paper examines the economic effects of artificial intelligence (AI) within the process of digital transformation at the firm level. While prior research often treats AI as a technological input similar to earlier ICT investments, the present study argues that its primary economic value stems from its integration into managerial decision-making processes. The aim of the paper is to develop an integrated theoretical framework that explains how AI influences productivity and long-term competitive advantage through improved information processing and resource allocation. The paper adopts a conceptual approach based on the theoretical integration of the resource-based view, information economics, and the economics of digital technologies. The analysis indicates that AI enhances firm performance primarily when embedded in managerial processes and supported by organizational complementarities. The paper contributes to the literature by explicitly modeling managerial decision-making as the key transmission mechanism between AI adoption and economic outcomes.

Keywords: Artificial intelligence; managerial decision-making; firm performance; resource allocation; organizational complementarities

1 Introduction

The diffusion of digital technologies has reshaped firm behavior and economic performance over the past decades. Early waves of digitalization largely driven by investments in information and communication technologies (ICT) were primarily associated with automation, cost reduction, and incremental efficiency improvements. Yet, a recurring finding in the productivity literature is that technology investments do not translate into sustained performance gains by default; rather, firms typically realize economic value only when digital tools are paired with complementary organizational redesign and managerial practices (Brynjolfsson & Hitt, 2000; Bloom et al., 2012).

AI represents a qualitatively different component of digital transformation. Unlike earlier ICT systems that improved the storage and transmission of information, AI systems expand predictive capacity and can inform choices under uncertainty (Agrawal et al., 2018). By lowering the cost of prediction and enabling the processing of high-volume, high-velocity data, AI has the potential to influence not only operational routines but also the strategic and managerial core of the firm. In other words, AI's economic relevance is not limited to automation; it increasingly concerns how decisions are formed, evaluated, and executed.

Despite rapidly growing scholarly attention, research on the firm-level economic effects of AI remains theoretically fragmented. One stream treats AI as part of broader digital investment and documents positive but heterogeneous productivity effects (Brynjolfsson et al., 2021). A second stream, grounded in the resource-based view (RBV), conceptualizes advanced digital technologies as strategic resources whose value depends on firm-specific complementarities (Barney, 1991). A third stream, drawing on information economics and decision theory, emphasizes how information constraints and bounded rationality shape organizational outcomes (Simon, 1955; Arrow, 1974).

While these perspectives are individually influential, they are rarely integrated in a way that specifies a clear transmission mechanism between AI adoption and firm-level performance.

This paper argues that the central mechanism is managerial decision-making. AI can improve the informational environment in which managers operate affecting the quality, speed, and scope of judgment yet the resulting economic impact is contingent rather than automatic. The same AI technologies can yield markedly different outcomes across firms because their value depends on how they are embedded in decision routines, governance structures, and complementary intangible investments. What is missing from much of the existing literature is an explicit conceptualization of managerial decision-making as the channel through which AI reshapes resource allocation and, ultimately, productivity and competitive advantage.

Accordingly, the aim of this paper is to develop an integrated theoretical framework that explains how artificial intelligence influences firm-level economic performance through its effects on managerial decision-making and resource allocation. The paper adopts a conceptual approach based on the analytical integration of the resource-based view, information economics, and the economics of digital technologies.

The theoretical contribution of this paper is threefold. First, it clarifies why AI should not be treated as a homogeneous continuation of earlier ICT investments, emphasizing its role in prediction and decision support. Second, it extends the resource-based perspective by specifying managerial decision-making as a mediating mechanism in value creation. Third, it links insights from information economics to firm-level productivity outcomes by highlighting how AI can mitigate informational constraints and bounded rationality provided that complementary organizational conditions are in place.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature and identifies the research gap. Section 3 develops the integrated theoretical framework linking AI, managerial decision-making, and firm-level economic performance. Section 4 discusses the theoretical and practical implications of the framework. Section 5 concludes.

2 Literature Review

2.1 Digital transformation and firm performance

The economic analysis of digital transformation originates in the literature on ICT and productivity. Early empirical studies were shaped by the so-called productivity paradox, famously summarized by Solow's observation that computers were visible everywhere except in productivity statistics. Subsequent research gradually demonstrated that the paradox was not a failure of technology per se, but rather a reflection of adjustment costs, measurement limitations, and, crucially, the absence of complementary organizational change.

A central insight emerging from this stream of research is that digital technologies operate as general-purpose technologies whose economic effects materialize only when accompanied by intangible investments organizational capital, human capital, and managerial quality (Brynjolfsson & Hitt, 2000; Bloom et al., 2012; Brynjolfsson et al., 2021). Firms that combined ICT investments with restructuring, improved management practices, and process innovation systematically outperformed those that treated digital tools as isolated technical upgrades.

More recent scholarship conceptualizes digital transformation not as a discrete technological adoption decision, but as a continuous organizational reconfiguration process (Verhoef et al., 2021). This shift in

perspective is important because it frames digital technologies as embedded within broader institutional and managerial systems.

However, much of this literature treats advanced digital tools including artificial intelligence as extensions of earlier ICT waves, without fully differentiating their economic mechanisms.

2.2 Artificial intelligence and firm-level outcomes

AI has attracted attention across macroeconomic, organizational, and innovation research. At the macro level, discussions center on labor displacement, task reallocation, and aggregate productivity growth (Acemoglu & Restrepo, 2020). At the firm level, empirical evidence generally identifies a positive association between AI adoption and performance outcomes such as innovation intensity, profitability, and productivity (Brynjolfsson et al., 2021; Cockburn et al., 2018). Yet these effects are neither uniform nor automatic.

A recurring empirical pattern is heterogeneity. Firms with similar AI technologies often experience markedly different economic outcomes. Explanations typically focus on data availability, workforce skills, and absorptive capacity. While these factors are undoubtedly relevant, they do not fully clarify the internal mechanism through which AI reshapes firm performance.

Moreover, AI is frequently analyzed through the lens of automation and labor substitution. Although automation effects are important, this perspective risks underestimating AI's role in augmenting managerial cognition. By reducing the cost of prediction and expanding the feasible scope of data-driven analysis, AI may alter how strategic alternatives are evaluated, how risks are assessed, and how resources are allocated. This decision-centered dimension remains under-theorized in much of the empirical literature.

2.3 Resource-based view and managerial decision-making

The resource-based view (RBV) posits that sustained competitive advantage arises from valuable, rare, inimitable, and non-substitutable resources (Barney, 1991). In the digital context, advanced technologies are often interpreted as strategic intangible assets whose value depends on firm-specific complementarities. However, RBV alone does not specify the micro-level processes through which such resources generate economic outcomes.

Here, insights from information economics and bounded rationality theory become relevant. Firms operate under conditions of imperfect information and cognitive constraints (Simon, 1955; Arrow, 1974). Decisions are made with limited knowledge, incomplete forecasts, and constrained processing capacity. From this perspective, technologies that improve predictive accuracy and information processing can reduce uncertainty and alter the quality of managerial choices.

Nevertheless, improved information does not automatically translate into improved performance. The transformation of information into economic value requires interpretation, organizational alignment, and the authority to implement decisions. This observation suggests that managerial decision-making may function as the missing link between technological capability and firm-level outcomes. While strands of the literature implicitly recognize this connection, they rarely model it explicitly.

2.4 Research gap

Taken together, the literature on digital transformation, artificial intelligence, and strategic resources highlights the importance of complementarities and intangible capital. Yet it leaves open a central

question: through which internal mechanism does artificial intelligence translate into sustained economic performance?

Existing research often stops at documenting associations between AI adoption and productivity, without specifying how AI reshapes the decision processes that determine resource allocation. The absence of an explicitly theorized transmission channel limits our understanding of why performance effects vary across firms.

This study addresses that gap by conceptualizing artificial intelligence as a strategic intangible resource whose economic impact operates primarily through managerial decision-making and organizational complementarities. By integrating insights from the resource-based view, information economics, and the economics of digital technologies, the paper develops a coherent framework that links AI adoption to firm-level economic outcomes via a clearly specified decision mechanism.

3 Integrated Theoretical Framework

This section develops the integrated theoretical framework of the paper. Building on the literature reviewed in the previous section, the framework explains how artificial intelligence influences firm-level economic performance indirectly, through its effects on managerial decision-making and resource allocation. Rather than treating AI as a direct production input, the analysis emphasizes its role as a strategic intangible resource whose economic value depends on organizational complementarities and its embedding in managerial processes.

3.1 Artificial Intelligence as a Strategic Intangible Resource

Within the proposed framework, artificial intelligence is conceptualized not merely as an operational technology, but as a strategic intangible resource whose economic value depends on organizational embedding (Barney, 1991; Teece, 2007). Unlike earlier waves of digitalization, which were primarily associated with automation and efficiency gains, AI technologies expand predictive capacity and enable probabilistic reasoning under uncertainty. This shift from automation to prediction alters the informational architecture of the firm and provides the basis for a different understanding of how digital technologies affect firm performance.

Reducing the cost of prediction does not automatically generate value. Instead, it changes the relative economics of decision-making. When prediction becomes cheaper and more scalable, new decision problems become tractable, and existing ones can be addressed with greater precision. However, the benefits materialize only if firms possess the complementary assets required to interpret and deploy AI-generated outputs effectively.

In this sense, AI resembles other forms of intangible capital: its productivity impact is indirect and mediated (Haskel & Westlake, 2018; Brynjolfsson et al., 2021). Data quality, managerial capabilities, organizational routines, and governance structures condition its effectiveness. Firms with similar technological infrastructure may therefore experience divergent outcomes depending on how deeply AI is integrated into their strategic and operational processes.

Importantly, treating AI as a strategic resource shifts analytical attention from hardware and software to decision environments. The relevant question is not simply whether a firm adopts AI, but whether AI meaningfully reshapes how key decisions are formulated, evaluated, and implemented.

3.2 Managerial Decision-Making as the Transmission Mechanism

If AI reshapes the informational environment of the firm, its economic consequences must operate through decision processes. Within the proposed framework, managerial decision-making serves as the central transmission mechanism linking AI-enabled information processing to resource allocation outcomes. Without managerial interpretation, judgment, and implementation authority, predictive outputs remain informational artifacts rather than drivers of firm performance.

AI affects decision-making along at least three dimensions: quality, speed, and scope (Kahneman et al., 2011). First, improved predictive accuracy may enhance the evaluation of strategic alternatives, reducing systematic biases and mitigating certain aspects of bounded rationality (Simon, 1955; Arrow, 1974). Second, faster information processing can compress decision cycles, enabling more timely strategic responses. Third, expanded analytical scope allows managers to consider a broader set of variables and contingencies than would be feasible under purely human cognitive constraints.

These improvements, however, are neither uniform nor guaranteed. The interaction between AI systems and managerial cognition may generate complementarities but also tensions. Overreliance on algorithmic outputs, insufficient interpretive capacity, or misaligned incentive structures can limit or even distort potential gains. Thus, the transmission mechanism from AI to performance is contingent upon organizational alignment and managerial competence.

Through its influence on decision quality, AI ultimately shapes resource allocation. Investment choices, pricing strategies, innovation portfolios, and market positioning decisions become more data-informed (Brynjolfsson & Hitt, 2000). The cumulative effect of these adjustments rather than isolated automation gains constitutes the primary channel through which AI affects firm-level economic performance.

3.3 Conceptual Model

The preceding analysis makes it possible to synthesize the core argument of the paper into a conceptual model. The economic relevance of artificial intelligence cannot be adequately captured by viewing it as a direct input into production. Instead, its effects unfold through a structured sequence of organizational processes. The model therefore departs from purely technological interpretations and places managerial decision-making at the center of the analytical framework.

As shown in Figure 1, artificial intelligence functions as a strategic intangible resource that reshapes the informational conditions under which managerial decisions are formed. By reducing prediction costs and expanding analytical capacity, AI modifies the quality and scope of managerial judgment. This modification does not directly increase output; rather, it influences how resources are allocated across competing projects, time horizons, and strategic alternatives.

Managerial decision-making thus operates as the primary transmission channel between AI adoption and firm-level economic performance. Improvements in decision quality are expected to enhance the efficiency of resource allocation, which in turn affects productivity and competitive positioning. Importantly, the model does not assume a mechanical or universally positive relationship. The strength of these linkages depends on complementary organizational conditions.

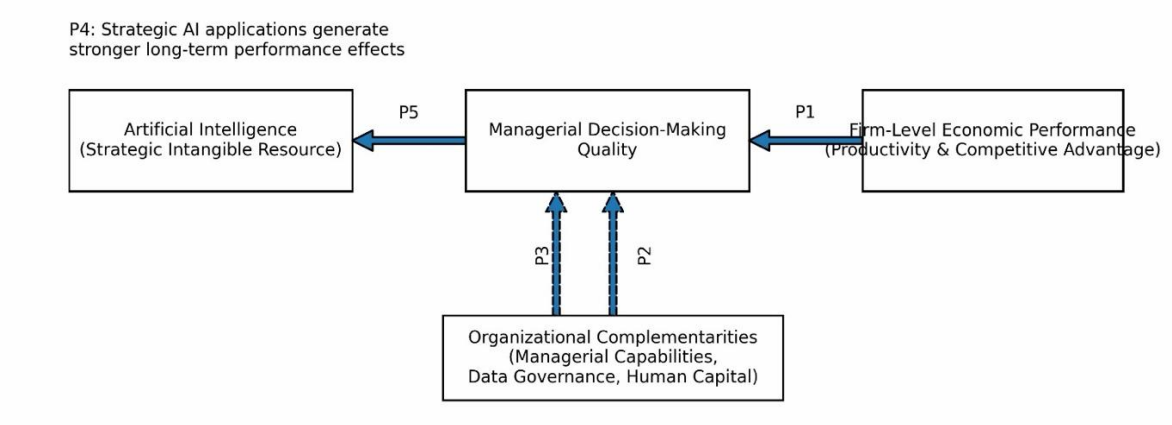
Organizational complementarities including managerial capabilities, human capital, and data governance structures moderate the relationship between AI and decision-making effectiveness. Where such complementarities are strong, AI-generated insights are more likely to be interpreted correctly and embedded into strategic action. Where they are weak, the same technologies may yield limited or inconsistent economic outcomes.

The model also distinguishes between operational and strategic applications of artificial intelligence. While operational uses may generate short-term efficiency improvements, strategic applications embedded in high-level managerial decisions are expected to produce more persistent performance effects. This distinction underscores that the economic impact of AI is gradual and cumulative, emerging through repeated decision cycles rather than through isolated technological adoption events.

Taken together, the conceptual framework specifies a mediated and contingent relationship between artificial intelligence and firm-level economic performance. AI reshapes decision environments; managerial decision-making translates informational improvements into resource allocation choices; and organizational complementarities determine the magnitude of the resulting economic effects. These relationships are visually summarized in Figure 1.

Figure 1

Conceptual model: Artificial intelligence as a strategic intangible resource and managerial decision-making as a transmission mechanism



Source: Author's creation

3.4 Theoretical Propositions

The conceptual model developed above provides the basis for a set of theoretical propositions. These propositions are not presented as empirically verified claims, but as analytically derived implications of the integrated framework. Each proposition captures a distinct element of the mediated and contingent relationship between artificial intelligence and firm-level economic performance.

P1. Firms that embed artificial intelligence within managerial decision-making processes are expected to achieve superior economic performance relative to firms that deploy AI primarily for isolated operational tasks. As indicated in Figure 1, the performance effect arises through enhanced decision quality rather than through automation alone.

P2. The impact of artificial intelligence on managerial decision-making quality is likely to be stronger in organizations characterized by high managerial capability. Where interpretive skills, strategic judgment, and implementation authority are well developed, AI generated insights are more effectively translated into actionable choices.

P3. Organizational complementarities, particularly robust data governance structures, skilled human capital, and supportive organizational routines, positively condition the relationship between artificial intelligence and decision effectiveness. As indicated in Figure 1, these complementarities moderate the strength and reliability of the AI performance linkage.

P4. Strategic applications of artificial intelligence, especially those embedded in high-level investment, pricing, and competitive positioning decisions, are expected to generate more persistent economic effects than purely operational applications. The model in Figure 1 reflects this distinction by emphasizing cumulative performance implications over time rather than immediate output gains.

P5. By reducing informational constraints and mitigating elements of bounded rationality, artificial intelligence enhances the efficiency of resource allocation within the firm. This improvement in allocation efficiency mediated through managerial decision-making constitutes a central pathway through which AI influences productivity and competitive advantage.

4 Theoretical Discussion and Implications

This section discusses the broader implications of the proposed framework for theory, managerial practice, and public policy. Building on the preceding conceptual analysis, the discussion highlights why the economic effects of artificial intelligence are mediated through managerial decision-making and conditioned by organizational complementarities.

4.1 Theoretical Implications

The proposed framework advances the debate on the economic implications of artificial intelligence by shifting analytical attention from technology adoption alone to the organizational architecture of decision-making. Much of the existing literature documents positive associations between AI adoption and productivity (Brynjolfsson et al., 2021; Cockburn et al., 2018), yet such associations do not explain why performance effects vary so substantially across firms. The present analysis suggests that this heterogeneity is not anomalous, but structurally embedded in the way AI interacts with managerial processes, organizational capabilities, and complementary intangible assets.

By positioning managerial decision-making as the central mediating mechanism, the analysis extends the resource-based view beyond a static inventory of strategic assets (Barney, 1991; Teece, 2007). AI may satisfy criteria associated with valuable and difficult-to-imitate resources, yet its contribution to competitive advantage depends on how it reshapes organizational judgment. In this sense, AI is less a standalone capability and more an enhancer or, in some contexts, a distorter of managerial cognition.

Integrating insights from information economics further strengthens this argument. Firms operate under conditions of imperfect information and bounded rationality (Simon, 1955; Arrow, 1974). AI systems reduce certain informational frictions, particularly those related to prediction and pattern recognition. Still, reduced prediction costs do not eliminate uncertainty; they alter its structure. The economic effect of AI therefore depends not only on the quantity of information available but also on how managers interpret probabilistic outputs and incorporate them into strategic reasoning.

The distinction between operational and strategic AI applications also carries theoretical significance. Automation-oriented deployments may improve efficiency in discrete tasks, yet they do not necessarily reconfigure the firm's decision environment. Strategic applications, by contrast, influence resource allocation across investment portfolios, innovation trajectories, and market positioning. Their impact accumulates over time through repeated decision cycles. This cumulative dimension helps explain why AI related productivity gains may follow a delayed or uneven trajectory.

4.2 Managerial Implications

From a managerial perspective, the framework implies that investments in artificial intelligence cannot be evaluated solely in technological or financial terms. Organizational readiness, interpretive capacity, and governance structures are equally critical. Firms that underestimate the importance of these complementarities risk treating AI as an isolated technical solution rather than as an embedded component of strategic decision-making (Bloom et al., 2012; Brynjolfsson et al., 2021).

4.3 Policy Implications

The policy implications of the framework are similarly nuanced. Public initiatives that promote AI diffusion may increase adoption rates, but adoption alone does not guarantee productivity growth. Support for managerial education, data governance standards, and institutional capacity building may prove just as important. Especially for small and medium-sized enterprises, the constraint may lie less in technological access than in organizational capability.

Overall, the analysis underscores a central theoretical insight: artificial intelligence does not automatically generate economic value. Its effects are mediated, contingent, and gradual. AI alters the informational foundations of decision-making, but it is managerial interpretation, implementation capacity, and organizational alignment that ultimately determine whether those altered conditions translate into sustained performance improvements.

5 Conclusion

This paper has argued that the firm-level economic significance of artificial intelligence cannot be understood by focusing on technological adoption alone. Its economic value emerges primarily through the informational conditions under which managerial decisions are formed and implemented. By altering prediction costs and expanding analytical scope, AI reshapes the environment in which resource allocation takes place, but its effects on performance remain indirect, mediated, and contingent.

Conceptualizing managerial decision-making as the central transmission mechanism helps explain why similar AI technologies may generate divergent outcomes across firms. AI does not replace strategic judgment; rather, it interacts with it. Where managerial capability, data governance, human capital, and organizational routines are well developed, AI-generated insights are more likely to be translated into sustained competitive advantage. Where such complementarities are weak, technological adoption may yield only limited or inconsistent gains.

The framework also highlights the distinction between operational and strategic applications of artificial intelligence. While automation-oriented uses may improve efficiency in discrete tasks, more persistent economic effects are expected to arise when AI is embedded in high-level managerial decisions concerning investment, innovation, pricing, and competitive positioning. In this sense, the economic consequences of AI are cumulative and path-dependent rather than immediate or uniform.

The paper is subject to several limitations. As a conceptual study, it does not empirically test the proposed relationships. In addition, the strength of the identified mechanisms may vary across industries, institutional settings, regulatory contexts, and levels of data intensity. The framework also abstracts from broader macroeconomic dynamics, including labor market adjustments and inter-firm competitive responses.

These limitations point to several avenues for future research. Empirical studies may test the moderating role of managerial capability and organizational complementarities using firm-level data. Micro-level

research may further examine how managers interpret and act upon AI-generated insights in practice. Comparative studies across industries and institutional environments may also clarify the boundary conditions under which AI contributes most strongly to firm performance.

Overall, the contribution of the paper lies in reframing the relationship between artificial intelligence and firm performance. Rather than asking only whether AI improves productivity, the more analytically relevant question is how AI reshapes managerial decision environments and, through them, the allocation of organizational resources. From this perspective, the economic consequences of AI do not arise from technology in isolation, but from its interaction with managerial judgment and organizational structure.

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APPLICATION OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN LIGHT INDUSTRY AND INCREASING EFFICIENCY

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Abstract

In the context of rapid digital transformation and the advancement of Industry 4.0, the adoption of artificial intelligence technologies has become increasingly significant in the light industry. This paper aims to examine the key areas of artificial intelligence implementation in sectors such as textiles, apparel, and footwear, and to evaluate its contribution to efficiency improvement. Using a conceptual and analytical approach supported by international industry practices, the study explores the role of artificial intelligence in enhancing product design, automating production processes, improving quality control, optimizing supply chain operations, and strengthening marketing strategies. The findings indicate that the effective integration of artificial intelligence leads to higher productivity, lower operational costs, reduced material waste, and improved product quality, thereby increasing overall competitiveness. In addition, the study identifies major challenges related to the adoption of artificial intelligence, including high upfront investment requirements, a shortage of skilled professionals, and concerns about data security. The results suggest that the strategic application of artificial intelligence is a crucial factor in achieving sustainable development and long-term efficiency growth in the light industry.

Keywords: Artificial intelligence, light industry, production efficiency, digital transformation, smart manufacturing, Industry 4.0

1 Introduction

In recent decades, the acceleration of globalization and the rapid advancement of digital technologies have fundamentally transformed traditional industrial structures. In this context, industries are increasingly required to adopt innovative technological solutions to remain competitive, flexible, and sustainable. The light industry, which plays a vital role in national economies by meeting consumer demand, generating employment, and supporting industrial diversification, is undergoing a similar transformation. Despite its economic significance, the light industry has historically faced challenges such as relatively low productivity, inefficient resource utilization, limited value addition, and slow responsiveness to dynamic market changes.

The growing pressure of global competition and rising consumer expectations has intensified the need for technological modernization within the light industry. Traditional production and management models are no longer sufficient to ensure efficiency, cost-effectiveness, and high-quality output in a rapidly changing market environment. Therefore, the strategic integration of advanced digital technologies has become essential for enterprises aiming to enhance operational performance and long-term competitiveness.

Among these technologies, artificial intelligence (AI) has emerged as a key driver of industrial innovation and transformation. AI technologies—including machine learning, computer vision, and big data analytics—enable enterprises to process large volumes of information, automate complex tasks, and support data-driven decision-making. In manufacturing sectors, AI facilitates the transition from labor-intensive and experience-based operations to intelligent, automated, and adaptive production systems (Cavadov et al., 2024).

The light industry presents unique characteristics compared to heavy industry, such as high product diversity, short product life cycles, frequent changes in consumer preferences, and complex production processes. These factors highlight the relevance and potential impact of AI applications in product design, production planning, quality control, supply chain coordination, and marketing activities. By adopting AI technologies, light industry enterprises can improve production efficiency, reduce operational costs, minimize material waste, and enhance product quality, while simultaneously responding more effectively to evolving market demands (Hajiyeva et al., 2024).

This study aims to systematically examine the main applications of AI technologies in the light industry and assess their contribution to operational efficiency and sustainable development. By integrating theoretical frameworks with international practical experiences, the research provides a comprehensive understanding of how AI can support the digital transformation of the light industry. The findings are intended to offer valuable insights for policymakers, industry practitioners, and researchers seeking to promote innovation-driven growth and long-term competitiveness in the sector.

2 Literature Review

The application of artificial intelligence (AI) in industrial sectors has received increasing attention in both academic and practical contexts over the past decade. Prior studies emphasize that AI technologies—including machine learning, computer vision, deep learning, and big data analytics—play a pivotal role in optimizing production processes, improving resource utilization, and supporting data-driven decision-making in manufacturing environments (Cavadov et al., 2024; Hajiyeva et al., 2020). In particular, research highlights the transformative potential of AI for enhancing operational efficiency, quality control, and supply chain management, especially within industries characterized by high variability and complex production processes.

Despite these advancements, existing studies on AI adoption in the light industry remain limited. Most literature focuses on heavy or high-tech industries, while the unique characteristics of light industry—such as high product diversity, rapid turnover, short product life cycles, and frequent changes in consumer preferences—have received comparatively little attention (Hajiyeva et al., 2023; Hajiyeva et al., 2024). Furthermore, while AI's role in industrial automation, predictive maintenance, and intelligent production is well-documented, research on its application in areas like marketing, product design optimization, and consumer behavior analysis in light industry is still sparse (Kerimova et al., 2024; Mammadova & Mammadov, 2025).

Several studies have also highlighted challenges that constrain AI adoption, including high initial investment requirements, shortage of skilled professionals, and concerns regarding data security and system integration (Nushaba et al., 2024). These gaps indicate the need for a comprehensive examination of AI technologies tailored to the specific demands and operational realities of the light industry.

This study addresses these gaps by systematically reviewing theoretical approaches and practical applications of AI in the light industry context. By synthesizing insights from international research and Azerbaijani industry practices, the study highlights both the opportunities and limitations of AI implementation. The originality of this research lies in its holistic focus on efficiency enhancement across production, management, and market-related functions in the light industry, an area that has been underexplored in existing literature. In doing so, the study contributes to advancing knowledge on how AI can support sustainable development and competitiveness in the sector, offering a practical

framework for policymakers, industry practitioners, and researchers alike (Hajiyeva et al., 2025; Mammadova & Mammadov, 2025).

3 Methodology

This study employs a conceptual, analytical, and comparative research design to examine the application of artificial intelligence (AI) technologies in the light industry and their contribution to operational efficiency. The research integrates theoretical frameworks, international best practices, and Azerbaijani industry examples to provide a comprehensive understanding of AI implementation and its practical impact. Secondary data sources, including academic publications, conference proceedings, industry reports, and case studies from Azerbaijani light industry enterprises, were analyzed to illustrate local practices, challenges, and outcomes.

A systematic literature review was conducted to identify trends, opportunities, and gaps in AI applications within the light industry. International experiences were compared with Azerbaijani practices to assess adaptability, efficiency gains, and challenges. Analytical evaluation focused on measurable indicators such as production efficiency, operational cost reduction, resource optimization, product quality improvement, and supply chain performance. Where available, secondary quantitative data were employed to support findings, enabling a more evidence-based understanding of AI's impact.

The scope of the research encompasses key light industry sectors, including textiles, apparel, and footwear, with emphasis on enterprises operating in Azerbaijan. While the study is primarily qualitative, the integration of secondary quantitative data allows for a comparative assessment of AI effectiveness across different contexts. Ethical standards were strictly maintained, with all data sources being publicly accessible and properly cited, following academic integrity guidelines and respecting intellectual property rights.

By employing this methodology, the study not only synthesizes theoretical insights but also provides practical, evidence-based analysis of AI applications in the light industry. This approach highlights opportunities for efficiency improvement, identifies key implementation challenges, and informs strategies for technological adoption and sustainable development in Azerbaijani enterprises.

4 Results

The analysis indicates that the integration of artificial intelligence (AI) technologies substantially enhances operational efficiency in the light industry. Enterprises adopting AI across production, quality control, supply chain management, and marketing demonstrate improved productivity, reduced operational costs, and higher product quality. Predictive maintenance and intelligent scheduling enabled by AI minimize downtime and optimize workforce allocation, while computer vision and deep learning technologies ensure accurate defect detection and precise process control.

Resource optimization emerges as a key benefit of AI adoption. Data-driven approaches facilitate efficient allocation of raw materials, streamlined inventory management, and effective energy consumption monitoring. As a result, material waste is minimized, costs are lowered, and sustainability objectives are more effectively achieved. AI-powered supply chain systems also enhance responsiveness to market demand, enabling enterprises to adapt quickly to changing consumer preferences and improving overall logistics efficiency.

Strategic decision-making is further strengthened through AI-supported analyses of market trends, consumer behavior, and production performance. Enterprises can identify new product opportunities,

refine design and marketing strategies, and better manage risks. Comparative evaluation of international practices and Azerbaijani case studies shows that while AI adoption in local enterprises remains in its early stages, organizations implementing advanced AI solutions report measurable efficiency gains and competitive advantages.

The study identifies challenges that may impede AI implementation, including high initial investment requirements, a shortage of skilled personnel, data security concerns, and organizational adaptation needs. Addressing these challenges is critical to sustaining the benefits of AI integration. Overall, the findings confirm that AI technologies act as a major driver of digital transformation, efficiency improvement, and sustainable development in the light industry, offering a strong foundation for long-term competitiveness and innovation.

5 Theoretical Foundations of Artificial Intelligence in the Industrial Context

Artificial intelligence represents one of the most significant achievements of contemporary information technologies and serves as a key driver of industrial transformation and modernization. From a theoretical perspective, artificial intelligence refers to a set of technologies designed to simulate human cognitive functions, enabling computer systems to perform tasks such as learning, reasoning, perception, and decision-making. With continuous improvements in computational capacity and the rapid expansion of available data, artificial intelligence has evolved from a predominantly theoretical concept into a practical tool with wide-ranging industrial applications. (Kerimova et al., 2024)

Within industrial production systems, artificial intelligence relies primarily on core technologies including machine learning, deep learning, computer vision, and big data analytics. Machine learning techniques analyze historical data to identify patterns and generate predictions related to production processes and market demand. Deep learning methods are particularly effective in processing complex and unstructured data, while computer vision technologies play a critical role in automated inspection and quality assurance. Big data analytics supports data-driven decision-making by integrating information from multiple sources across the production chain. The combined use of these technologies establishes a robust theoretical and technological foundation for intelligent and optimized industrial operations. (Hajiyeva et al., 2020)

In the framework of Industry 4.0, artificial intelligence is widely recognized as a fundamental enabler of smart manufacturing. By integrating artificial intelligence with the Internet of Things, automated machinery, and advanced information systems, enterprises can develop highly interconnected, responsive, and adaptive production environments. Such systems enhance operational efficiency, improve resource utilization, and strengthen the ability of firms to respond to rapidly changing market conditions.

Overall, the theoretical foundations of artificial intelligence in the industrial domain provide essential support for its application in the light industry. A systematic understanding of these concepts and technologies contributes to a clearer interpretation of how artificial intelligence facilitates efficiency improvement, process optimization, and high-quality industrial development.

6 Characteristics and Development Trends of the Light Industry

The light industry, as a vital component of national economies, encompasses a wide range of sectors, including textiles, apparel, footwear, household textiles, and handicrafts. It not only directly satisfies everyday consumer needs but also plays a crucial role in job creation, economic diversification, and regional development. In recent years, the acceleration of globalization and shifts in consumer behavior

have imposed both structural and technological pressures on the light industry, necessitating adaptation and modernization.

The light industry exhibits several distinctive characteristics. First, it features a high diversity of products with rapid turnover, and market demand is highly dynamic. Second, production processes are complex, involving multiple stages such as raw material procurement, processing, assembly, and quality inspection. Third, products often have relatively low added value, making cost control and efficiency improvement critical for enterprise survival and competitiveness. Finally, the industry includes enterprises of varying scales, ranging from small-scale artisanal workshops to large industrial corporations, which increases the complexity of management and technology adoption.

Regarding development trends, digitalization, intelligent manufacturing, and sustainability are emerging as the primary directions for the light industry. Digital technologies improve the accuracy of production planning and supply chain transparency, while intelligent production systems enhance efficiency and reduce waste through automation and data-driven decision-making. Sustainability initiatives emphasize resource conservation, environmental protection, and the adoption of eco-friendly production practices. Moreover, the integration of advanced technologies such as artificial intelligence, the Internet of Things, and big data analytics is driving the industry toward higher value-added production and smart manufacturing.

Overall, the structural features of the light industry underscore its strong reliance on technological innovation and digital transformation. A systematic analysis of these characteristics and development trends provides a clear understanding of the necessity and potential benefits of applying artificial intelligence in the sector, supporting enterprises in improving efficiency, optimizing production processes, and strengthening market competitiveness.

7 Application of Artificial Intelligence Technologies in the Light Industry

With the rapid advancement of AI technologies, their application in the light industry has become increasingly widespread, covering areas from product design to production management, quality control, supply chain optimization, and marketing. The integration of AI not only enhances production efficiency and resource utilization but also improves the flexibility and competitiveness of enterprises in responding to dynamic market demands.

7.1 AI in Product Design and Development

The light industry is characterized by a high diversity of products and fast design turnover. By applying AI, companies can use machine learning to analyze consumer preferences and market trends, enabling precise product forecasting and design optimization. Tools such as computer vision and generative design assist designers in quickly producing innovative solutions, thereby shortening development cycles and increasing market responsiveness.

7.2 Intelligent Production and Process Automation

AI applications in production primarily include intelligent equipment control, automated production lines, and predictive maintenance. By collecting and analyzing real-time data, firms can optimize production schedules, reduce downtime, and lower labor costs. Additionally, deep learning algorithms can monitor production environments and equipment status, allowing predictive fault detection and autonomous adjustments, which significantly improve overall production efficiency.

7.3 Quality Control and Defect Detection

Computer vision and image recognition technologies play a crucial role in product quality inspection within the light industry. High-precision automated inspection systems can detect defects and anomalies in real time, reducing human error and enhancing product consistency and conformity rates. This not only saves labor but also strengthens brand reputation and customer satisfaction.

7.4 Supply Chain and Inventory Management

AI facilitates intelligent supply chain management, including demand forecasting, inventory optimization, and logistics scheduling. By analyzing historical sales data and market trends, enterprises can plan inventory more accurately, reduce stockpiling and shortages, enhance operational efficiency, and further reduce costs.

7.5 Marketing and Customer Relationship Management

In marketing and customer management, AI enables personalized recommendations, dynamic pricing, and customer relationship optimization through data analysis and behavior modeling. Companies can tailor strategies to consumer preferences, increase sales conversion, and improve customer loyalty and satisfaction.

In summary, the application of AI in the light industry spans production, management, product development, and market expansion. By systematically integrating these technologies, light industry enterprises can achieve digital and intelligent transformation, enhance overall operational efficiency, and strengthen market competitiveness, thereby providing robust technological support for sustainable industry development. (Hajiyeva et al., 2023)

8 Impact of Artificial Intelligence on Efficiency Enhancement in the Light Industry

The introduction of AI technologies is profoundly transforming the operational models and competitive landscape of light industry enterprises. The effects of AI extend beyond individual production processes, influencing resource management, supply chain optimization, product quality control, market responsiveness, and strategic decision-making. By systematically integrating intelligent technologies, enterprises can achieve comprehensive efficiency improvements, reduce operational costs, and enhance market competitiveness and sustainability. (Hajiyeva et al., 2023)

8.1 Enhancing Productivity and Reducing Costs

AI technologies significantly increase productivity by optimizing production processes at multiple levels. For instance:

- Intelligent production scheduling: Machine learning algorithms analyze historical production data and equipment usage patterns to dynamically schedule tasks and balance line workloads.
- Predictive maintenance: Deep learning models can anticipate potential equipment failures, minimizing unplanned downtime, reducing emergency repair costs, and extending machinery lifespan.
- Automated operations: Robotics and intelligent control systems replace human labor in repetitive tasks, such as automated sewing, cutting, and assembly, thereby reducing labor costs and minimizing human error.

- Real-time performance monitoring: AI systems continuously track production metrics, identify bottlenecks, and provide optimization recommendations, ensuring continuous and high-efficiency output.

The combined application of these measures enables light industry enterprises to enhance capacity, lower operating expenses, and optimize workforce allocation. (Hajiyeva et al., 2025)

8.2 Resource Optimization and Waste Reduction

Efficient resource management is critical for cost control and sustainable development in the light industry. AI facilitates:

- Optimized material utilization: Data-driven algorithms can allocate raw materials efficiently, reducing waste in cutting, processing, and production stages.
- Intelligent inventory management: By combining sales forecasts, market trends, and production plans, AI systems calculate precise inventory levels, minimizing overstocking and shortages.
- Energy and resource monitoring: AI continuously analyzes energy consumption and waste generation, providing actionable insights for resource conservation and eco-friendly production.

Systematic resource optimization not only lowers costs but also aligns with sustainability goals, supporting environmentally responsible practices.

8.3 Improving Product Quality and Market Competitiveness

Product quality is central to maintaining competitiveness in the light industry. AI applications in quality management include:

- Automated defect detection: Computer vision and deep learning identify defects in real-time during production, such as fabric flaws or stitching errors.
- Process parameter adjustment: AI systems adjust production parameters based on inspection data and historical trends, ensuring product consistency and compliance.
- Consumer feedback analysis: By analyzing market feedback and sales trends, enterprises can refine product design and functionality to better meet customer needs.

High-quality products enhance customer satisfaction, strengthen brand reputation, and increase market share, thereby boosting overall competitiveness. (Mammadova & Mammadov, 2025)

8.4 Supply Chain Optimization and Responsiveness

AI also plays a critical role in supply chain management:

- Demand forecasting and production planning: AI analyzes historical sales and market data to predict product demand accurately.
- Logistics and distribution optimization: Intelligent routing and inventory allocation reduce delivery costs and minimize delays.
- Supply chain resilience: AI identifies potential bottlenecks and risks in real-time, enabling enterprises to respond effectively to market fluctuations.

Intelligent supply chain management not only reduces costs but also accelerates product responsiveness, enhancing customer satisfaction and market adaptability (Hajiyeva et al., 2023).

8.5 Strategic Decision-Making and Long-Term Development

Beyond operational efficiency, AI supports strategic-level decision-making:

- Market trend analysis: AI evaluates consumer behavior and competitor strategies, informing product portfolio, pricing, and marketing plans.
- Innovation and R&D support: AI assists in identifying potential innovation areas and assessing feasibility of new products, accelerating R&D cycles and time-to-market.
- Risk management and sustainable growth: AI helps detect market, financial, and supply chain risks, supporting enterprises in making informed long-term strategic decisions.

Strategic AI applications enhance short-term operational efficiency while providing technological support for long-term growth, innovation, and sustainable development.

9 Challenges and Barriers to the Implementation of Artificial Intelligence

Although AI demonstrates significant potential and value in the light industry, its practical implementation faces numerous challenges and obstacles. These issues encompass financial and technical limitations, human capital and skill gaps, data security, and ethical considerations. Understanding and addressing these challenges is critical for the successful deployment of AI technologies in industrial settings (Nushaba et al., 2024).

The introduction of AI often involves substantial initial investment costs, including hardware acquisition, software development, and system integration. Many small and medium-sized enterprises lack sufficient financial resources, which restricts technological upgrades. Furthermore, the complexity and rapid evolution of AI technologies require enterprises to maintain continuous technological updates; otherwise, systems may become outdated or face compatibility issues. The absence of standardized solutions and mature implementation frameworks further increases the difficulty of adoption.

Effective operation of AI systems depends heavily on highly skilled professionals, such as data scientists, algorithm engineers, and AI system operators. Light industry enterprises often struggle to attract, train, and retain such talent. Skill shortages not only limit the deployment and optimization of AI systems but also reduce the potential return on investment, as systems may fail to operate at their full capacity.

AI relies on large volumes of data, including production information, supply chain details, and consumer insights. Ensuring data security and privacy during collection, storage, and analysis is essential. Data breaches or misuse can harm an enterprise's reputation and create legal liabilities. Additionally, the lack of transparency and explainability in AI decision-making can raise ethical concerns, potentially undermining trust between enterprises, customers, and society.

The implementation of AI is not merely a technological issue but also requires organizational and managerial adaptation. Traditional management structures may be inadequate for intelligent production and data-driven decision-making, leading to internal resistance and execution challenges. Employee acceptance, training, and workflow redesign are critical factors for successful AI adoption.

In conclusion, light industry enterprises must address financial, technical, human, and ethical challenges when applying AI technologies. Through careful investment planning, technological capacity building,

talent development, robust data security measures, and organizational adjustments, enterprises can maximize the benefits of AI, achieve intelligent transformation, and support sustainable industrial development.

10 Conclusion

This study demonstrates that the adoption of AI technologies significantly enhances operational efficiency, resource optimization, product quality, and strategic decision-making in the light industry. By integrating AI into production, quality control, supply chain management, and marketing, enterprises achieve measurable improvements in productivity, cost reduction, and market responsiveness. The analysis of Azerbaijani case studies, alongside international practices, highlights the potential for AI to drive competitive advantage and support sustainable industry development.

The practical relevance of this research lies in providing actionable insights for light industry enterprises, policymakers, and stakeholders seeking to implement AI solutions. AI applications can shorten production cycles, minimize waste, improve product consistency, and enable data-driven strategic planning, ultimately contributing to long-term competitiveness and innovation.

Despite these benefits, the study also identifies key challenges, including high initial investment costs, a shortage of skilled personnel, data security concerns, and the need for organizational adaptation. Addressing these challenges is essential to maximizing the benefits of AI and ensuring successful digital transformation in the sector.

Future research should focus on empirical and quantitative analyses, including case studies, surveys, and performance metrics, to provide a more detailed evaluation of AI adoption impacts. Additionally, exploring the integration of emerging technologies, such as the Internet of Things (IoT) and advanced analytics, with AI could further enhance efficiency and sustainability in the light industry.

In conclusion, the strategic application of AI technologies represents a critical driver for modernization, efficiency improvement, and sustainable development in the light industry, offering a foundation for continuous innovation and long-term growth.

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RESPONSIBLE AI IN DIGITAL MARKETING: IMPLICATIONS FOR COMPETITIVE ADVANTAGE IN RURAL TOURISM

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Abstract

Artificial Intelligence has become an important tool in digital marketing and managerial decision-making in today's digital environment. In contemporary digital environments, AI technologies enable businesses to reach wider audiences, analyze consumer behavior more effectively, and optimize marketing strategies through digital platforms. This form of digital marketing enables tourism businesses to improve online visibility, engage more effectively with customers, and receive immediate feedback on products and services. However, responsible AI use remains a challenge in rural tourism, where digital resources and skills may be limited and concerns related to transparency and ethical decision-making persist. Based on this context, the aim of this paper is to analyze both the positive and negative aspects of adopting Artificial Intelligence in digital marketing and to demonstrate how responsible AI use can contribute to competitive advantage in rural tourism.

Keywords: Artificial Intelligence, Digital Marketing, Rural Tourism, Competitive Advantage, Responsible AI.

1 Introduction

Artificial Intelligence (AI) is increasingly embedded in digital marketing through applications such as audience segmentation, personalization systems, automated content, interaction tools, and campaign optimization analytics (Davenport et al., 2020; De Bruyn et al., 2020). In marketing terms, AI transforms how organizations create and transfer market knowledge, enabling faster interaction and scaling of customer touchpoints, while simultaneously introducing risks related to opacity, bias, and misaligned objectives (De Bruyn et al., 2020). From a consumer standpoint, AI can deliver convenience and relevance but can also generate costs related to data capture, classification, delegation, and social experience when consumers perceive loss of control, unfairness, or reduced human connection (Puntoni et al., 2021). AI tools are nowadays routinely discussed as mechanisms for improving customer interaction, personalization, and strategic decision-making in tourism businesses. A recent review highlights that AI tourism research frequently focuses on applications such as chatbots, natural language processing systems, and deep learning methods supporting personalization and analytics, while also emphasizing ethical and privacy concerns as persistent challenges (López-Naranjo et al., 2025). Alongside these developments, marketing literature stresses that customer experience spans multiple touchpoints across the customer journey, requiring coordinated management across channels and stakeholders (Lemon & Verhoef, 2016). This creates an inherent tension: while AI enhances marketing effectiveness, the legitimacy and sustainability of these gains depend on the responsible governance of data and algorithmic decision-making.

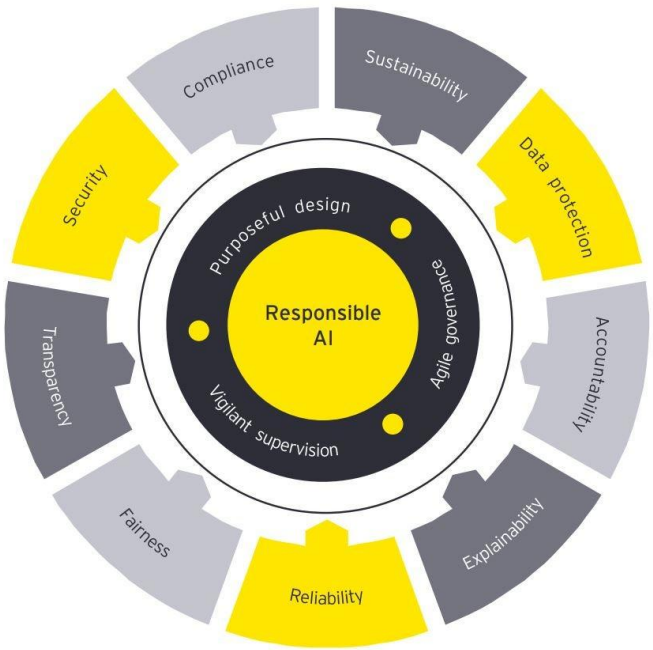
Tourism is one area where these dynamics are particularly pronounced, as digital marketing directly influences destination visibility, customer decisions, and overall experience. At the same time, rural tourism presents additional challenges. Rural destinations and enterprises often operate under structural

constraints, including limited digital infrastructure, lower levels of digital literacy, and restricted access to technological resources.

Evidence from rural small and medium-sized enterprises (SMEs) indicates that unreliable connectivity limits diversification opportunities and reduces resilience, shaping the feasibility of digital marketing and AI adoption (Morris et al., 2022). As tourism becomes increasingly embedded in "smart tourism ecosystems," where value is created through interactions among technologies, data, and multiple actors (Gretzel et al., 2015), uneven digital capacity may become a structural barrier to competitive participation for rural destinations. Simultaneously, "responsible AI" has emerged as a central governance priority across sectors (Figure 1). International frameworks emphasize principles such as transparency, accountability, fairness, and respect for human rights, including the OECD AI Principles (OECD, 2019), the UNESCO Recommendation on the Ethics of AI (UNESCO, 2021), and risk-based governance approaches such as the AI Risk Management Framework developed by the National Institute of Standards and Technology (NIST, 2023). In Europe, the AI Act entered into force in August 2024, establishing obligations for AI systems based on their risk levels and implications for fundamental rights (European Commission, 2024).

Figure 1

Responsible AI Principles



Against this background, a critical question emerges: how can rural tourism businesses leverage AI in digital marketing in ways that are not only effective but also responsibly governed, and can such governance become a source of competitive advantage rather than merely a compliance requirement? In response, this paper examines how AI integration in digital marketing affects rural tourism businesses, focusing on both its opportunities and risks. It also discusses how responsible AI use may support competitive advantage in rural tourism, especially in context where digital resources and skills are limited. While existing studies have explored AI applications in marketing and tourism, and others have addressed ethical AI frameworks, there remains a gap in understanding how these dimensions interact in resource-constrained rural areas.

This paper contributes to the literature in several important ways:

- First, it integrates research on artificial intelligence in digital marketing, rural tourism, and AI governance into a unified analytical framework, addressing a gap where these domains are often examined separately. By bringing together technological, strategic, and ethical perspectives, the study provides a more holistic understanding of AI adoption in rural tourism.
- Second, this paper contributes by introducing the concept of *responsible AI capability* as a driver of trust-based competitive advantage in rural tourism. Building on the resource-based view and dynamic capabilities theory, responsible AI is conceptualized not merely as a compliance requirement, but as a strategic organizational capability that combines technological adoption with ethical governance and customer-oriented practices.
- Third, the study advances the notion of trust-based competitive advantage, arguing that in rural tourism where authenticity, credibility, and human interaction are central, competitive positioning increasingly depends on how responsibly businesses use AI in their digital marketing strategies. In this sense, responsible AI capability enables firms to differentiate not only through efficiency and innovation, but also through transparency, reliability, and customer trust.
- Finally, by incorporating a contextual illustration from rural guesthouses in Albania, the paper adds practical relevance to the theoretical discussion, highlighting both the opportunities and risks associated with AI adoption in resource-constrained environments.

Building on this context, the following research questions guide the analysis:

- *RQ1*: What AI-enabled digital marketing applications are most emphasized in tourism research, and what benefits are reported?
- *RQ2*: What risks and negative externalities are most salient for AI-enabled digital marketing in tourism, especially in rural contexts?
- *RQ3*: How do responsible AI frameworks operationalize "trustworthy" AI in ways relevant to digital marketing decisions and customer-facing automation?
- *RQ4*: Through what mechanisms can responsible AI become a source of competitive advantage for rural tourism enterprises?

2 Methods

This study employed a rapid scoping review design to map and synthesize evidence at the intersection of responsible AI, digital marketing, competitive advantage, and rural tourism. A scoping approach is appropriate for clarifying concepts, identifying knowledge gaps, and mapping existing literature (Munn et al., 2018). The review process was informed by established scoping methodologies (Arksey & O'Malley, 2005; Levac et al., 2010) and aligned with PRISMA-ScR reporting guidance (Tricco et al., 2018).

Searches were conducted in March 2026 using scholarly databases and publisher platforms, alongside institutional sources such as NIST, OECD, UNESCO, and EU repositories. Search strings combined keywords related to artificial intelligence, digital marketing, rural tourism, and responsible AI. Inclusion criteria focused on peer-reviewed studies and authoritative policy documents relevant to AI in marketing and tourism, responsible AI governance, and rural tourism digitalization. Both empirical and conceptual studies were included, while purely technical AI papers without marketing or tourism relevance were excluded.

Selected studies were screened and analyzed based on key dimensions, including AI applications, marketing outcomes, governance concerns and implications for customer experience and competitiveness. Data were synthesized using thematic analysis, identifying patterns related to AI-enabled marketing capabilities, associated risks, rural constraints, and responsible AI practices.

3 Results

The final evidence set comprised a selection of sources grouped into key thematic clusters, including tourism AI applications, customer experience and chatbot studies, AI in marketing, rural tourism digital adoption, and responsible AI governance frameworks. Overall, the literature highlights both the growing importance of AI-enabled digital marketing in tourism and the increasing relevance of governance considerations related to trust, transparency, and ethical use.

Figure 2

Risks of Artificial Intelligence

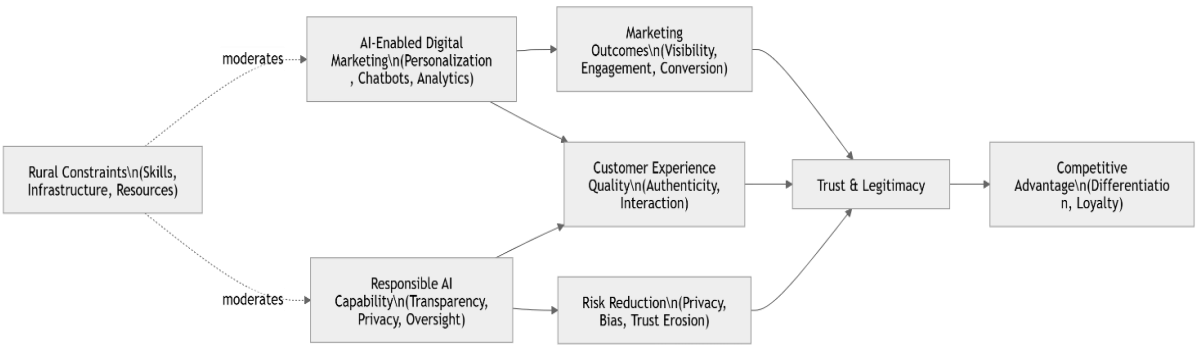


Figure 2 summarizes the main risk areas associated with AI-enabled digital marketing, which arise in parallel with the increasing use of technologies such as natural language processing, deep learning, chatbots, automated customer service, and personalized recommendation systems.

Existing studies indicate widespread use of natural language processing and deep learning, particularly in applications such as chatbots, automated customer service, and personalized recommendations (López-Naranjo et al., 2025). These technologies are shown to reshape the customer journey by enabling more interactive, responsive, and data-driven experiences (Ghesh et al., 2024). However, evidence also suggests variability in user acceptance, with some studies indicating differences in trust and booking intention between AI-driven and human interactions depending on context (Wüst & Bremser, 2025). At the same time, emerging technologies such as large language models offer new opportunities for content generation and decision support, while raising concerns related to misinformation, bias, and overreliance (Carvalho & Ivanov, 2024).

3.1 Negative Externalities and Risk Hotspots

Across studies, a consistent pattern emerges in which AI-driven marketing generates both benefits and risks for consumers. While AI enhances personalization and convenience, it can also lead to tensions related to data capture, perceived loss of control, and reduced human interaction (Puntoni et al., 2021). In digital marketing, privacy concerns and ethical data use are identified as key challenges, requiring balanced approaches that protect user trust (Saura et al., 2024).

Moreover, poorly governed AI systems may introduce bias, reduce transparency, and ultimately undermine marketing effectiveness despite strong technical performance (De Bruyn et al., 2020).

3.2 Rural Constraints and Adoption Challenges

Rural contexts are consistently associated with structural constraints that affect both AI implementation and governance capacity. Evidence from rural SMEs shows that unreliable connectivity and limited digital infrastructure can restrict business operations and reduce opportunities for diversification and resilience (Morris et al., 2022). In tourism, digital marketing capabilities are shown to influence destination image and visitor intention, indicating that limited digital capacity may directly affect competitiveness (Rodrigues et al., 2023). Furthermore, rural tourism businesses often rely on traditional communication methods, with limited adoption of digital marketing tools due to resource and capability constraints (Cheuk et al., 2018).

3.3 Responsible AI Governance in Digital Marketing

Governance frameworks consistently emphasize principles such as transparency, fairness, privacy, accountability, and human oversight (Jobin et al., 2019). The European "trustworthy AI" framework outlines key requirements including data governance, transparency, and system robustness (European Commission, 2019), while the NIST AI Risk Management Framework highlights the importance of managing AI risks to ensure trustworthiness (NIST, 2023). International frameworks such as those developed by OECD and UNESCO further reinforce the importance of ethical AI. In the European context, the AI Act introduces a risk-based regulatory approach, increasing the relevance of governance readiness for organizations using AI in marketing and customer-facing activities (European Commission, 2024).

4 Discussion

The findings indicate that AI-enabled digital marketing in tourism is increasingly centered on customer-facing automation, personalization, and analytics-driven optimization. While these capabilities improve efficiency and customer experience, they simultaneously introduce risks related to privacy, transparency, and perceived fairness, which can directly undermine trust and long-term performance (Puntoni et al., 2021; De Bruyn et al., 2020). In rural tourism, these dynamics are further intensified by structural constraints, including limited digital infrastructure, lower levels of digital literacy, and restricted access to technological resources (Morris et al., 2022). As a result, the strategic challenge is not limited to adopting AI technologies, but rather to ensuring that these technologies are implemented in a responsible and sensitive manner.

To address this gap, this paper advances the argument that responsible AI capability can function as a strategic resource and a dynamic capability that supports competitive advantage in rural tourism. Building on the resource-based view (Barney, 1991) and dynamic capabilities theory (Teece et al., 1997), responsible AI is conceptualized not merely as a compliance requirement, but as an organizational capability that integrates ethical governance, technological competence, and strategic alignment. This capability can be operationalized through key dimensions derived from AI governance frameworks, including:

- Privacy and data governance
- Transparency and explainability
- Human oversight in automated decisions
- Technical robustness and reliability

- Accountability mechanisms

When effectively implemented, these dimensions enable rural tourism enterprises to move beyond short-term efficiency gains toward trust-based differentiation, where competitive advantage is built on credibility, authenticity, and responsible use of customer data.

4.1 Responsible AI as a Driver of Competitive Advantage in Rural Tourism

Competitive advantage in rural tourism is traditionally based on authenticity, natural resources, and cultural heritage. However, in an increasingly digitalized environment, these factors alone are no longer sufficient to ensure long-term competitiveness. The integration of Artificial Intelligence (AI) in digital marketing introduces new dimensions of competitive advantage, particularly when applied responsibly. From a resource-based view (RBV), competitive advantage arises when firms utilize unique, valuable, and difficult-to-imitate resources (Barney, 1991). In this context, responsible AI can be considered a strategic capability that enhances the value of existing rural tourism assets by improving how they are presented, communicated, and delivered to the market.

Firstly, AI can enable hyper-personalization of customer experiences, allowing rural tourism businesses to tailor offerings based on individual preferences, travel behavior, and real-time interactions. This leads to higher customer satisfaction and loyalty, which are critical for small-scale rural enterprises that rely heavily on repeat visitors and word-of-mouth promotion.

Secondly, responsible AI enhances trust and transparency, which are essential elements of competitive differentiation. Rural tourism is often associated with authenticity and ethical consumption. Therefore, businesses that ensure transparent data usage, avoid manipulative marketing practices, and communicate clearly how AI-driven recommendations are generated can strengthen their credibility and brand positioning.

Thirdly, AI supports market access and visibility, reducing the structural disadvantages that rural areas face compared to urban destinations. Through AI-driven search engine optimization (SEO), automated content generation, and targeted advertising, rural tourism businesses can reach international markets more effectively. When combined with responsible practices, this visibility does not compromise authenticity but instead reinforces it through accurate and meaningful storytelling. Moreover, responsible AI contributes to operational efficiency and cost optimization, which is particularly important for resource-constrained rural enterprises. Automation of customer communication (e.g., chatbots), demand forecasting, and pricing strategies allows businesses to allocate resources more efficiently while maintaining service quality.

However, the sustainability of this competitive advantage depends on how AI is implemented. Unethical use of AI, such as biased algorithms, misuse of customer data, or over-automation that reduces human interaction can undermine the core values of rural tourism. Therefore, competitive advantage is not derived from AI adoption alone, but from the responsible integration of AI aligned with local values, community engagement, and ethical standards. In this regard, rural tourism businesses that successfully combine technological innovation with responsibility can create a hybrid competitive model, where digital efficiency enhances rather than replaces authenticity.

This model is difficult to replicate, as it requires not only technological adoption but also organizational learning, ethical awareness, and strategic vision.

4.2 Mini Case: Rural Guesthouses in Albania

The relevance of this framework can be illustrated through the case of rural guesthouses in Albania, a sector that has experienced increasing digital exposure in recent years, particularly through social media platforms such as Instagram, Facebook, and similar platforms. On one hand, a growing number of rural guesthouses have started to use AI-supported digital marketing tools, including:

- AI-assisted content creation (e.g., captions, storytelling, visual enhancement)
- Basic analytics tools to understand audience engagement
- Automated messaging systems for customer inquiries

These tools allow small rural businesses to significantly enhance their online visibility, reach international audiences, and present their offerings in a more professional and appealing way. In several cases, guesthouses that previously relied on word-of-mouth have successfully expanded their customer base through visually curated Instagram profiles and consistent digital storytelling. However, limited digital skills and insufficient understanding of AI tools create a set of critical risks.

- Firstly, limited knowledge about how AI systems process and use data can lead to unintentional misuse of customer information, raising concerns about privacy and compliance.
- Secondly, the use of generic or AI-generated content without strategic direction can result in loss of authenticity, which is a core value in rural tourism.
- Thirdly, the absence of transparency in communication, such as automated responses that are not clearly identified as such, can create a trust gap between businesses and customers. This trust gap is particularly significant in rural tourism, where customer expectations are strongly linked to authenticity, human interaction, and personalized experiences. When digital interactions appear artificial, inconsistent, or misleading, they can negatively affect perceived credibility and reduce customer loyalty.

Therefore, the Albanian case highlights a dual dynamic: through AI integration, rural businesses can increase visibility and growth potential, but without responsible use and adequate knowledge, they may face risks of trust erosion and reputational damage, which can lead to more serious consequences.

5 Limitations

This paper used a rapid scoping review approach rather than a fully exhaustive systematic review. Scoping methods are appropriate for mapping evidence and clarifying concepts, but they can be limited by selection coverage and typically do not require formal study quality appraisal (Munn et al., 2018). Although reporting was guided by PRISMA-ScR and scoping methodology standards, the evidence base spans heterogeneous research types (policy frameworks, empirical studies, and conceptual papers), and the synthesis is therefore more suitable for identifying themes and mechanisms than for estimating causal effect sizes (Arksey & O'Malley, 2005; Tricco et al., 2018). Finally, the rural context is diverse across countries and regions; digital divide findings and governance readiness can vary significantly by local infrastructure, institutional support, and market structure, which constrains generalizability of specific implementation recommendations (Morris et al., 2022; Lane & Kastenholz, 2015).

6 Conclusion

AI-enabled digital marketing offers rural tourism enterprises meaningful opportunities to expand reach, automate customer interaction, and optimize marketing decisions; however, it also introduces material risks centred on privacy, transparency, and customer trust. Evidence indicates that rural constraints, particularly connectivity and capability gaps, can limit both adoption and governance capacity, making responsible AI operationalization essential rather than optional. The synthesis suggests that responsible AI capability, grounded in widely recognized governance criteria (privacy/data governance, transparency, human oversight, robustness, accountability), can function as a strategic resource that supports trust-based differentiation and resilience-oriented competitive advantage in rural tourism. Future research should develop measurable constructs for "responsible AI capability" in tourism SMEs, test links to marketing performance and customer trust, and evaluate how evolving regulatory regimes affect adoption pathways.

Ultimately, in rural tourism, competitive advantage will not depend solely on the adoption of AI technologies, but on how responsibly these technologies are implemented and aligned with the values of trust, transparency, and authenticity.

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OVERCOMING THE VALLEY OF DEATH: STUDENT-LED INNOVATION AND AI VALIDATION

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Abstract

This study examines why student-developed prototypes at a Polish technical university struggle to move from working demonstrators toward practical adoption, the transition commonly described as the Valley of Death, and what role digital tools play in that process. Data were gathered through unstructured qualitative conversations with approximately 10 engineering students engaged in extracurricular hardware prototyping during the autumn semester of the 2025/2026 academic year. Three patterns recurred: participants had minimal awareness of formal technology transfer procedures; engineering teams prioritised technical specifications over end-user accessibility, producing devices that the intended population could not operate; and generative artificial intelligence served as a low-cost validation instrument, with participants aware of its epistemic limits. The findings contribute to research on student entrepreneurship and university innovation management and point to directions for future work.

Keywords: Valley of Death, technology transfer, student innovation, generative AI, innovation management

1 Introduction

Higher education institutions have traditionally served as primary generators of scientific knowledge and intellectual property. Translating that knowledge base into commercially viable products and services remains a persistent challenge across academic ecosystems worldwide. A substantial share of technically promising prototypes developed in university settings never reaches intended users, stalling in the transitional phase that innovation researchers identify as the Valley of Death. Auerswald and Branscomb (2003) locate this zone between the early-stage technology development that follows reduction to practice and the subsequent stages of product development and market entry, characterising it as a structural disjuncture in the innovation sequence rather than a simple capital shortfall. In that phase, teams frequently lack clarity about who the end-user is, what specific problem the product addresses, and whether the proposed offer is strong enough to justify the costs of implementation.

The majority of commercialisation policy and institutional support in higher education is directed at faculty-led research, particularly projects tied to national or European competitive grants. Student innovators are consistently overlooked, despite evidence that recent science and engineering graduates establish substantially more new firms than faculty members at the same institutions (Åstebro et al., 2012). Bergmann et al. (2016) further show that organisational university context has limited predictive power for student firm formation; regional and peer-network factors carry considerably greater weight. A substantial grassroots layer of activity therefore operates through science clubs, hackathons, and hardware laboratories that rarely appears in official technology transfer records or institutional reporting.

1.1 The Customer Detachment Problem

Engineering disciplines attract students with strong motivation to solve technically complex problems. That disposition is an asset in prototype development but creates a predictable failure pattern in

commercialisation. Teams invest heavily in the technical quality of a prototype while losing contact with the question of whether the intended user can actually operate it. Blank and Dorf (2012) argue that this failure mode is best addressed through a Customer Development framework running in parallel with product development, in which founders test hypotheses about users, problems, and solutions against external evidence before committing to design or manufacturing decisions. The risk of missing this step is sharpest when the intended user population differs from the developer population in physical capability or clinical context. Medical technology and assistive device development is particularly exposed: an able-bodied engineering student designing for a patient with motor impairment is working across an experiential gap that will not close without deliberate user-centred methods.

The commercial consequence of this pattern is prototypes that function in laboratory conditions but fail in actual use. Engineering design research documents that the cost of modifying a product rises steeply across the development cycle, with usability and accessibility deficiencies identified after manufacturing commitments carrying disproportionate financial and schedule consequences (Ulrich et al., 2020). For student teams working under fixed academic schedules and constrained budgets, late-stage discoveries of this kind are frequently project-terminating.

1.2 Artificial Intelligence as a Validation Instrument

Entrepreneurship pedagogy has long advocated iterative validation methods: customer discovery cycles, lean experimentation, minimum viable products (Blank, 2013; Ries, 2011). Student engineering teams face real structural barriers to applying these methods. Customer discovery requires access to relevant industry contacts, communication competencies that technical programmes do not necessarily develop, and time that competes with academic obligations.

The emergence of generative artificial intelligence has introduced a category of low-cost validation instrument that partially offsets these constraints. Chalmers et al. (2021) argue that AI can augment entrepreneurial cognition across tasks associated with idea production, opportunity exploitation, and venture scaling, while simultaneously introducing new categories of risk that need systematic attention. Townsend and Hunt (2019) theorise AI as enabling new forms of entrepreneurial action, creativity, and judgement under conditions of Knightian uncertainty. Nambisan (2017) characterises digital tools more broadly as rendering entrepreneurial processes less bounded in time, space, and agency, reducing the practical cost of early experimentation. More recent work has examined specific augmentation patterns in entrepreneurial settings (Shepherd & Majchrzak, 2022) and in management practice following the rapid diffusion of large language models (Korzynski et al., 2023). Within the conference's regional research community, Mikava and Mamulaidze (2023) document related implications of AI adoption in healthcare contexts in developing countries, where verification infrastructure shapes the magnitude of accuracy risks.

These capabilities carry real limits. Language models can produce confident outputs that are factually incorrect, particularly in specialist domains such as medical device regulation or patent law, and teams that accept such outputs without verification may incorporate erroneous assumptions into their development planning.

1.3 Technology Transfer Offices and the Student Gap

Universities have established Technology Transfer Offices to manage the commercialisation of research outputs, primarily intellectual property generated through faculty-led and institutionally funded research. Siegel et al. (2007) describe TTO structures, staffing, and incentive systems as configured around the licensing of faculty-disclosed inventions and negotiation of agreements with industrial

partners. Lockett and Wright (2005) document that formal university spin-out activity depends on TTO resources and capabilities, including business-development expertise and expenditure on intellectual property protection. This institutional design fits faculty-driven research but creates a structural mismatch with early-stage student projects, which are typically exploratory, informally organised, and not yet at a stage where formal IP management is the appropriate next step.

Student entrepreneurial activity consistently appears outside formal TTO channels. Boh et al. (2016) find that successful student venture programmes commonly operate independently of TTO infrastructure. Hayter et al. (2017) document that graduate students play roles in spin-off formation comparable to those of faculty but receive markedly less institutional support. Bergmann et al. (2016) reinforce this picture by showing that organisational university features carry limited explanatory weight for student firm establishment. The Polish technology transfer system, organised through the PACTT network of academic technology transfer centres, exhibits a similar orientation toward faculty research compliance and grant valorisation. Lodz University of Technology operates dedicated technology transfer units within this national framework.

These dynamics sit within a broader literature on university innovation systems. The triple helix model frames innovation as emerging from overlapping university, industry, and government spheres (Etzkowitz & Leydesdorff, 2000), while more recent work characterises enterprise ecosystems as integrated adaptive systems in which cross-sector partnership and knowledge exchange outperform hierarchical coordination (Nahara, 2024). Innovation has a documented role in regional economic growth (Hysai & Sulçaj, 2024), yet realising that potential through student activity depends on deliberately building entrepreneurial competency rather than expecting it to emerge on its own (Rasmussen & Wright, 2015).

This study examines student-led initiatives at one Polish technical university and addresses three research questions: (RQ1) how students describe their awareness of formal technology transfer pathways and procedures; (RQ2) what barriers they report when moving from prototype development toward practical deployment; and (RQ3) how student teams characterise the role, benefits, and limitations of generative AI tools during early validation.

2 Method

2.1 Research Design

The study employed a qualitative single-case study design (Yin, 2018), with one technical university as the unit of analysis and in-situ conversational inquiry as the primary data-generation mode. The aim was not to test a predefined hypothesis or to produce findings generalisable through statistical inference. It was to document the conditions of early-stage student innovation as they actually operate: the assumptions guiding project decisions, the institutional knowledge gaps present in practice, and the points at which commercialisation processes break down. This required sustained, contextually embedded engagement with participants in their working environments rather than interaction through formal interview instruments.

Unstructured conversations were selected over structured protocols for reasons specific to the research context. Extracurricular science clubs are informal environments sensitive to perceived evaluation. A formal interview protocol would have altered participant behaviour in ways likely to suppress candid disclosure, particularly about knowledge deficits in areas such as intellectual property procedures that students might regard as things they should know. The unstructured, conversational approach preserved

the ecological validity needed to capture authentic accounts, at the acknowledged cost of the cross-participant comparability that structured instruments provide.

2.2 Research Context

Data collection took place at the Lodz University of Technology during the autumn semester of the 2025/2026 academic year, between October and December 2025. Research sites included shared student workspaces, hardware laboratories, and prototyping facilities used by extracurricular science clubs.

The participant cohort comprised 10 students, including both undergraduate and master's level students drawn from a range of engineering programmes. Specific programme affiliations were not systematically recorded: any indication that data were being formally collected risked shifting interaction dynamics toward guarded, socially desirable responses. This is a recognised trade-off in qualitative case study work with informal communities (Yin, 2018). The single selection criterion was active, hands-on involvement in science clubs engaged in physical hardware prototyping, specifically projects in medical technologies, assistive devices, or robotic rehabilitation.

2.3 Data Collection

Data collection occurred through opportunistic conversations at workbenches and during active prototyping sessions. The researcher engaged with teams in their working environment rather than in isolated settings. Three thematic areas structured the inquiry without prescribing specific questions: awareness of technology transfer infrastructure and intellectual property rights; the criteria governing design decisions, with particular attention to the weight given to end-user accessibility; and the integration of generative AI tools into project validation and market exploration.

2.4 Data Analysis

Audio recording was not used, judged likely to affect the conversational quality essential to the approach. Detailed field notes were produced immediately after each campus visit. These notes were analysed using inductive thematic synthesis, examining the observational data for patterns that recurred consistently across participants rather than appearing as isolated observations. Three such patterns were identified and constitute the findings in Section 3. Their generalisability beyond this institutional context cannot be established from the data collected here.

3 Results

The campus conversations yielded observations across three areas: student awareness of institutional support structures, the relationship between design decisions and end-user needs, and the use of generative AI tools for early validation. The patterns below were observed consistently across multiple participants and sessions, rather than emerging from isolated exchanges. Table 1 provides an overview before the subsections address each in detail.

Table 1

Overview of observed patterns by thematic area

Theme	Core pattern	Consistency across cohort
TTO awareness	Students unaware of the TTO's existence and mandate	Consistent across all participants
TTO awareness	No participant had contacted the TTO or any institutional IP service	Universal

Usability gap	Design choices driven by internal technical metrics; user testing absent before prototype completion	Majority of projects
Usability gap	Usability deficiencies found late produced sharp cost increases; at least one project abandoned	Documented in medical technology projects
AI integration	AI used for market exploration, pitch drafting, and technical translation; not used for final decisions	All participants
AI integration	Participants aware of hallucination risk; applied verification at consequential steps	Consistent

3.1 Technology Transfer Awareness

The most consistent finding was the degree to which students were disconnected from the formal infrastructure designed to support commercialisation. Lodz University of Technology operates a technology transfer function within the national PACTT network, covering intellectual property protection, licensing, and spin-off support. None of the participants were aware of its existence. Several indicated a general understanding that the university had some administrative function related to patents, but described it as belonging to faculty and grant-funded research, with no relevance to extracurricular student projects.

The pattern is consistent with how TTO operations are structured. Faculty researchers interact with technology transfer functions because competitive funding agencies require documented valorisation pathways as a condition of grant compliance. Student-led extracurricular work carries no equivalent obligation and therefore receives no equivalent information. Science clubs serve as the primary practical support structure, providing access to equipment, peer expertise, and informal guidance. Students reach advanced stages of prototype development without understanding whether their work is legally protectable, who holds intellectual property rights over it, or what institutional resources might assist. Table 2 presents this distribution.

Table 2

Reported awareness and use of institutional versus informal support channels

Channel	**Student awareness**	**Actual use reported**
Technology Transfer Office	Very low; most students unaware of its existence	None
IP protection procedures	Very low; no knowledge of available mechanisms	None
University spin-off support	Very low; not associated with student extracurricular work	None
Student science clubs	High; primary reference point for practical support	Universal
Generative AI tools	High; actively integrated into project workflows	All participants
Informal peer networks	High; relied upon for advice and problem-solving	Common

3.2 Losing Sight of the End User

Engineering students in hardware projects tend to measure success against technical performance criteria: whether the device functions as specified and whether it meets the engineering targets. These are necessary questions but insufficient when the intended user differs from the developer team in relevant physical or cognitive characteristics. The pattern appeared in multiple conversations about medical technology and rehabilitation projects.

One case was described in enough detail to be illustrative. A student team had developed a robotic device to support hand movement recovery after stroke, with affordability as the primary design constraint, since the intended route to users was through the public healthcare system. The engineering work under those constraints was considerable. The team selected a compact, non-standard electrical connector for the charging interface, a component requiring precise fine motor control to operate. Upper-limb motor impairment affects the substantial majority of acute stroke survivors (Stinear et al., 2020), so for much of the intended group the device could not be charged independently. Feedback from intended users did eventually reach the team, but only after the design had been finalised, by which point the issue surfaced too late to be addressed within the project. The prototype did not find users, and the project went no further. The team's strength lay in building hardware rather than in testing it with the people who would use it; once the device failed to gain traction, they moved on rather than iterate on it. Table 3 presents the usability failure patterns observed across the projects discussed during fieldwork.

Table 3

Usability failure patterns observed in student hardware projects

Failure pattern	Description	Consequence observed
Absence of user testing	Prototypes completed without participation of intended end-users at any design stage	Fundamental usability deficiencies identified late or not at all
Specification-driven design	Technical performance metrics used as primary success criteria; accessibility not in scope	Products impractical for intended target demographic
Demographic mismatch	Able-bodied developers designing interaction interfaces for users with motor or cognitive impairments	Physical interaction elements inaccessible to intended users
Late-stage redesign costs	Usability deficiencies identified after prototype completion or manufacturing commitment	Remediation costs exceed budget; project abandoned

3.3 Use of Generative AI for Early Validation

All participants reported integrating generative AI tools into their project workflows. The usage was pragmatic: participants did not treat AI outputs as authoritative but used the tools as a first-stage instrument for tasks that would otherwise require specialist access or extensive stakeholder networks. Primary applications included generating candidate market segments, drafting initial value propositions, translating technical documentation into accessible language, and reviewing project materials for clarity. These capabilities allowed faster and more affordable progression through early validation than would otherwise have been possible.

A consistent feature of the observed usage was awareness of the tools' limits. Several participants described specific cases where AI-generated outputs had contained factually incorrect information delivered with apparent confidence. One team had queried regulatory requirements for their device and received a response that, when checked against official documentation, contained material errors that would have affected subsequent development decisions. The discrepancy was caught through independent verification, not through any trust in the output. Participants generally characterised AI as useful for accelerating initial exploration, not as a substitute for primary sources, particularly in regulated or clinical domains. Table 4 presents the use cases and limitations identified.

Table 4

Observed generative AI use cases among student participants

Use case	Description	Limitations acknowledged by participants
Market segment exploration	Generating candidate target audiences and alternative application contexts	Outputs require independent verification; contextual accuracy cannot be assumed
Value proposition drafting	Articulating initial pitch framing and business model concepts	Outputs tend toward generic formulations; grounding in specific evidence required
Technical translation	Reformulating engineering documentation into accessible language for non-technical audiences	Technical nuance may be lost; specialist review advisable
Regulatory and IP scoping	Exploring medical device regulations and patent landscape as initial orientation	High risk of factually incorrect outputs; human expert verification essential
Documentation review	Improving clarity and coherence of project reports and proposal materials	Stylistic improvements do not address factual or methodological gaps

4 Discussion

The three patterns identified here are broadly consistent with existing literature on student entrepreneurship and academic technology transfer, while offering institution-specific observations that extend the evidence base. The near-total absence of TTO awareness aligns with what Siegel et al. (2007) describe: TTO operations configured around the licensing of faculty-disclosed inventions and incentive systems oriented to academic researchers rather than to extracurricular student activity. Boh et al. (2016) and Hayter et al. (2017) provide empirical support from other national contexts, showing that student venture activity regularly occurs outside formal TTO channels and that graduate students contribute to spin-off formation while receiving comparatively little institutional backing. Bergmann et al. (2016) add that organisational university features are weak predictors of student firm formation relative to regional and peer-network influences. At this institution, the gap appears more complete than prior studies in other national systems have typically characterised: no participant had had any prior contact with the TTO or its associated services. Supplementary data gathered at the same institution during the 2025/2026 academic year through a student startup survey coordinated by the Centre for Innovation and Entrepreneurship (N = 21) points in the same direction; the majority of respondents with active startup concepts reported being unaware that institutional support was available to them.

The usability findings have direct practical relevance. Blank and Dorf (2012) identify the tendency to advance product development without parallel customer hypothesis testing as a central commercialisation failure mode, and the cases here are a direct instance of it in physical hardware aimed at users whose physical condition differs sharply from the developers' own. The stroke rehabilitation case in Section 3.2 shows how a single unexamined assumption about the user can leave an otherwise competent piece of engineering with no viable route to adoption. What stands out is not only that the assumption was wrong, but that the team did not treat the failure as something to investigate and correct: building was within their competence, customer discovery was not, and the project was abandoned rather than revised.

On artificial intelligence, the findings suggest a more measured picture than either enthusiast or sceptic accounts would predict. Chalmers et al. (2021) argue that AI can augment entrepreneurial cognition while introducing new categories of risk. Townsend and Hunt (2019) and Shepherd and Majchrzak

(2022) extend this augmentation framing under conditions of uncertainty. Nambisan (2017) emphasises that digital tools lower the barriers to entrepreneurial experimentation. Korzynski et al. (2023) document how large language models have been integrated into routine management practice at considerable pace. The usage patterns here are broadly consistent with these accounts: participants reduced the practical cost of early exploration in ways that appeared to confer real advantages. The regulatory scoping case, in which a team received materially incorrect guidance on medical device requirements, shows that the risk of consequential error in high-stakes domains is concrete rather than theoretical. That participants caught the error through independent verification reflects a degree of epistemic caution that should not be assumed across all student teams. Mikava and Mamulaidze (2023) draw a parallel about AI limits in healthcare contexts in developing countries.

Read against the innovation-systems literature outlined earlier, the informal student layer documented here behaves like an enterprise ecosystem in miniature: self-organising, reliant on peer networks, and quick to iterate. What it lacks is the institutional anchoring that makes such ecosystems productive at scale, and the connection to industry and government partners stays largely absent for these teams. This is consistent with the argument that entrepreneurial competency in universities has to be built deliberately rather than assumed (Rasmussen & Wright, 2015), and it locates student activity as an underused channel within the wider university innovation system.

Several limitations require acknowledgement. The sample comprised approximately 10 students from a single institution, all engaged in hardware prototyping within science clubs. The findings cannot be generalised to broader student populations, different institutional environments, or other project types without further empirical support. The unstructured qualitative methodology precludes systematic cross-participant comparison, and analytical conclusions rest substantially on the researcher's interpretive judgement applied to retrospective field notes. The absence of recorded data and the deliberate non-recording of demographic information both limit verifiability and depth. Future work should use larger and more diverse samples across multiple institutions, and consider combining observational methods with structured instruments to allow more rigorous cross-case comparison. Cross-national comparison at technical universities across different European higher education systems would be particularly useful, given the variation in how university-industry knowledge transfer is organised.

Three institutional responses emerge from the findings as practical and low-cost. Technology Transfer Offices could run brief awareness sessions in science clubs at key points in the academic year, not to impose procedural requirements on projects not yet ready for formal management but to make students aware that IP protection options exist and at what stage they become relevant.

Engineering curricula could require a user-testing checkpoint before prototype finalisation, creating a structural incentive to engage with intended users while design modifications are still feasible. And institutions could provide targeted guidance identifying AI use cases that carry elevated risk of incorrect outputs in regulated domains, alongside pointers to authoritative verification sources.

Declaration of Generative AI Use

In accordance with the EECME conference policy on generative AI in academic work, the author declares that generative AI tools were used in preparing this manuscript only for initial structural drafting assistance and linguistic proofreading. AI was not used to produce empirical findings, to interpret data, or to substitute for the author's analytical judgement at any stage of the research. The rehabilitation device example in Section 3.2 is a contextual illustration drawn from fieldwork conversations and does not identify specific individuals, projects, or institutional units.

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CHAPTER II:
AI, DIGITAL RISK AND REGULATED SYSTEMS

POGLAVJE II: UI, DIGITALNA TVEGANJA IN REGULATIVNI SISTEMI

BARRIERS TO DIGITAL BANKING SERVICES IN STRENGTHENING FINANCIAL INCLUSION

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Abstract

Digital banking services are widely considered as a key driver of financial inclusion, as they expand access to formal banking and financial systems. However, significant barriers continue to limit their effectiveness, particularly for underserved populations. This article examines the main obstacles to the adoption of digital banking services and their implications for strengthening financial inclusion. The aim of this study is to identify the technological, socio-economic and behavioral barriers that hinder the use of these services. A qualitative literature review methodology is used, drawing on recent academic research, reports, and data from developing countries. The findings reveal that low levels of digital literacy, inadequate infrastructure, accessibility issues, security concerns and a lack of trust in digital platforms remain major challenges. These barriers especially affect low-income individuals and rural communities. The article concludes that addressing these barriers through inclusive policies, improved digital infrastructure, better consumer education and robust regulatory frameworks is essential to maximizing the role of digital banking services in achieving sustainable financial inclusion.

Keywords: privacy concerns, digital exclusion, digital illiteracy, behavioral barriers, underserved populations

1 Introduction

Financial inclusion has become a cornerstone of sustainable economic development, ensuring access to affordable and tailored banking and financial services for individuals and businesses, regardless of their income level or geographic location. In recent years, digital banking services has emerged as a major transformative tool in addressing this purpose. Through technologies such as mobile banking apps, online banking platforms, and digital payment systems, banks and financial institutions have been able to extend their reach beyond traditional physical branches, offering digital financial services to previously underserved or unbanked populations (Ozili, 2020).

According to a 2025 World Bank study conducted as part of Global Findex, by 2024, 79% of the world's adult population had a bank account or an account at another similar financial institution. More than half of these accounts were digitally enabled, allowing their holders to make digital payments and online transactions via a phone or bank card.

Despite the potential of digital banking services, their adoption and effectiveness in strengthening financial inclusion remain uneven across different regions and demographic groups. While the number of adults with bank accounts is steadily increasing, in 2024, 1.3 billion adults around the world still lacked access to a financial account and therefore could not directly benefit from digital financial services (Klapper et al., 2025). Most of these adults are women, those with lower levels of education, low-income individuals, young people, and those living in rural areas.

Numerous barriers continue to hinder access to, use of, and trust in digital banking services. These barriers range from limited internet access and inadequate digital infrastructure to low levels of financial literacy and incomplete regulatory frameworks.

Vulnerable groups, including low-income adults, older people, and those living in remote areas, are disproportionately affected, widening the gap between those who can benefit from digital banking and financial innovations and those who cannot (Mookerjee, Bhuriya, & Josphin, 2025).

The purpose of this article is to identify the main obstacles to the adoption of digital banking services and to examine how these barriers hinder the broader goal of financial inclusion. By exploring and analyzing these issues, the study intends to provide insights that can help banks, financial institutions, regulatory bodies and financial technology providers develop more inclusive and accessible digital banking ecosystems.

This article uses qualitative research methods to identify the main barriers and challenges related to digital banking services and improving global financial inclusion. A literature review was conducted, drawing on recent academic studies, reports, and data from developing countries. The article was further strengthened by statistical data on mobile phone ownership and usage, obtained from surveys conducted for various World Bank reports.

While this article does not rely on primary data collection, it provides a comprehensive overview of the barriers hindering the widespread adoption of digital banking services.

2 Main Barriers to Digital Banking Services

Based on a comprehensive literature review and analysis of banking reports conducted as part of this study, the following main challenges were identified as hindering the development of digital banking services in the process of expanding financial inclusion worldwide:

2.1 Digital connectivity barriers

Affordability remains one of the main obstacles to digital financial inclusion. Access to digital banking services is inextricably linked to the ability to acquire the necessary tools and cover the recurring costs associated with digital communications. Globally, 86% of adults own a mobile phone. In low and middle income developing countries, 91 percent of mobile phone owners use their phones every day, and an additional 6 percent use them at least every week. In Sub-Saharan Africa as well, the majority of mobile phone owners use their phones every day. However, the cost of acquiring internet-connected devices, such as smartphones, tablets or computers, remains prohibitive for low-income people. According to a survey of adults who do not own a mobile phone, 69 percent of participants in South Asia and 77 percent in Sub-Saharan Africa stated that the reason they could not afford to buy a mobile phone was their inability to purchase it (Klapper et al., 2025). In many developing countries, even the purchase of basic phones can represent a significant portion of annual income. According to a cost analysis by the GSMA, the price of a mobile phone with basic internet access in low-income countries amounts to 18 percent of the average monthly income of an adult. In Sub-Saharan Africa, purchasing such devices can cost up to 73 percent of the average monthly income (GSMA, 2024). This financial barrier is particularly acute for disadvantaged groups, including rural populations and the unemployed.

In addition to the cost of purchasing devices, the financial burden is further exacerbated by recurring expenses such as mobile data plans, internet subscription fees, electricity charges for charging devices, and maintenance costs. Due to these costs, users limit their digital activities, resulting in a decrease in the frequency and variety of financial transactions conducted through digital platforms.

2.2 Infrastructure limitations

The efficiency of digital banking services depends heavily on the availability and quality of technical infrastructure. In particular, a lack of infrastructure acts as a serious barrier in rural and remote areas (Zhang et al., 2020). Incomplete or unstable mobile network coverage often hinders seamless access to digital platforms. Even in areas with coverage, network congestion, low bandwidth, and frequent service interruptions can significantly degrade the user experience. These issues not only limit accessibility but also undermine trust in digital banking systems, as transaction failures or delays can result in substantial financial losses. Broadband internet accessibility is also a major limiting factor. Broadband internet coverage is disproportionately distributed in rural areas compared to urban areas (Barboza & Leong, 2021). For low-income households, the cost of broadband services further restricts access.

Electricity infrastructure also plays a crucial role. In areas with unstable electricity supply, charging devices is difficult, making it hard to maintain continuous access to digital banking services. Frequent power outages can disrupt transactions and discourage users from using digital platforms. Furthermore, environmental factors such as floods, earthquakes, and extreme weather conditions can damage digital infrastructure nationwide, disrupting or restricting access to digital banking services (Yin, Wang & Wu, 2023).

2.3 Identification Barriers

While regulatory frameworks are essential for ensuring the security and soundness of the financial system, they can unintentionally result in preventing vulnerable groups from accessing digital services. One of the major barriers is strict Know Your Customer (KYC) requirements, which often mandate the presentation of official identification when opening a bank account. In many countries, a significant portion of the population does not possess official identification due to geographical or socioeconomic challenges. This problem disproportionately affects women, migrants and rural populations (Swain & Kumar, 2022).

SIM card registration policies also make accessibility more difficult. Since mobile banking services are often tied to a SIM card registered in the user's name, individuals without valid identification cannot independently register for or use these services. The widespread use of SIM cards registered in another person's name further complicates issues related to authentication, security, and ownership. Across developing countries, 23 percent of mobile phone owners use SIM cards registered under someone else's name rather than their own. In African countries such as Morocco, Comoros, the Republic of the Congo, and Tanzania, as well as in Jordan and Nepal, the percentage of mobile phone users who do not have SIM cards registered under their own name exceeds 40 percent (Joseph, Chegere & Mdadila, 2026).

2.4 Literacy Gap

Digital literacy is an essential factor in the successful adoption and use of digital banking services. Without the necessary skills and knowledge, technological accessibility alone is insufficient to guarantee true financial inclusion. Many people lack the basic reading, writing, and arithmetic skills necessary to understand financial information and navigate digital interfaces. This problem is particularly pronounced among older adults and those with lower levels of education. Even those who are literate may lack digital skills such as using mobile applications, managing passwords, and identifying secure websites. Complex interfaces, jargon, and poor application design further exacerbate these problems (Sabri et al., 2026).

Language challenges also play a critical role. Digital platforms are often designed in the main or prevalent languages, but not all users speak these languages. The lack of localized content hinders accessibility and makes adoption more difficult. Furthermore, low levels of financial literacy worsen the problem. If users do not properly understand the benefits, risks, and functions of digital financial services, they may not be able to use the services effectively or may misuse them.

2.5 Sociocultural Constraints

Sociocultural factors and gender inequality significantly impact the use of digital banking services. These barriers are deeply rooted in social norms, traditions, and power structures.

Women, in particular, face multifaceted exclusion. Compared to men, women are less likely to own mobile devices, access the internet, or possess identities. Cultural norms restrict mobility, making it difficult for women to access financial services or participate in digital education programs. In many households, men control financial resources and technological assets, hindering women's autonomy in using digital tools. Even if women have access to devices, they may not have the freedom to use them independently (BIGD, 2024).

Social perceptions and trust also influence adoption of digital banking services. In some countries, skepticism towards digital technology or its perception as risky leads to reluctance to use it. Additionally, intergenerational differences may emerge; older generations are less likely to adopt digital services due to resistance to change or unfamiliarity with the modern technologies.

2.6 Security and privacy concerns

Trust is essential for the adoption of digital banking services. Security and privacy concerns can be a significant barrier to using digital platforms. Users often fear financial fraud, identity theft, and unauthorized transactions. Cybercrime, phishing, and fraud exacerbate these fears and erode trust in digital services.

In environments where theft is particularly prevalent, the risk of losing a mobile device is even more of a deterrent. For low-income individuals, losing a device means not only a financial loss but also a loss of access to financial services (Aracil, Méndez, & Fuertes, 2025).

Privacy concerns are also crucial. Users may hesitate to share their personal and financial information for fear of being tracked, having their data misused, and having their privacy violated.

These problems are further exacerbated by inadequate consumer protection mechanisms. Without clear recourse options, users may feel vulnerable and unprotected in the event of a dispute or fraud.

2.7 Behavioral Barriers

Behavioral factors and usage habits play a significant role in the effectiveness of digital financial inclusion policies. Even with accessibility provided, users may not fully adopt digital banking services if they perceive them as worthless or irrelevant (Daud & Ahmad, 2023). Traditional financial practices, such as cash transactions or informal savings methods, are often deeply ingrained and preferred. Irregular internet use due to budget constraints weakens familiarity with and trust in digital platforms. Users who access the internet intermittently are less likely to develop the habits necessary for regular use.

Device sharing further complicates the issue by weakening privacy and increasing dependence on others. This can lead individuals to avoid sensitive financial transactions (Persaud & Thaffe, 2023).

Additionally, behavioral biases such as risk aversion, distrust of new technologies, and resistance to change can also hinder digital financial inclusion.

2.8 Policy design limitations

The design and implementation of policies aimed at promoting digital financial inclusion can create obstacles if they do not consider the context. Top-down approaches that focus solely on technology dissemination often ignore underlying socioeconomic and cultural barriers. For example, free mobile device distribution programs may have limited long-term effectiveness if beneficiaries lack the necessary technical skills, resources, or autonomy to use the devices effectively (Ozturk & Ullah, 2022).

In some cases, policy interventions that do not consider the dynamics among family members may lead to the redistribution of resources to the original beneficiaries. Women, in particular, may lose control over the devices or financial accounts provided by these programs. For example, a study that provided free smartphones to women in rural Tanzania found that the annual per capita consumption of food and basic necessities in households that received smartphones increased by 20 percent compared to households that received simple mobile phones or cash. However, by the end of the study period, only one-third of the women who received smartphones still owned them (Klapper et al., 2025).

Short-term policies without continuing support mechanisms yield only temporary results and are not sustainable. A lack of collaboration between banks and financial institutions further weakens the effectiveness of these policies.

2.9 Competition Barriers

The structure of digital banking environment can have a significant impact on accessibility and affordability. If a small number of providers dominate the market, low competition can lead to poor service quality, high transaction fees and limited innovation.

Monopoly or oligopoly structures can hinder the development of user-centric solutions tailored to the needs of marginalized groups (Basnayake et al., 2024). Furthermore, a lack of interoperability between digital banking platforms leads to silos that limit user choice and ease of use. Barriers to entry for new providers, including regulatory hurdles and high infrastructure costs, further restrict competition and innovation.

2.10 Product design issues

The design of digital banking services is critical in terms of accessibility and usability. Many digital banking and financial services are not designed with those with low literacy levels or first-time users in mind. Complex interfaces, unclear descriptions, and unintuitive navigation can hinder usage rates (Demirgüç-Kunt et al., 2022).

Limited customization options and a lack of localization reduce the usability of services for diverse demographic groups. For example, failure to consider local languages, cultural preferences, and user behavior patterns can lead to decreased user engagement. Accessibility challenges also affect individuals with disabilities, who may face additional problems when using standard digital banking services.

2.11 Operational capability barriers

Banks and financial institutions may lack the necessary technical expertise, infrastructure, and resources to effectively implement and manage digital banking services. Smaller banks and microfinance institutions, in particular, may struggle to adopt advanced technologies due to high cost constraints (Kumar & Mohanty, 2021).

In addition, effective customer support is crucial for troubleshooting and trust-building. However, many digital banking platforms and applications lack accessible and rapid support systems. Users experiencing problems may stop using digital services if they don't receive timely assistance (World Bank, 2022). Moreover, digital banking services are integrated with other digital payment and financial systems. However, limited service coverage, inadequate training, and the lack of a seamless digital community among financial participants can restrict service adoption.

2.12 Problems related to institutional and trust deficiencies in financial systems

In some cases, low trust in formal banks and financial institutions poses a significant challenge to the adoption of digital banking services (Peng, Hermes & Lensink, 2026). Past experiences of financial instability, corruption, or exclusion can lead to distrust of banks and digital banking services. This barrier may cause individuals to turn to the informal financial system despite the availability of digital alternatives. A lack of transparency regarding fees, terms, and conditions of digital services further erodes trust. Users may hesitate to utilize digital financial services due to fear of hidden fees or unfavorable conditions.

3 Discussion/Conclusion

The development of digital banking services has emerged as an important mechanism for strengthening financial inclusion, particularly for underserved and marginalized populations. However, the findings of this study demonstrate that the adoption and effective use of digital banking services continue to be constrained by a complex combination of economic, infrastructural, socio-cultural, behavioral, technological, and institutional barriers. These barriers are interconnected and mutually reinforcing, which means that financial exclusion cannot be addressed through technological advancement alone.

Compared with previous studies, this article contributes to the existing literature by providing a more integrated understanding of the barriers affecting digital banking adoption in the context of financial inclusion. While earlier research has often focused on isolated factors such as internet access, digital literacy, or trust in financial institutions, this study highlights the multidimensional nature of the problem and emphasizes the interaction between structural and behavioral determinants. In particular, the article underlines how economic inequality, weak regulatory systems, limited digital skills, gender disparities, and low institutional trust collectively influence the willingness and ability of individuals to use digital financial services. This broader analytical perspective represents an important extension of prior research on digital financial inclusion.

The study also confirms several findings identified by earlier authors, especially regarding the importance of affordable digital infrastructure, financial literacy, and secure technological systems in increasing adoption rates. Similar to previous studies, the results suggest that trust and perceived security remain central determinants of user acceptance of digital banking services. However, unlike many earlier works that primarily emphasize technological solutions, this article argues that social and institutional dimensions are equally significant in achieving sustainable financial inclusion.

The findings therefore suggest that policy interventions should move beyond expanding access to technology and should instead focus on creating inclusive financial ecosystems that respond to the realities and needs of vulnerable groups.

To overcome the identified barriers, a coordinated and adaptive approach is necessary. Governments, banks, fintech companies, regulatory authorities, and international organizations must collaborate to design user-centered digital financial systems that are accessible, secure, affordable, and culturally inclusive. Policies aimed at improving digital infrastructure and reducing service costs should be complemented by measures that strengthen digital and financial literacy, enhance cybersecurity, promote consumer protection, and reduce gender-based inequalities in access to financial technologies. In addition, increasing transparency and accountability within financial institutions can contribute to building greater public trust in digital banking systems.

This study also opens several directions for future research. Further empirical studies could examine the relative impact of specific barriers across different demographic groups, regions, or income levels. Comparative cross-country analyses may provide deeper insights into how institutional and cultural contexts influence digital banking adoption. Future research could also investigate the long-term effects of fintech innovations, artificial intelligence, and mobile banking technologies on financial inclusion outcomes. Moreover, qualitative studies exploring user experiences and perceptions could contribute to a better understanding of behavioral resistance to digital financial services.

In conclusion, achieving meaningful financial inclusion through digital banking services requires more than simply providing access to technology. It requires the development of a fair, secure, inclusive, and sustainable digital financial ecosystem that addresses both structural inequalities and user-specific challenges. By identifying and analyzing the multiple barriers to digital banking adoption, this study contributes to the ongoing discussion on how digital transformation can be leveraged to promote inclusive economic participation and reduce financial exclusion worldwide.

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THE ALGORITHMIC ASSESSMENT OF DIGITAL TRUST: BANK OF ITALY'S AI-DRIVEN CYBER RISK INDEX AND THE NEW PARADIGM OF CREDITWORTHINESS

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Abstract

This paper examines how cyber risk can be incorporated into corporate creditworthiness assessment by building on the Bank of Italy's recent proposal for an AI-driven cyber vulnerability indicator. The article addresses a methodological gap between the growing financial relevance of cybersecurity incidents and the still limited integration of unstructured cyber-risk evidence into credit models. Using a simulated database of 10,000 Italian non-financial firms, the paper develops an illustrative framework that combines traditional financial indicators with a cyber-risk score derived from an Italy-specific taxonomy of attack disclosures, regulatory compliance, security certifications, and defensive technologies. The simulated results indicate that adding the cyber-risk score increases the share of firms requiring manual review and reduces automatic approvals, especially among companies with weak debt-service capacity or adverse credit-register signals. The paper concludes that cyber resilience should be treated as a structural determinant of credit risk rather than as a separate operational issue.

Keywords: Cyber risk; Creditworthiness; Banca d'Italia; Natural language processing; Digital resilience.

1 Introduction

The assessment of corporate creditworthiness has traditionally relied on structured financial information, particularly cash-flow statements, income statements, balance sheets, payment histories, and collateral information. Textual information has become increasingly important in accounting and finance because it contains qualitative signals that are not always visible in standardized numerical ratios (Loughran & McDonald, 2016). Within the older credit-assessment paradigm, cybersecurity was often treated as an operational or information-technology matter rather than as a core determinant of repayment capacity.

That separation is no longer sustainable. Cyber incidents can interrupt business continuity, reduce cash flows, trigger litigation, damage reputation, and weaken the capacity of firms to service debt. The Bank of Italy's recent work on the cyber risk of non-financial firms proposes an indicator of cyber-risk vulnerability for Italian companies by applying natural language processing (NLP) and a large language model (LLM) to financial statements, news reports, and cyber-industry sources (Columba et al., 2026). The same work emphasizes that cyber risk may have material effects on business continuity and should therefore be incorporated into credit-risk assessments (Banca d'Italia, 2026).

Figure 1

The ten types of credit risk in banks

Source: Cybersecurity360 (2026).

The relevance of this shift is reinforced by the institutional role of Banca d'Italia's In-house Credit Assessment System (ICAS-BI). Since 2013, ICAS-BI has rated the creditworthiness of Italian non-financial corporations by combining statistical probability-of-default estimates with expert qualitative and quantitative assessment (Banca d'Italia, n.d.). This makes the Bank of Italy's cyber-risk initiative especially important: if a cyber-vulnerability indicator is connected to credit-risk assessment, digital resilience becomes a financial variable and not merely a compliance or technology concern.

The research gap addressed in this paper is the limited operational specification of how an AI-derived cyber-risk indicator can be connected with conventional credit metrics in a transparent credit-assessment workflow. The objective of the article is therefore to design and illustrate a simulation framework that combines conventional financial indicators with a cyber-vulnerability score derived from unstructured cyber-risk evidence. The focus is not to reproduce the proprietary Bank of Italy model, but to demonstrate how the logic of such a model can be implemented, interpreted, and evaluated in a banking-credit context.

2 Simulation Design and Cyber-Risk Scoring Framework

The study uses an illustrative simulation of 10,000 Italian non-financial firms. The simulation is designed to resemble the structure of a bank credit-assessment workflow rather than to claim access to

confidential supervisory data. Each synthetic firm is assigned variables normally relevant to credit decisions, including annual revenue, EBITDA, debt-to-equity ratio, debt service coverage ratio (DSCR), liquidity ratio, average collection period, credit-register status, non-performing-loan indicator, business-plan viability, real guarantees, and an environmental, social, and governance (ESG) score.

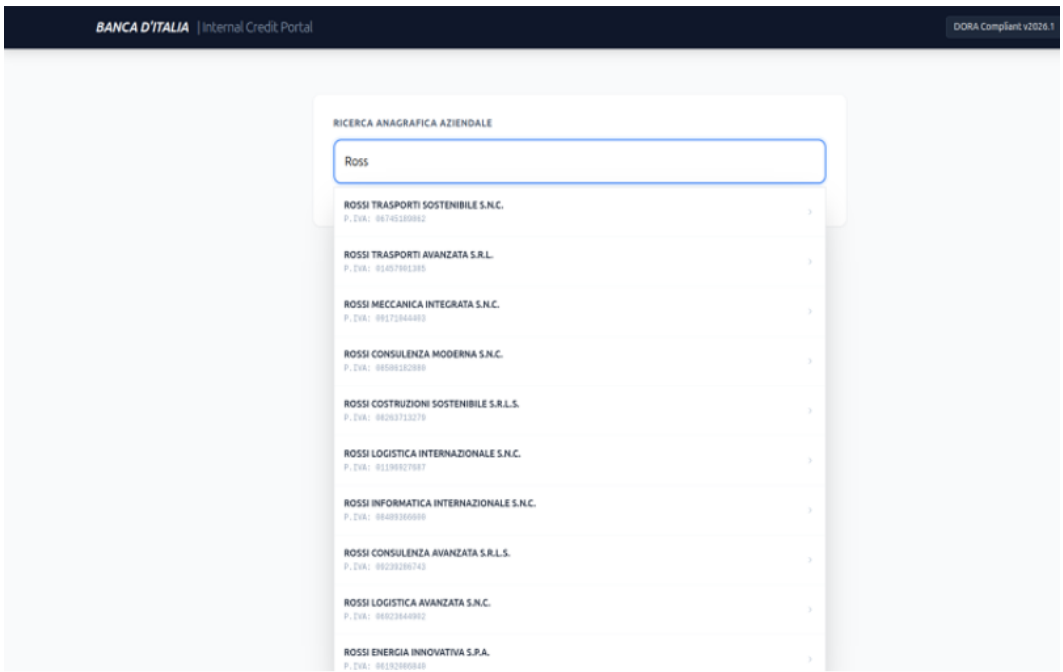
The cyber-risk component is organized through an Italy-oriented taxonomy consistent with the logic described in the Bank of Italy's cyber-risk work. The taxonomy separates risk-increasing and risk-mitigating textual signals. Risk-increasing signals include disclosed cyberattacks, ransomware exposure, data breaches, repeated adverse press coverage, and weak incident-response language. Risk-mitigating signals include evidence of regulatory compliance, adoption of recognized security standards, cyber-insurance arrangements, investments in defensive technologies, staff training, and explicit governance responsibility for cyber resilience.

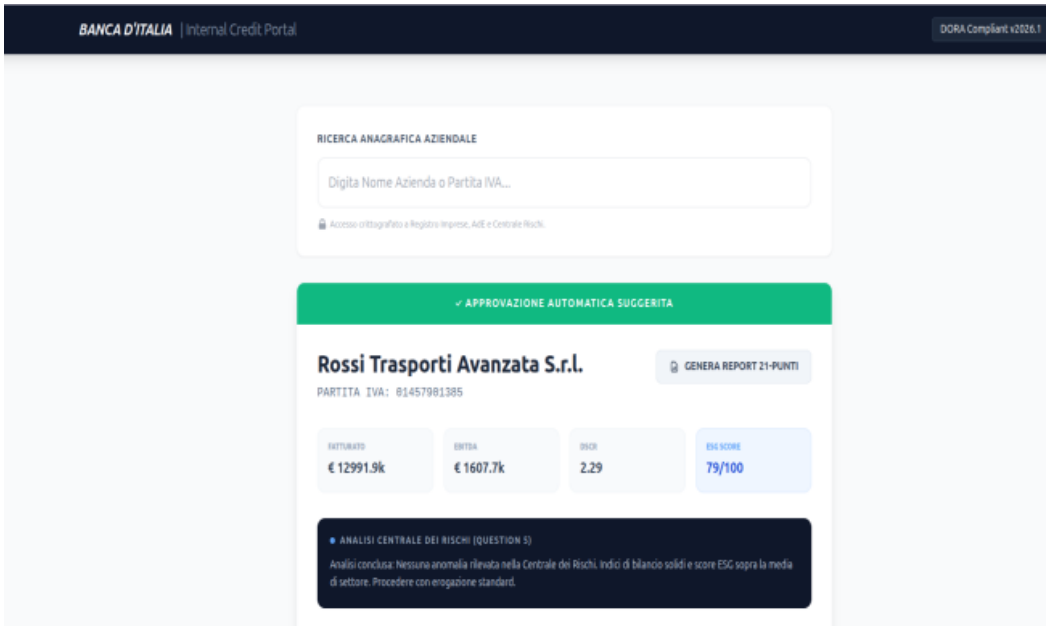
The NLP/LLM pipeline is represented in four stages. First, unstructured texts are collected from simulated annual-report disclosures, press notes, and cybersecurity incident descriptions. Second, the texts are classified into taxonomy categories. Third, each firm receives a normalized cyber-vulnerability index from 0 to 100, where a higher value indicates greater exposure. Fourth, the cyber-vulnerability index is added to the credit-assessment model as an adjustment to the preliminary financial-risk classification. This approach follows the broader literature on machine learning in finance, where unstructured text is transformed into structured signals that can be combined with numerical predictors (López de Prado, 2018; Roberts et al., 2024).

For validation, the simulation applies three transparent checks. Internal consistency is assessed by verifying whether high-risk cyber disclosures increase the vulnerability score. Sensitivity is evaluated by comparing credit recommendations before and after the cyber score is included. Face validity is assessed through three company cases that represent low, medium, and high credit-risk profiles. The validation is intentionally simple because the purpose of the paper is to present an interpretable framework for academic and conference discussion, not a production-grade credit model.

Figure 2

Example of the simulated database interface and first company summary





Source: Authors' elaboration based on the simulated database.

Figure 2 presents the simulated interface used to retrieve a company record and summarize the initial automated assessment. The example is Rossi Trasporti Avanzata S.r.l., a transport company with revenue of €12,991,900, EBITDA of €1,607,700, a DSCR of 2.29, and an ESG score of 79 out of 100. The system reports no anomalies in the credit register and recommends standard disbursement because the financial and credit-history indicators are strong.

Figure 3

Creditworthiness evaluation for Rossi Trasporti Avanzata S.r.l.

VALUTAZIONE MERITO CREDITIZIO

Protocollo Interno: BI-REC-2026-X

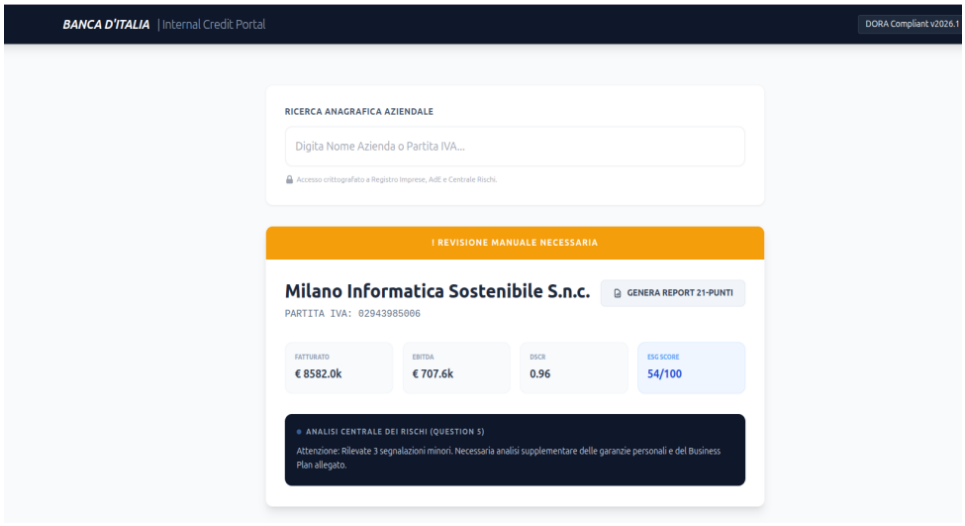
LEGALE & COMPLIANCE			
1. Anzianità Operativa	**26 Anni**	2. Struttura Legale & UBO	**Verificato via Registro Imprese**
3. Verifica KYC/AML	**PASSED (Clean)**	4. Regolarità Fiscale (DURC)	**CONFORME**
STORIA CREDITIZIA			
5. Centrale dei Rischi	**REGOLARE**	6. Esposizione Interbancaria	**Analisi Real-time conclusa**
7. Sofferenze / NPL	**Assenti**	8. Credit Utilization Ratio	**62.4%**
PERFORMANCE FINANZIARIA			
9. Fatturato Annuo	**€ 12,991,940**	10. Margine EBITDA	**€ 1,607,726**
11. Debt/Equity Ratio	**1.18**	12. DSCR Index	**2.29**
13. Indice Liquidità Corrente	**1.45**	14. Giorni Medi Incasso (DSO)	**42 gg**
GARANZIE E FUTURO			
15. Finalità Finanziamento	**Capitale Circolante**	16. Business Plan Viability	**Positivo**
17. Garanzie Reali	**Verificate**	18. Fideiussioni	**Rilasciate**
19. Elegibilità Fondo PMI	**Idoneo**	20. Rischio Settore (ATECO)	**Basso**
21. Score ESG Sostenibilità	**79/100**		

Source: Authors' elaboration based on the simulated database.

Figure 3 shows the detailed creditworthiness evaluation for the same firm. The legal structure and ultimate beneficial owner are verified, the know-your-customer and anti-money-laundering checks are clean, tax regularity is compliant, and the Central Credit Register status is regular. The company has no non-performing loans, shows a strong DSCR, and maintains an above-average ESG score. This case represents the low-risk benchmark in the simulation.

Figure 4

Creditworthiness evaluation for Milano Informatica Sostenibile S.a.c.



VALUTAZIONE MERITO CREDITIZIO

Protocollo Interno: BI-REC-2026-X

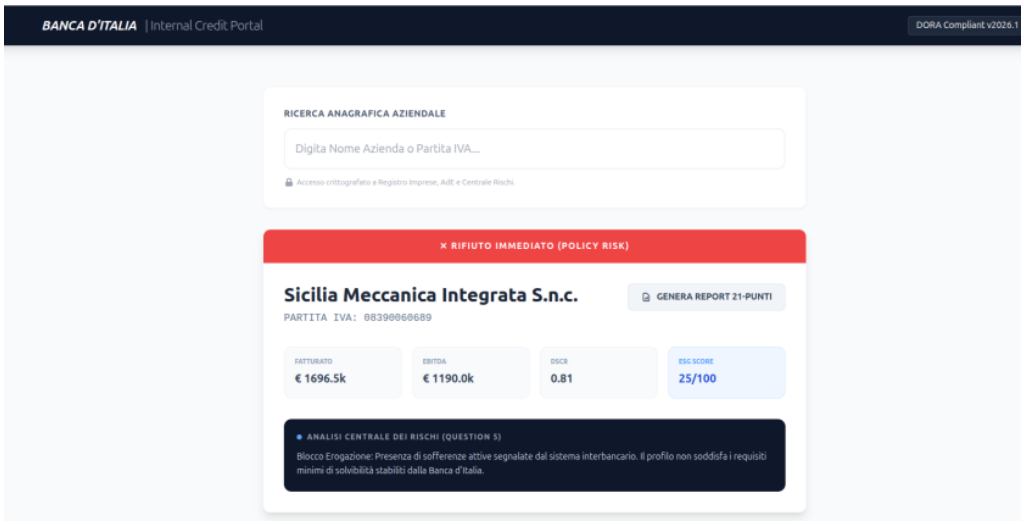
LEGALE & COMPLIANCE			
1. Anzianità Operativa	48 Anni	2. Struttura Legale & UBO	Verificato via Registro Imprese
3. Verifica KYC/AML	PASSED (Clean)	4. Regolarità Fiscale (DURC)	CONFORME
STORIA CREDITIZIA			
5. Centrale dei Rischi	REGOLARE	6. Esposizione Interbancaria	Analisi Real-time conclusa
7. Sofferenze / NPL	Presenti	8. Credit Utilization Ratio	62.4%
PERFORMANCE FINANZIARIA			
9. Fatturato Annuo	€ 8,581,981	10. Margine EBITDA	€ 707,563
11. Debt/Equity Ratio	1.18	12. DSCR Index	0.96
13. Indice Liquidità Corrente	1.45	14. Giorni Medi Incasso (DSO)	42 gg
GARANZIE E FUTURO			
15. Finalità Finanziamento	Capitale Circolante	16. Business Plan Viability	Positivo
17. Garanzie Reali	Verificate	18. Fideiussioni	Rilasciate
19. Elegibilità Fondo PMI	Idoneo	20. Rischio Settore (ATECO)	Basso
21. Score ESG Sostenibilità	54/100		

Source: Authors' elaboration based on the simulated database.

Figure 4 illustrates a medium-risk case. Milano Informatica Sostenibile S.a.c. has a long operating history and formally compliant legal and tax indicators, but it also has non-performing loans and a DSCR of 0.96. The firm therefore generates slightly less cash flow than required to cover its debt obligations. Under the simulation logic, the case requires manual review rather than automatic approval.

Figure 5

Creditworthiness evaluation for Sicilia Meccanica Integrata S.n.c.



VALUTAZIONE MERITO CREDITIZIO

Protocollo Interno: BI-REC-2026-X

LEGALE & COMPLIANCE

1. Anzianità Operativa	42 Anni	2. Struttura Legale & UBO	Verificato via Registro Imprese
3. Verifica KYC/AML	PASSED (Clean)	4. Regolarità Fiscale (DURC)	CONFORME

STORIA CREDITIZIA

5. Centrale dei Rischi	ALERT	6. Esposizione Interbancaria	Analisi Real-time conclusa
7. Sofferenze / NPL	Presenti	8. Credit Utilization Ratio	62.4%

PERFORMANCE FINANZIARIA

9. Fatturato Annuo	€ 1,696,519	10. Margine EBITDA	€ 1,190,027
11. Debt/Equity Ratio	1.18	12. DSCR Index	0.81
13. Indice Liquidità Corrente	1.45	14. Giorni Medi Incasso (DSO)	42 gg

GARANZIE E FUTURO

15. Finalità Finanziamento	Capitale Circolante	16. Business Plan Viability	Positivo
17. Garanzie Reali	Verificate	18. Fideiussioni	Rilasciate
19. Elegibilità Fondo PMI	Idoneo	20. Rischio Settore (ATECO)	Basso
21. Score ESG Sostenibilità	25/100		

Source: Authors' elaboration based on the simulated database.

Figure 5 presents the high-risk case, Sicilia Meccanica Integrata S.n.c. The Central Credit Register status is marked as an alert, non-performing loans are present, revenue is comparatively low, and the DSCR is 0.81. Even where some operating indicators remain formally acceptable, the combined credit profile is weak. In a model that also penalizes high cyber vulnerability, this type of firm is the most likely to move from review to rejection.

3 Results

Table 1

Comparison of the three illustrative firms

Metric	Firm 1: Rossi Trasporti	Firm 2: Milano Informatica	Firm 3: Sicilia Meccanica
Operating history	26 years	48 years	42 years
Central Credit Register	Regular	Review needed	Alert
Annual revenue	€12,991,900	€8,581,981	€1,696,519
EBITDA	€1,607,700	€707,563	€1,190,027
DSCR	2.29	0.96	0.81
ESG score	79/100	54/100	21/100
Illustrative recommendation	Proceed with standard disbursement	Manual review	High-risk review or rejection

Source: Authors' elaboration based on the simulated database.

The three examples confirm that conventional financial ratios remain central to creditworthiness assessment, but they also show why an additional cyber-vulnerability score can be useful. Firm 1 is financially resilient and has no adverse credit-register indicators. Firm 2 has acceptable size and operating history but weak debt-service capacity and non-performing-loan evidence. Firm 3 combines adverse credit-register information with weak debt-service capacity and low ESG performance. These differences provide a practical basis for testing how cyber vulnerability would change credit recommendations.

Table 2

Illustrative aggregate effect of adding a cyber-vulnerability score to the simulated credit model

Credit recommendation	Baseline model: firms	Baseline model: %	Model with cyber score: firms	Model with cyber score: %	Change
Automatic approval	5,240	52.4%	4,480	44.8%	-760
Manual review	3,110	31.1%	3,690	36.9%	+580
High-risk rejection	1,650	16.5%	1,830	18.3%	+180
Total	10,000	100.0%	10,000	100.0%	0

Source: Authors' simulation.

Table 2 reports an illustrative aggregate result from the simulated population. After the cyber-vulnerability score is added, automatic approvals decrease from 52.4% to 44.8%, while manual reviews increase from 31.1% to 36.9% and high-risk rejections increase from 16.5% to 18.3%. The most frequent movement is from automatic approval to manual review, which is consistent with the interpretation that cyber-risk information should not mechanically replace financial assessment but should trigger additional scrutiny when digital resilience is weak.

4 Discussion

The main implication of the simulation is that cyber risk should be incorporated into credit assessment as an incremental and interpretable layer rather than as an isolated score. This is consistent with Banca d'Italia's ICAS-BI approach, in which statistical information is combined with expert assessment and qualitative judgment (Banca d'Italia, n.d.). A cyber-vulnerability indicator can strengthen such a framework because it captures forward-looking operational and governance weaknesses that may not yet be visible in accounting data.

The findings also support the concept of a persistent cyber scar. When a firm suffers a cyber incident, the immediate increase in vulnerability may outweigh the slower benefits of later defensive measures. This interpretation is compatible with evidence that firms may underreport cyberattacks and that undisclosed incidents are associated with negative capital-market consequences once discovered (Amir et al., 2018). Credit rating agencies have also warned that severe cyber incidents can affect credit quality through business disruption, reputational damage, legal exposure, and remediation costs (Moody's Investors Service, 2020; S&P Global Ratings, 2021).

For banks, the operational challenge is to combine cybersecurity expertise, AI governance, explainability, and credit-risk analysis. For firms, the implication is equally direct: cyber resilience affects access to finance. Investments in security controls, incident response, regulatory compliance, and transparent disclosure may reduce the likelihood that a firm will be classified as risky when non-financial information is added to credit models. The Financial Stability Board's work on cyber incident reporting and the G7 Cyber Expert Group's statement on AI and cybersecurity reinforce the need for consistent reporting, common terminology, and responsible AI governance in the financial sector (Banca d'Italia, 2023; G7 Cyber Expert Group, 2025).

The study has limitations. The database is simulated, and the proposed scoring framework is illustrative. The results should therefore be interpreted as a demonstration of model logic rather than as empirical measurement of the Italian corporate sector. Future research should test the framework on real firm-level financial statements, verified incident databases, and industry-specific cybersecurity disclosures. It should also compare alternative weighting schemes, examine bias and explainability in LLM-based classification, and evaluate whether the cyber score improves out-of-sample prediction of default or credit deterioration.

5 Conclusion and Recommendations

The Bank of Italy's cyber-risk indicator represents a conceptual turning point because it connects digital governance with financial risk management. By transforming unstructured cybersecurity information into a quantitative vulnerability score, the approach creates a practical bridge between cyber resilience and creditworthiness. The simulation presented in this paper shows that adding a cyber-risk layer can materially change credit recommendations, especially by moving firms from automatic approval to manual review when financial weakness and digital vulnerability appear together.

Financial authorities and intermediaries should treat cyber-risk information as a necessary complement to conventional financial ratios. They should strengthen internal capacity to interpret AI-based cyber indicators, adopt common taxonomies for incident reporting, require clear source documentation for automated assessments, and ensure that human experts remain responsible for final credit decisions. Non-financial firms should treat cybersecurity investment, governance, and disclosure as strategic determinants of credit access and cost of capital, not merely as technical expenditures.

In a digital economy, creditworthiness increasingly depends on the security, continuity, and transparency of the systems through which companies operate. The future of credit assessment will therefore be shaped not only by balance-sheet strength, but also by the quality of a firm's digital resilience.

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ADVANTAGES AND PITFALLS OF ARTIFICIAL INTELLIGENCE IN THE LEGAL PROFESSION

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Abstract

Artificial intelligence (AI) is rapidly reshaping the legal profession by changing how lawyers conduct research, review documents, draft first versions of legal texts, communicate with clients, and organise routine work. The objective of this article is to examine the main advantages and pitfalls of AI in legal practice and to identify the safeguards required for its responsible use. The article is based on a theoretical and desk-research approach, drawing on recent professional commentary, legal-education scholarship, algorithmic-governance literature, and previously published studies in the AIJES and AIJJS journals. The analysis shows that AI can improve speed, consistency, knowledge retrieval, contract review, document summarisation, client intake, and access to legal services. At the same time, it can create serious risks, including fabricated authorities, misleading outputs, privacy and confidentiality breaches, bias, insufficient transparency, weak accountability, and excessive dependence on automated systems. The article concludes that AI should be understood as an assistive technology rather than a substitute for lawyers. Its benefits can be realised only when law firms and legal institutions combine innovation with human oversight, verification protocols, data-protection safeguards, AI literacy, and professional accountability.

Keywords: artificial intelligence, legal profession, legal research, document review, ethics

1 Introduction

Over the last several years, artificial intelligence (AI) has become increasingly relevant in professional and business environments. Its ability to process large volumes of data, identify patterns, and generate rapid outputs makes it especially attractive in a world in which speed, accuracy, and efficiency are highly valued (Abney, 2024; Couture, 2025). In the legal profession, these qualities are particularly important because legal work often requires the review of extensive documents, the organisation of complex facts, and the identification of relevant legal sources within strict time limits.

AI is now used in a wide range of everyday and professional contexts, from answering general questions to supporting specialised tasks. The legal profession has not remained untouched by this development. On the one hand, AI promises greater speed, lower costs, and improved workflow management. On the other hand, it introduces new professional, ethical, and practical risks that can directly affect clients, courts, and the integrity of legal work (Stefanowicz, 2026; Tyrie, 2025). These risks are not merely technical; they concern the core values of legal practice, including confidentiality, competence, independence, diligence, and accountability.

Supporters of AI argue that it can accelerate legal processes by helping lawyers review contracts, identify relevant documents in discovery, conduct research more efficiently, and prepare first drafts in less time than traditional methods allow (Abney, 2024; Stefanowicz, 2026). Critics, however, warn against false confidence in AI outputs, privacy and confidentiality breaches, copyright concerns, and a gradual erosion of professional judgment (Pasquale, 2015; Tyrie, 2025).

Empirical work on ChatGPT in legal education has also shown that generative AI may produce plausible legal answers while still demonstrating limitations in accuracy, depth, and reasoning (Choi et al., 2022).

The aim of this article is to examine the principal advantages and pitfalls of AI in legal professions. The discussion focuses on areas in which AI can genuinely improve legal practice, while also highlighting the safeguards required if the technology is to be used responsibly. The article is theoretical in nature and relies on desk research, professional commentary, and recent scholarship on AI, legal theory, algorithmic governance, and digital transformation. It also positions the discussion within the academic context of the AIJES and AIJJS journals, where recent publications have examined AI in relation to legal theory, leadership, corporate reputation, healthcare, ethics, and rule-of-law challenges (Ağtaş, 2025; Minghirași, 2025; Mikava & Mamulaidze, 2023).

2 Advantages of AI in the Legal Profession

There is broad agreement that AI can support lawyers in numerous ways. Although current AI systems are still far from replicating the human element of legal experience, judgment, and client trust, they can assist with many routine and time-consuming tasks. In practice, this means improved workflow, faster data gathering, more efficient editing of legal documents, and additional time for lawyers to focus on demanding intellectual work such as counselling clients, drafting complex legal opinions, and shaping litigation strategy (Abney, 2024; Couture, 2025; Susskind, 2023).

AI is particularly effective in tasks based on pattern recognition and large datasets. It can quickly identify relevant documents, keywords, clauses, and recurring issues, which makes it valuable for document review and early case preparation (Abney, 2024; Kapoor et al., 2024). While these tasks can of course be performed without AI, the technology can substantially improve speed and consistency when large volumes of material must be processed.

Contract analysis is another area in which AI can be highly useful. It can identify, extract, and classify business information across numerous contracts, detect missing or problematic clauses, and support the preparation of draft revisions based on predefined options (Stefanowicz, 2026). At its best, AI performs well when the data are sufficient and the user's instructions are detailed and precise. It is much less reliable when questions are open-ended or depend heavily on human credibility assessments, strategic intuition, or emotional nuance (Kapoor et al., 2024).

AI can also generate significant organisational benefits for law firms. By automating labour-intensive administrative processes, including parts of legal research and client lead generation, firms may reduce costs and deliver services more efficiently (Abney, 2024; Couture, 2025). This efficiency can improve access to legal services more broadly, because professionals burdened by routine tasks may have more time available for clients who need substantive legal support.

An additional advantage lies in error detection. Legal practice demands concentration, precision, and sustained attention. When lawyers work under pressure or manage many matters at once, mistakes can occur. AI tools can review large quantities of data with high consistency and help detect omissions, inconsistencies, or drafting errors in human-produced work (Abney, 2024). However, this function is useful only if the tool is treated as a second layer of review, not as a final authority.

Finally, AI can strengthen communication and business development. Innovative software can help law firms connect with potential clients, streamline intake, and improve responsiveness. Better client management may contribute to a clearer service experience and, ultimately, to stronger client satisfaction and growth (Abney, 2024; Couture, 2025).

2.1 Legal research

AI is making legal research faster and more comprehensive than many traditional methods. It can assist with case-law and statute analysis, support cross-jurisdictional comparisons, and help lawyers locate relevant authorities more quickly (Stefanowicz, 2026; Susskind, 2023).

Such tools can identify similar cases and precedents across jurisdictions and thereby make comparative legal analysis more efficient. They can also assist in locating relevant statutes and regulations in complex matters and in tracing how courts have interpreted particular legal concepts over time (Minghirași, 2025; Stefanowicz, 2026). This is especially relevant in fields where algorithmic governance and automated decision-making are beginning to affect legal interpretation, procedural fairness, and the rule of law (Minghirași, 2025).

Even so, AI-assisted research must remain subject to professional review. A tool may retrieve or summarise material rapidly, but the lawyer remains responsible for evaluating legal relevance, accuracy, jurisdictional authority, and persuasive value. The problem is not simply that an AI system may be wrong; it is that an incorrect answer may appear fluent, authoritative, and complete (Choi et al., 2022; Tyrie, 2025).

2.2 Communication with potential clients

AI can improve client intake processes and initial communication. AI-powered chatbots and virtual assistants can answer basic enquiries, collect preliminary information, and help schedule appointments. This enables law firms to offer more continuous responsiveness and make early consultations more efficient (Stefanowicz, 2026).

AI tools can also help draft initial emails, explain procedural issues in plain language, and prepare follow-up messages regarding the status of a matter or the next recommended steps (Stefanowicz, 2026). However, these uses should remain limited to administrative and procedural support. Substantive legal advice should remain the responsibility of a qualified legal professional, and AI-generated communications should include clear limitations where appropriate (Stefanowicz, 2026; Tyrie, 2025).

The distinction between administrative communication and legal advice is important because clients may not always recognise when a response is automated or preliminary. Human oversight protects not only the client but also the professional reputation of the law firm. In this respect, the use of AI in law is similar to its use in other professional services: technological efficiency can improve responsiveness, but trust still depends on transparency, responsibility, and human judgment (Ağtaş, 2025; Couture, 2025).

2.3 Summaries of documents

Document summarisation is one of the most practical and widely adopted AI applications in legal practice. AI can condense lengthy contracts, court filings, motions, and compliance documents into concise overviews, allowing lawyers to prioritise review and identify key risks more quickly (Kapoor et al., 2024; Stefanowicz, 2026).

Generative AI can also analyse patterns in existing documents and produce first-draft summaries, pleadings, or statements of facts. Used carefully, this can shorten preparation time and improve case organisation. Yet such outputs should never be treated as a substitute for a thorough reading of the original material or for professional legal judgment (Kapoor et al., 2024; Tyrie, 2025).

Where AI-generated summaries are used in practice, it is advisable to make clear that the text requires review by a lawyer. Failing to do so may mislead clients and potentially harm the reputation of the law firm. The importance of review is reinforced by scholarship on ethical AI, which emphasises transparency, responsibility, privacy, fairness, and non-maleficence as recurring principles of responsible AI governance (Jobin et al., 2019).

3 Pitfalls of AI in the Legal Profession

Despite its benefits, AI also presents important disadvantages and risks. One of its most serious limitations is its difficulty in handling complex legal concepts, subtle factual contexts, and the broader social meaning of disputes. As a result, AI may misinterpret legal rules, overlook crucial nuance, or generate plausible but inaccurate responses (Choi et al., 2022; Kapoor et al., 2024; Tyrie, 2025).

Another concern is the weakening of the human dimension of legal service. Personal interaction between lawyers and clients is central to trust, empathy, and effective representation. If a firm relies too heavily on automated systems beyond initial intake or administrative support, the attorney-client relationship may suffer. Many clients want to know that they are receiving personalised advice rather than a generic automated response, especially in emotionally charged or high-stakes matters (Abney, 2024; Susskind, 2023).

Ethical issues are equally significant. The use of AI in law raises concerns regarding privacy, confidentiality, data protection, transparency, and bias. These issues are particularly sensitive because legal professionals are entrusted with privileged information and are expected to act fairly and independently. If AI systems are trained on biased data or used without clear governance, they may reproduce or even amplify discriminatory outcomes (CEPEJ, 2018; Jobin et al., 2019; Pasquale, 2015).

For that reason, AI should not be allowed to perform the fundamental work for which clients are paying without close supervision. Automation may support legal practice, but responsibility for legal advice, strategic decision-making, and professional accountability cannot be delegated to a machine (CEPEJ, 2018; Tyrie, 2025). This principle is consistent with recent AIJJS discussions of algorithmic governance, which emphasise the need to protect procedural fairness, transparency, and the rule-of-law foundations of legal decision-making (Minghirași, 2025).

3.1 Key risks for legal professionals

Recent discussions on AI in legal practice highlight several concrete risks. One of the most prominent is the generation of fake citations or fabricated authorities. Any AI-generated reference must therefore be checked against trusted legal databases before it is used in court filings, opinions, or client work. Failure to verify such material may lead to sanctions or professional misconduct findings (Tyrie, 2025).

A related danger concerns the delegation of responsibility. Lawyers should not transfer responsibility for the accuracy of legal research or legal reasoning to AI tools. The duty of care remains with the professional using the technology (Tyrie, 2025). Research on AI and legal tasks similarly warns that tasks requiring judgment, creativity, prediction, or contextual evaluation are more difficult to assess than routine information-processing tasks (Kapoor et al., 2024).

Another challenge is inadequate training and governance. Many legal professionals still lack a clear understanding of how AI works, what its limitations are, and how it should be used responsibly. AI literacy, internal policies, and continuing professional education are therefore essential.

Conferences, seminars, and structured internal training can help lawyers use AI more correctly and effectively (Couture, 2025; Tyrie, 2025).

There is also a broader risk of overdependence. Excessive reliance on AI can gradually erode the human judgment, diligence, and care that define the legal profession. Convenience should not replace critical thinking. This is why law firms need internal procedures that distinguish between low-risk administrative tasks and high-risk tasks involving legal advice, client rights, confidential information, or court submissions (CEPEJ, 2018; Pasquale, 2015).

Table 1

Advantages, pitfalls, and safeguards in the use of AI in legal practice

Area of use	Main advantage	Main pitfall	Suggested safeguard
Legal research	Faster retrieval and comparison of sources (Stefanowicz, 2026; Susskind, 2023).	Fabricated or inapplicable authorities (Choi et al., 2022; Tyrie, 2025).	Mandatory verification in trusted legal databases.
Document review	Efficient processing of large datasets and documents (Abney, 2024; Kapoor et al., 2024).	Missed context, privilege issues, or overbroad reliance on outputs (Kapoor et al., 2024).	Human review of key documents and clear privilege protocols.
Client intake	Improved responsiveness and workflow (Couture, 2025; Stefanowicz, 2026).	Confusion between administrative support and legal advice (Tyrie, 2025).	Clear disclaimers and escalation to qualified lawyers.
Governance and ethics	Support for transparent and accountable processes when properly managed (CEPEJ, 2018; Jobin et al., 2019).	Bias, opacity, confidentiality breaches, and weak accountability (Pasquale, 2015).	Internal AI policies, training, data safeguards, and audit trails.

Note. The table summarises the article's discussion and links practical uses of AI to professional safeguards.

4 Striking the Right Balance

AI offers substantial potential to improve legal service delivery, increase access to justice, and boost efficiency, particularly in routine tasks such as drafting, document analysis, and summarisation. Yet the technology is only as safe as the people and institutions that use it (Tyrie, 2025). This dual character has also been noted in AIJES scholarship on AI and corporate reputation, where the same technology is presented as capable of strengthening organisational processes while also increasing exposure to ethical, transparency, privacy, and accountability risks (Ağtaş, 2025).

The legal profession must therefore strike a careful balance between innovation and control. Responsible integration of AI requires robust safeguards, including internal verification protocols, staff training on technical and ethical limitations, the selective use of legal tools trained on trustworthy datasets, and mandatory human review of all important outputs before they are relied upon in practice or submitted to a court (CEPEJ, 2018; Jobin et al., 2019; Tyrie, 2025).

This balance also requires realistic expectations. AI is most useful when it performs bounded, reviewable, and well-defined tasks. It is less reliable when it is asked to make normative judgments, resolve legal uncertainty, interpret client priorities, or replace strategic decision-making.

The future of legal services will therefore depend not on the simple adoption of new tools but on the profession's ability to integrate them into responsible working practices (Couture, 2025; Susskind, 2023).

In this sense, AI should be understood as an assistive technology. It can enhance legal work, but it cannot replace the professional duties of interpretation, judgment, empathy, and responsibility. The most sustainable approach is neither unconditional enthusiasm nor complete rejection, but disciplined use based on competence, transparency, and accountability.

5 Conclusion

AI is not likely to replace lawyers in the foreseeable future, but it is already changing the way legal services are delivered. When used responsibly, AI can become a transformative tool that supports research, document review, communication, efficiency, and access to justice (Couture, 2025; Susskind, 2023; Tyrie, 2025). The central finding of this article is that the legal value of AI does not lie in autonomous replacement of lawyers, but in the careful redistribution of work: routine, repetitive, and data-intensive tasks can be accelerated, while lawyers can devote more time to interpretation, strategy, ethical reasoning, and client care.

This finding is consistent with previous studies that present AI as a technology with both enabling and disruptive effects. In AIJJS, Minghirași (2025) argues that algorithmic governance challenges established legal concepts and requires renewed attention to fairness, interpretation, and legal accountability. In AIJES, Ağtaş (2025) similarly frames AI as a double-edged tool that can strengthen organisational capacity while also creating reputational and governance risks. The present article extends those discussions to the daily work of lawyers and law firms by focusing on concrete legal tasks such as research, document review, summarisation, contract analysis, and client communication.

The article also upgrades the discussion by linking practical legal uses of AI with professional safeguards. It shows that the main question is not simply whether AI is useful, but under what conditions it can be used safely. The practical answer is that AI should be embedded in a controlled professional environment: outputs should be verified, confidential information should be protected, staff should be trained, and responsibility should remain clearly assigned to human professionals. These safeguards are not optional additions; they are the conditions under which AI can support legal work without weakening professional standards.

When misused, AI can expose lawyers and law firms to serious risks, including professional dishonour, sanctions, wasted costs, confidentiality breaches, and damage to the justice system itself (Tyrie, 2025). These risks are especially severe because legal practice does not tolerate unverified authority, careless handling of client information, or the delegation of professional judgment to opaque systems. AI may produce quick answers, but legal work requires accountable answers.

Future research should examine how law firms are actually adopting AI tools, how professional regulators respond to AI-related misconduct, and how clients understand the use of automated systems in legal service delivery. Further empirical work could also compare the performance of general-purpose and legal-specific AI systems in tasks such as summarisation, case-law retrieval, risk identification, and legal drafting. Such research would help move the debate beyond general expectations and toward evidence-based standards for responsible adoption.

In the longer term, the successful integration of AI into legal practice will depend less on how advanced the technology becomes and more on how effectively the profession adapts its ethical frameworks, governance mechanisms, training, and professional culture. Legal AI should therefore be used to enhance the lawyer's craft, not to replace it. The professional future of law will be strongest where technological innovation remains guided by human judgment, institutional responsibility, and respect for the rule of law.

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UPORABA UMETNE INTELIGENCE ZA PREPREČEVANJE PRANJA DENARJA

THE USE OF ARTIFICIAL INTELLIGENCE IN THE PREVENTION OF MONEY LAUNDERING

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Abstrakt

V članku predstavimo koncept pranja denarja ter raziščemo kako akterji na področju kibernetskega kriminala uporabljajo kripto sredstva in umetno inteligenco za izvajanje svoje dejavnosti in prikrivanje izvora premoženja. Sprva so bila kripto sredstva s strani bank in državnih organov popolnoma neregulirana in nekontrolirana. Omogočala so neposredne transakcije med končnimi uporabniki, brez finančnih posrednikov, na anonimen način. To je ustvarilo visoko tveganje za pranje denarja, zato so zakonodajalci začeli postopoma uvajati omejitve, da bi kontrolirali trgovanje s kripto sredstvi in znali povezati kripto denarnice z identitetami dejanskih lastnikov.

Ugotovimo, da kriminalne združbe razvijajo metode za pranje denarja in opredelimo katere, ter raziščemo, kako organi pregona in zakonodajalci odgovarjajo s protiukrepi ter kakšno vlogo ima pri tem umetna inteligenca.

Ključne besede: pranje denarja, kriptovalute, kibernetski kriminal, umetna inteligenca, agenti UI

Abstract

In this paper, we present the concept of money laundering and examine how actors in the field of cybercrime use crypto assets and artificial intelligence to facilitate their activities and conceal the origin of their wealth. Initially, crypto assets remained largely unregulated and uncontrolled by banks and government authorities, enabling anonymous peer-to-peer transactions without the oversight of financial intermediaries. This lack of transparency created a high-risk environment for money laundering, prompting legislators to gradually introduce regulatory frameworks aimed at monitoring crypto-asset trading and establishing links between crypto wallets and the identities of their actual owners.

Our findings identify and categorize the evolving methodologies developed by criminal organizations for money laundering. Furthermore, we investigate the countermeasures implemented by law enforcement agencies and regulatory bodies, with a specific focus on the pivotal role of artificial intelligence in these illicit financial flows.

Keywords: money laundering, cryptocurrencies, cybercrime, artificial intelligence, AI agents

1 Uvod

V vseh vejah poslovanja, vključno s poslovanjem kriminalnih organizacij, se v današnjem času uporablja umetna inteligenca (UI). Za uspešen pregon vseh vrst kriminala je pomembno, da se UI uporablja tudi za odkrivanje in preprečevanje kriminalnih dejavnosti.

Eden od načinov boja proti vsem oblikam kriminala je preprečevanje pranja denarja. To so aktivnosti, ki kriminalce ovirajo, da pridobljen denar zakonito porabijo ali investirajo v legalne dejavnosti. Preprečevanje pranja denarja otežuje poslovanje kriminalnih združb in posameznikov, vpliva pa na vsakega, tudi poštenega državljana. Banke in druge finančne institucije so dolžne preverjati izvor denarja, komitenti ga morajo pojasniti. Zato je postalo pranje uradnih državnih valut zelo oteženo. Kriminalci iščejo rešitve v kripto svetu.

V članku opisujemo kibernetski kriminal podprt z integracijo umetne inteligence ter pojasnjujemo koncepte pranja denarja, vključno z identifikacijo načinov izvajanja ter mehanizmov za zamejevanje in preprečevanje teh nezakonitih dejavnosti. Hkrati analiziramo kakšen vpliv ima UI na razvoj kibernetske kriminalitete in na poslovanje kriminalnih subjektov. Po drugi strani pa želimo razjasniti, ali UI služi represivnim organom in kakšno vlogo ima na področju preprečevanja pranja denarja s pomočjo kripto sredstev.

2 Kibernetski kriminal

Predstavili bomo kibernetski kriminal, ki je podprt z UI. To je sicer le del dejavnosti kriminalnih združb, a postaja vse bolj obsežen in težko obvladljiv. Kriminalne združbe zaslužijo ogromno denarja, ki ga želijo porabiti za zakonite namene. Zato je pomembna sestavina kibernetskega kriminala pranje denarja, pri čemer v današnjem času pogosto uporabljajo kripto sredstva in UI (Kshetri, 2023; Tropina, 2021).

2.1 Uporaba kriptovalut in umetne inteligence v kriminalne namene

Orodja UI postajajo vse bolj dostopna, razširjena in napredna, zato se njihova uporaba širi v številnih panogah. Uporaba UI se v poslovnem svetu osredotoča na produktivnost in zamenjavo postopkov, ki jih opravljajo ljudje. V zadnjem obdobju žal zaznavamo zaskrbljujoč trend: kibernetski kriminalci uporabljajo UI za implementacijo vedno bolj prepričljivih in personaliziranih prevar, ki jih s pomočjo UI še bolj agresivno širijo. Chainalysis (2025) ugotavlja, da številni kriminalci združujejo uporabo kriptovalut in avtomatizacijo aktivnosti s pomočjo UI za goljufanje v velikem obsegu. Med pogoste prevare, podprte z UI, sodijo globoki ponaredki (ang. deepfake), boti za ribarjenje podatkov (ang. phishing bot), lažne trgovalne platforme, kloniranje glasu in lažno predstavljanje v klepetalnih aplikacijah.

Prevare, podprte z UI, izkoriščajo hitrost, obseg in naprednost sodobnih modelov strojnega učenja (ang. machine learning - ML). Zato so bolj prilagodljive, prepričljivo človeške in težje prepoznavne kot so bile prevare pred uporabo UI (Chainalysis, 2025; Reuters, 2025). Kombinacija uporabe UI in kripto sredstev oz. verig blokov (ang. blockchain) daje kriminalcem veliko novih možnosti izogibanja represivnim organom. Kripto svet je obsežen, decentraliziran, brez nadzornih institucij, hitro se razvija in ni enotno reguliran med jurisdikcijami. V EU imamo precej obsežno uredbo MiCA (Evropski parlament, 2023), v številnih drugih državah (npr. ZDA) je zakonodaja razdrobljena ali je še ni. UI doda dodatno plast zavajanja z možnostmi ustvarjanja lažnih identitet, realističnih pogovorov in spletnih strani, ki so skoraj nerazločljive od pravih.

Goljufi se vse pogosteje zatekajo k UI, ker omogoča razširljivost in avtomatizacijo ter vzbuja videz pristnosti. Chainalysis (2025) na podlagi sledenja kripto plačil ponudnikom orodij UI ugotavlja, da se delež stroškov, ki jih kriminalni akterji namenjajo za implementacijo in uporabo UI orodij, signifikantno povečuje. V omenjeni raziskavi o uporabi UI za kriminalne dejavnosti avtorji ugotavljajo trend neprestane rasti prenesenih sredstev iz kripto denarnic kriminalnih združb v kripto denarnice proizvajalcev orodij UI v zadnjih petih letih, s čimer dokazujejo, da kriminalna podjetja povečujejo

investicije v UI. Ugotovili so, da je v l. 2025 delež prihodkov iz prevar s pomočjo UI narasel na 60%. Ta delež se je povečeval od l. 2021, ko je UI začela prehajati v splošno rabo.

UI nudi orodja, ki izjemno dobro kreirajo realistične, a lažnive vsebine, ki jim rečemo globoki ponaredki (ang. deepfake). Videoposnetki ali slike, ustvarjene z UI, prikazujejo zaupanja vredne javne osebnosti, vplivneže ali direktorje, ki promovirajo lažne kripto projekte ali nagradne igre. Žrtve so pogosto dovzetne za manipulativne tehnike, kar vodi v uspešno izvedbo prevar.

Zaradi uporabe UI je v zadnjem letu izjemno naraslo število prevar s pomočjo ribarjenja podatkov (ang. phishing). O uspešnosti prevarantov poročajo banke, Si-Cert (Si-Cert, 2026) in mediji. Goljufi z UI oblikujejo sofisticirana e-sporočila, lažne spletne strani in neposredna sporočila, ki posnemajo naravni jezik in prilagajajo napade glede na spletno vedenje uporabnika.

UI omogoča težko prepoznavno lažno predstavljanje podpore strankam. Goljufi z UI posnemajo podporne agente borz ponudnikov denarnic ali vzdrževalcev programske opreme ter v realnem času pridobivajo prijavne podatke ali obnovitvene fraze za napade na sisteme ali izvedbo finančnih goljufij. Goljufi uporabljajo trgovalne bote, ki simulirajo uspešne posle ali ponujajo lažne trgovalne signale, da bi uporabnike spodbudili k pologu sredstev ali sledenju vprašljivim finančnim nasvetom. Celotne spletne strani ali mobilne aplikacije temeljijo na prevarantskih algoritmih, podprtih z UI, ki obljubljajo visoke donose, a si prilastijo vložena kripto sredstva (Chainalysis, 2025).

Goljufi uporabljajo slike ali dokumente, ustvarjene z UI, za obhod postopkov identifikacije stranke in dvofaktorske avtentikacije (2FA) (Chainalysis, 2025). To je še posebej zaskrbljujoče, saj z dvofaktorsko avtentikacijo varujemo vstope v spletne in mobilne banke, pa tudi v nekatere druge varnostno pomembne aplikacije.

Vsebina, ustvarjena z UI, daje prevaram stopnjo realizma, ki jo je težko ločiti od legitimne komunikacije. Phishing e-sporočila posnemajo ton uradnih sporočil, lažne spletne strani so podobne pravim investicijskim platformam, globoki ponaredki pa povečujejo verodostojnost objav na družbenih omrežjih. Včasih smo goljufe prepoznali po slabi slovenščini. S prihodom generativne UI je postal jezik prevarantov enak živemu poslovnemu jeziku.

Goljufi danes delujejo z veliko hitrostjo in obsegom. Z UI lahko v nekaj sekundah ustvarijo tisoče personaliziranih sporočil, lažnih profilov ali odzivov v klepetu v več jezikih. Poleg tega lažno predstavljanje identitete in podpore strankam zmanjšuje zanesljivost tradicionalnih metod preverjanja. Logičen sklep je, da mora temu slediti zakonodaja in dejavnosti organov pregona.

V nekaterih kriminalnih dejavnostih, npr. izsiljevanjih (ang. ransomware), je prihodek kriminalcev v kripto sredstvih. Veliko se zasluži s krajami iz kripto denarnic, z DeFI platform (ang. decentralized finance platform) in z goljufivimi finančnimi naložbami. Nekateri kriminalci proizvajajo programsko opremo, prodajajo ukradene podatke ali opravljajo storitve za druge kriminalce in dobijo plačilo v kripto sredstvih (Europol, 2020).

2.2 Pranje denarja

Denar, ki je pridobljen z nelegalnimi aktivnostmi, imenujemo umazan denar. Evropska unija pravno opredeljuje pranje denarja (ang. money loundering) kot ravnanja, ki vključujejo pretvorbo ali prenos premoženja, prikrivanje njegovega izvora ali pomoč pri izogibanju pravnim posledicam (Council of the European Union, 2018). Slovenska zakonodaja določa, da pranje denarja zajema pretvorbo ali prenos sredstev, pridobljenih s kaznivim dejanjem, prikrivanje ali prikazovanje lažnega izvora sredstev ter

pridobitev, posedovanje ali uporabo takšnih sredstev (Državni zbor RS, 2022). Ključni element je torej transformacija umazanega denarja v navidezno zakonit denar.

Nelegalen denar je lahko v gotovini ali pa, kar je vse bolj pogosto, v kripto sredstvih. Če se kripto sredstva ne porabijo za razvoj kriminalne dejavnosti (npr. nakupe programskih orodij, ukradenih podatkov ali storitev na temnem spletu), jih želijo lastniki brez sledu konvertirati v legalen denar.

V teoriji in praksi se pranje denarja najpogosteje opisuje kot proces v treh osnovnih fazah (United Nations Office on Drugs and Crime, n.d.):

- Plasiranje sredstev (ang. placement): nezakonito pridobljen denar se prvič vnese v finančni sistem tako, da se zmanjša tveganje zaznave. Gotovina se npr. položi na bančne račune, razdeli na manjše zneske (ang. structuring) ali pretvori v elektronski denar. Za ta namen se pogosto uporabi posameznike, ki prenašajo sredstva v imenu drugih, tako imenovane denarne mule (ang. money mule).
- Prikrivanje izvora denarja (ang. layering): denar se premika skozi kompleksne transakcije. Opravljajo se večkratni prenosi med računi, med državami in med različnimi finančnimi instrumenti. Pri tem sodelujejo navidezna podjetja (ang. shell companies), offshore jurisdikcije in kripto sistemi. Namen je prikriti sled denarja in otežiti identifikacijo izvora.
- Integracija (ang. integration): denar deluje kot zakonit prihodek in se vrne v legalno ekonomijo, npr. za nakup nepremičnin, investicije, luksuzno potrošnjo.

Kripto sredstva imajo pomembno vlogo pri pranju denarja (FBI, 2012). Njihova ključna prednost za pranje denarja je psevdonimnost (ang. pseudonymity), kar pomeni, da identiteta uporabnika ni neposredno razkrita in se namesto imen uporabljajo psevdonimi. To so naslovi denarnic (ang. wallet addresses) (FATF, 2014). Transakcije na verigah blokov (ang. blockchain) so psevdoanonimne, hkrati pa so podatki na njih popolnoma javni. Vidne so vse transakcije, zneski, čas transakcij in povezani naslovi. Organi pregona so sčasoma odkrili, kako nadgraditi zakonodajo in slediti transakcijam na najpomembnejših verigah blokov. Po sprejetju zakonodaje, ki od menjalnic kriptovalut zahteva identifikacijo stranke (ang. KYC), lahko organi pregona premostijo psevdoanonimnost ter razkrijejo identiteto lastnikov denarnic. Menjalnice iz držav, kjer se zahteva KYC, so zato med kriminalci postale nezaželene. Kripto valute z javnimi podatki, kot sta npr. bitcoin in ethereum, so za pranje denarja postale neprimerne. Kriminalci so se zato preusmerili na t. i. zasebnostne kovance (ang. privacy coins), kjer so transakcije težje sledljive (npr. na Monero in Zcash) ter uvedli metode za preprečevanje sledljivosti in odkrivanja dejanskih lastnikov denarnic (Europol, 2019; Europol, 2020).

Za organe pregona je pomembno, da poznajo aktivnosti in taktike kriminalcev, če se želijo proti njim boriti. Zato morajo vedeti, kako kriminalci uporabljajo kripto sredstva in UI za pranje denarja.

UI sama po sebi ne "pere denarja", vendar omogoča avtomatizacijo, optimizacijo in prikrivanje finančnih tokov, kar bistveno poveča učinkovitost pranja denarja. Regulatorji opozarjajo, da nove tehnologije ustvarjajo nove priložnosti (FATF, 2021). Ključni načini uporabe UI so:

- Avtomatizacija prikrivanja izvora denarja, saj UI omogoča avtomatsko izvajanje velikega števila transakcij, optimizacijo poti prenosa sredstev (npr. med računi ali kripto naslovi). Posledica tega je hitrejše in bolj kompleksno prikrivanje izvora denarja (FATF, 2021).
- Ustvarjanje lažnih identitet (ang. synthetic identity fraud), kjer se UI uporablja za generiranje lažnih profilov in ponarejenih dokumentov, kar omogoča odpiranje računov za pranje denarja (Europol, 2023a).

- Izogibanje sistemom zaznavanja, ker lahko UI analizira, kako delujejo bančni sistemi za preprečevanje pranja denarja (ang. anti money laundering - AML) in kateri vzorci sprožijo alarm. S tem znanjem lahko prilagajajo transakcije, da ne izgledajo sumljive in ostanejo "pod radarjem" (FATF, 2021).
- Upravljanje mrež denarnih mul (ang. money mule), saj UI pomaga koordinirati velike mreže oseb in optimizirati razdelitev sredstev. S tem postane prikrivanje izvora denarja bolj učinkovito (Europol, 2020).
- Generiranje in analiza podatkov: UI omogoča analizo velikih količin podatkov ter iskanje optimalnih poti za skrivanje denarja in izogibanje nadzoru (FATF, 2021).

Ena od storitev, ki jo kriminalci uporabljajo za oteževanje sledenja njihovega kripto prometa, je uporaba mešalnikov (ang. mixer). Kripto mešalnik je storitev, ki združi kripto sredstva več uporabnikov, jih premeša ter nato vrne enakovredno količino sredstev na nove naslove, tako da je bistveno težje slediti izvoru transakcije na verigi blokov (Europol, 2023b). To deluje na naslednji način: uporabnik pošlje kripto sredstva na naslov mešalnika, ki nato združi sredstva številnih uporabnikov, jih razdeli na manjše dele in večkrat premakne. Uporabnik prejme svoja kripto sredstva na drug naslov.

3 Boj proti kibernetskemu kriminalu

Neprestana bitka proti kibernetskemu kriminalu poteka na več načinov.

Izjemno pomembna je preventiva. Uspešno preprečujemo kazniva dejanja kibernetske kriminalitete, kjer je napadalec in žrtev tehnologija. Preventiva pa žal ni dovolj učinkovita, kjer se uporabljajo metode socialnega inženiringa, kar potrjujejo empirični podatki o nenehni rasti goljufij in kaznivih dejanj, ki jih omogočijo uporabniki zaradi svoje naivnosti, pohlepnosti ali neosveščenosti. Upamo pa, da bomo z uporabo UI preprečili več tovrstnih kaznivih dejanj kot jih danes.

Eden od načinov boja proti kibernetskemu kriminalu je, da se kriminalce ujame po kaznivem dejanju, nekje med procesom pranja denarja, jim odvzame nezakonito pridobljena sredstva in obtoži za kazniva dejanja.

3.1 Preprečevanje prevar s pomočjo UI

V poročilih Europola (2020 do 2025) zaznamo moč in nemoč v boju proti kibernetskemu kriminalu. Organi pregona dosegajo uspehe, a hkrati ugotavljajo, da so kriminalci inovativni, imajo velika finančna sredstva in zavidljive tehnične zmogljivosti, tako za uspešne kibernetske napade kot za izogibanje regulatornim in represivnim organom.

Europol opozarja, da UI spreminja organizirani kriminal, a hkrati omogoča učinkovitejši pregon. Analizirajo lahko obsežne digitalne sledi in razvejane finančne tokove. UI omogoča spremljanje transakcij v realnem času, samodejno ocenjevanje tveganja kripto denarnic in prioritetno razvrščanje primerov za preiskovalce (Europol 2025b).

UI povečuje obseg kripto prevar in hkrati otežuje njihovo zaznavanje (Chainalysis, 2025), kar pomeni, da je boj proti kibernetskemu kriminalu iz leta v leto zahtevnejši. Starejši sistemi za odkrivanje goljufij niso bili zasnovani za prepoznavanje prevar, podprtih z UI. Statična pravila in filtri ključnih besed težko zaznajo dinamično, z UI ustvarjeno vsebino, ki se nenehno prilagaja. Zato so nujni obrambni sistemi, podprti z UI (Chainalysis, 2025).

V sodobni kibernetski in finančni varnosti UI deluje forenzično (retrospektivno) in preventivno. Za boj proti porastu kripto prevar, podprtih z UI, preiskovalci uporabljajo napredne tehnike zaznavanja, kot so

prepoznavanje vzorcev, jezikovna analiza in vedenjsko modeliranje (Chainalysis, 2025). Pomembno vlogo pri sledenju finančnih tokov ima analitika verig blokov. Ključno je medsektorsko sodelovanje med varnostnimi podjetji, kripto borzami, regulatorji in organi pregona, ki si izmenjujejo podatke o grožnjah in proaktivno zapirajo prevarantske kampanje.

Cilj preventivnega delovanja je zaznati indikatorje pripravljalne faze kriminala, kot so nenavadno vedenje zaposlenih ali uporabnikov, dostopanje do podatkov, ki niso v domeni njihovega dela, zgodnji poskusi premikanja sredstev ali testnih transakcij ter anomalije v digitalni identiteti (Parimalla idr., 2025). Uporabljajo se vedenjski modeli UI (ang. behavioral AI). UI gradi "normalno" vedenjsko osnovo in zazna odstopanja kot so nenavadni prijavni (ang. login) časi, dostop iz novih naprav, nenadno povečanje privilegijev in neobičajni podatkovni dostopi, kar so zgodnji indikatorji kompromitacije ali zlorabe (Buczak in Guven, 2016). Za analitiko vedenja uporabnikov in sistemskih entitet se UI uporablja za modeliranje "normalnega" vedenja uporabnikov, zaznavanje subtilnih odstopanj in oceno tveganja v realnem času. S tem ne iščejo znanih napadov, ampak odstopanja od običajnega vedenja, kar je lahko indikator za pripravo napada (Khan et al., 2020).

S pomočjo UI zaznavajo kriminalne mreže pred izvršitvijo kriminalnih dejanj. UI gradi relacijske grafe interakcij: uporabnik ↔ uporabnik, uporabnik ↔ sistem, uporabnik ↔ podatki in uporabnik ↔ finančne aktivnosti. Nato modeli, zasnovani na nevronskih mrežah, zaznajo nenavadne povezave, nastajanje sledi omrežij in koordinirano vedenje (Ruff idr., 2021).

3.2 Forenzično preiskovanje

Za učinkovit pregon kibernetskega kriminala je pomembno, da organi pregona združujejo številne obveščevalne podatke: podatke iz verig blokov, podatke o strankah menjalnic, podatke s temnega spleta (ang. darknet), sankcijske sezname in druge podatke. UI povezuje te vire in s pomočjo analitskih metod generira poročila, ki bi jih ročno sestavljali mesece (Europol, 2023b). Europol je s pomočjo digitalne analitike razbil kripto-pralno mrežo vredno več kot 700 milijonov USD, ki je uporabljala lažne menjalnice in globalno prevarantsko infrastrukturo (Europol, 2025a).

Značilnost verig blokov je javna dostopnost in zagotovljena nespremenljivost. Česar s forenzičnimi analizami niso odkrili včeraj, lahko danes ali pa bodo jutri, saj napredek digitalne forenzike in računalniške procesne moči omogoča retrospektivno analizo podatkov, ki so bili v preteklosti zaradi tehnoloških omejitev ali šifriranja nedostopni. Veriga blokov je trajna forenzična evidenca. Implementacija UI je posebej učinkovita v kripto svetu, saj temelji na treh strateških prednostih: milijarde transakcij so analizirane v minutah, za analitiko prijazna struktura verig blokov in transparentnost podatkov (Bhatt in Sharma, 2026). Raziskave opozarjajo tudi na probleme: sistemi za preprečevanje pranja denarja generirajo veliko število napačnih alarmov, kriminalci se hitro prilagajajo ter pravna vprašanja razložljivosti odločitev UI (Bhatt in Sharma, 2026).

Uporabljajo se agenti UI (ang. AI agent). V kibernetskih preiskavah delujejo kot sistemi, ki lahko samostojno zbirajo, analizirajo in korelirajo podatke iz več virov ter predlagajo ali izvajajo preiskovalne korake. Prednost agentov UI je hitro učenje in delovanje z minimalnim ali ničelnim poseganjem človeka. Delujejo na več področjih:

- Avtomatsko zbirajo podatke iz javnih virov in temnega spleta, kjer spremljajo komunikacijo na temnem spletu, preiskujejo, ali so se zaupni podatki pojavili zunaj nadzorovanih sistemov in zaznavajo prodajo ukradenih podatkov.

- Povezujejo identitete in entitete v sistemu: IP naslove, naprave (ang. device fingerprinting), e-sporočila, kripto denarnice in uporabniške račune.
- Analizirajo transakcije in komunikacije.
- Zaznavajo anomalije kot so nenavadni prijavni (ang. login) vzorci, nenavadno premikanje med napravami znotraj omrežja (ang. lateral movement), nepooblaščen prenos podatkov iz organizacije (ang. data exfiltration).

S tem sistemi UI zaznajo zgodnje faze napada in prožijo alarme za dodatne preiskave. Poleg tega rangirajo alarme po tveganju, priporočajo preiskovalne korake in generirajo preiskovalna poročila, kjer navedejo avtomatske povzetke incidentov, časovnice napadov in povezave med entitetami (Nguyen, 2025).

3.3 Preprečevanje pranja denarja

Financial Action Task Force (2019) opozarja, da postaja kibernetska kriminaliteta eden ključnih virov "umazanega" denarja. Obstaja povezava med izsiljevalskimi (ang. ransomware) napadi, kriminalnim tržiščem na temnem spletu, hekerskimi skupinami in financiranjem terorizma (Europol, 2020). Organi pregona se usmerjajo na preprečevanje pranja denarja, kjer je UI nepogrešljivo orodje.

Preprečevanje pranja denarja (ang. anti money laundering – AML) se je resneje pričelo šele po l. 1986, ko je začela nastajati ustrezna zakonodaja, najprej v ZDA (United States Congress, 1986). Prvi globalni pravni instrument je Dunajska konvencija iz l. 1988 (United Nations). Evropska unija je prvo AML direktivo sprejela l. 1991. Med drugim je bila zahtevana identifikacija strank in poročanje o sumljivih transakcijah ter nadzoru finančnih institucij. Danes govorimo o identifikaciji stranke. Zelo pogosto se uporablja kratica KYC (ang. know your customer). Stranka, ki menjavo kriptovalut opravi v eni od menjalnic, ki jih zavezuje zakonodaja proti pranju denarja, ni več anonimna.

V prvih letih preprečevanja pranja denarja je regulatorne organe skrbel promet z drogami in drugimi prepovedanimi substancami ter iz tega pridobljen denar. Z razvojem interneta pa se je pokazalo, da je velik izvor ilegalnega denarja v prihodkih iz različnih aktivnosti kibernetske kriminalitete. Kibernetski kriminalci so začeli uporabljati elektronsko poslovanje za pranje denarja. Šele l. 2000 regulatorji začnejo razumeti, da problem ni omejen na droge in sprejmejo Palermsko konvencijo in protokol proti pranju denarja (United Nations, 2000). Budimpeška konvencija (Council of Europe, 2001) je prvi mednarodni pravni instrument za prepoznavanje digitalne oblike kriminala in njegovega potenciala za finančne zlorabe. Naslednja prelomna točka v razvoju pranja in preprečevanja pranja denarja je pojav kriptovalut. Regulatorji šele po letu 2010 začnejo aktivno povezovati pranje denarja s pomočjo kriptovalut in kibernetsko kriminaliteto.

Organi pregona uporabljajo metodo analize transakcijskega grafa (ang. transaction graph analysis). To je metoda omrežne analize, pri kateri so subjekti predstavljeni kot vozlišča grafa, transakcije med njimi pa kot povezave, z namenom identifikacije vzorcev interakcij, tokov vrednosti ter anomalij v kompleksnih sistemih (Newman, 2018; Akoglu idr., 2015). Medtem ko veriga blokov omogoča analizo transakcijskega grafa (Meiklejohn idr., 2013), šele povezovanje z realnimi podatki omogoča povezovanje digitalnih naslovov s konkretnimi posamezniki ali kriminalnimi skupinami. Taki podatki so KYC evidence menjalnic, IP naslovi, prijave v aplikacije, podatki iz zaseženih naprav, komunikacija na temnem spletu in odprtokodni viri. Kombinacija verižne (ang. on-chain) analitike in zunaj verižnih (ang. off-chain) obveščevalnih podatkov predstavlja ključno metodologijo pri preiskovanju kripto kriminalitete, saj omogoča identifikacijo celotnih kriminalnih omrežij in ne le posameznih transakcij (Meiklejohn idr., 2013). Meiklejohn idr. (2013) so ugotovili, kako je mogoče iz verig blokov pridobiti

realne identitete, a šele z uporabo UI je to postalo v praksi masovno izvedljivo (Europol, 2023b). Europol (2023b) navaja, da sedaj UI analizira, kdo komu pošilja sredstva, zaznava ponavljajoče vzorce in identificira skupine denarnic ter s tem odkrije, kdo je lastnik celotnega omrežja naslovov. Raziskave kažejo, da lahko UI modeli analizirajo milijarde transakcij na verigah blokov in prepoznajo vzorce pranja denarja (Greenberg, 2024).

Organi pregona uporabljajo forenziko na verigah blokov za sledenje sredstvom, pri čemer je ključna uporaba UI sistemov. UI sistemi gradijo grafe transakcij, identificirajo povezane denarnice, odkrivajo "layering" in "mixing" strategije ter rekonstruirajo tok nezakonitega kapitala. Napredni modeli uporabljajo Graph Neural Networks (GNN) (Weber idr., 2019), samonadzorovano učenje in klasifikacijo nezakonitih transakcij (Europol, 2023b). Metode, ki temeljijo na analizi transakcijskih grafov, so del širšega pristopa blockchain forenzike, ki jih uporabljajo organi pregona v okviru blockchain analitičnih orodij (Europol, 2023b; FBI, 2023).

Namesto iskanja konkretnih kriminalcev, UI išče vedenjske vzorce:

- premikanje kriptovalut iz ene verige blokov v drugo (ang. chain hopping) z namenom prikriti sled transakcij. Npr. Bitcoin → Ethereum → Tron → stablecoin → nova denarnica. Vsak skok zmanjša preglednost sledenja.
- uporabo mešalnikov,
- razdeljevanje transakcij (ang. smurfing),
- prehode prek menjalnic.

Novejši sistemi iskanja vedenjskih vzorcev uporabljajo tudi agente, temelječih na velikih jezikovnih modelih (ang. Large Language Model), ki avtomatsko odkrijejo vedenja pranja denarja in pripravljajo analitične razlage oz. poročila za preiskovalce (Lin et al., 2025). Primer takega agenta LLM je Microsoft Security Copilot.

UI deluje kot digitalni preiskovalni partner, ne samo kot orodje. Agenti UI samostojno povezujejo entitete, predlagajo preiskovalne hipoteze, pripravljajo poročila in zmanjšujejo kognitivno obremenitev analitikov (Caudena, 2025).

4 Zaključek

Europol (2023) navaja, da kibernetske kriminalne mreže delujejo kot profesionalna podjetja z delitvijo dela, specializiranimi storitvami in globalnimi partnerstvi. Veliko sredstev vlagajo v raziskave in razvoj dejavnosti, v orodja UI in druge napredne tehnologije, za večanje obsega delovanja, za lažje izogibanje organom pregona in kompleksne načine pranja denarja. Posledično je nujno, da v te tehnologije vlagajo tudi organi pregona ter vzpostavljajo globalno in povezano mrežo delovanja. To zahteva zaposlovanje visokokvalificiranih strokovnjakov za kibernetsko varnost in podatkovno znanost ter znatna finančna vlaganja v razvoj naprednih orodij UI. Vpeljava UI je danes ključna za preventivno odkrivanje verjetnih zlorab, forenzično raziskovanje na verigah blokov, odkrivanje hierarhičnih struktur kriminalnih združb in preprečevanje pranja denarja.

Kibernetska kriminaliteta se z uporabo UI, kljub delovanju organov pregona, še vedno povečuje. S tem se povečujejo potrebe po pranju denarja z uporabo kripto sredstev in UI. Regulatorni organi morajo z zakonodajo slediti tem trendom, organi pregona pa storiti vse, da onemogočajo kibernetski kriminal in poskuse pranja denarja. Ugotovili smo, da se na strani organov pregona uporabljajo sofisticirane metode UI in posebni avtonomni agenti UI. Vendar pa rezultati nakazujejo na verjetno nemoč organov pregona v manjših jurisdikcijah, kot je Slovenija. Omejeni viri otežujejo samostojno obravnavo kompleksnih

incidentov. Za uspešen pregon tehnološko razvite kriminalitete je potrebno obširno in poglobljeno znanje, vlaganje v napredne tehnologije, razvoj metod in agentov UI, globalno delovanje in povezovanje tako znotraj EU kot z organi pregona v drugih državah.

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CHAPTER III:
SUSTAINABLE ORGANISATIONS, GOVERNANCE AND HUMAN-CENTRED DEVELOPMENT

POGLAVJE III: TRAJNOSTNE ORGANIZACIJE, UPRAVLJANJE IN RAZVOJ, OSREDOTOČEN NA ČLOVEKA

VPLIV REGULACIJE NA INVESTICIJE V SONČNE ELEKTRARNE V SLOVENIJI

THE IMPACT OF REGULATION ON INVESTMENTS IN SOLAR POWER PLANTS IN SLOVENIA

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Povzetek

Prispevek obravnava vpliv regulatornih sprememb na investicije v sončne elektrarne v Sloveniji. Namen raziskave je analizirati, kako spremembe zakonodaje, tarifnega sistema in podpornih mehanizmov vplivajo na konkurenčnost in investicijsko odločanje. Metodologija temelji na analizi statističnih podatkov za obdobje 2005–2025 ter primerjalni ekonomski analizi različnih modelov podpor državnega subvencioniranja odkupa električne energije iz sončnih elektrarn in tržnih cen. Poudarek je na analizi regulatornega vpliva prehoda iz podpor električni energiji proizvedeni iz obnovljivih virov energije na samooskrbo z električno energijo iz obnovljivih virov energije. Rezultati kažejo, da regulatorne spremembe povečujejo investicijsko negotovost in pomembno vplivajo na spremembe hitre rasti pa tudi upada v naložbe novih sončnih elektrarn. Prispevek prispeva k razumevanju povezave med regulacijo in ekonomskimi učinki vlaganj v sončne elektrarne.

Ključne besede: regulacija, obnovljivi viri energije, sončna elektrarna, konkurenčnost, ekonomska analiza, ekonomski kazalniki

Abstract

This paper examines the impact of regulatory changes on investment in solar power plants in Slovenia. The purpose of the study is to analyse how changes in legislation, the tariff system, and support mechanisms affect competitiveness and investment decisions. The methodology is based on an analysis of statistical data for the period 2005–2025 and a comparative economic analysis of various models of state subsidies for the purchase of electricity from solar power plants and market prices. The focus is on analysing the regulatory impact of the transition from subsidies for electricity generated from renewable energy sources to self-sufficiency in electricity from renewable energy sources. The results show that regulatory changes increase investment uncertainty and significantly influence both the rapid growth and the decline in investments in new solar power plants. This paper contributes to the understanding of the link between regulation and the economic effects of investments in solar power plants.

Keywords: regulation, renewable energy sources, solar power plant, competitiveness, economic analysis, economic indicators

1 Uvod

Slovenija v zadnjih dveh desetletjih prestaja zahteven prehod z osredotočenega energetskega sistema na fosilna goriva k razpršeni proizvodnji, ki temelji na obnovljivih virih energije. Ključno vlogo pri tej

preobrazbi igra sončna energija, ki je zaradi svoje prilagodljivosti in sestavljivosti postala glavni temelj energetskega prehoda na ravni gospodinjstev. Razvoj tega trga pa ni potekal samodejno, temveč so ga močno oblikovali zakonodajni posegi. Država je s spreminjanjem finančnih spodbud neposredno usmerjala vlaganja in določala dinamiko postavljanja novih zmogljivosti.

1.1 Spremembe zakonodaje in podpornih mehanizmov

Razvoj spodbujanja proizvodnje električne energije iz obnovljivih virov energije, med katere sodijo tudi sončne elektrarne, je v obdobju 2005 in 2025, temeljil na zakonodaji, ki jo je država Slovenija integrirala na podlagi EU direktiv in usmeritev v svoj pravni red. Regulatorna zakonodaja je leta 2004 uvedla pojem kvalificirane proizvodnje električne energije, ki je temeljil na podporni shemi pri odkupu t.i. zelene električne energije (male hidroelektrarne, sončne elektrarne, vetrne elektrarne elektrarne na biomaso, bioplinarne, soproizvodnja toplote in elektrike ipd.). Vlada Republike Slovenije je v obdobju, ko je bila izgradnja malih elektrarn na začetku, uporabila sistem zagotovljene odkupne cene (Feed-in tarifa). Izdala je Sklep o cenah in premijah za odkup električne energije od kvalificiranih proizvajalcev električne energije (Uradni list RS, št. 8/04, 75/06, 65/08). Vlada Republike Slovenije z energetsko politiko in izdano Uredbo o podporah električni energiji, proizvedeni iz obnovljivih virov energije (Uradni list RS, št. 37/09, 53/09, 68/09, 76/09, 17/10, 94/10, 43/11, 105/11, 43/12, 90/12, 17/14, 74/16) dala večjo podporo malim, srednjim in velikim kvalificiranim elektrarnam, kar je spodbudilo eksponentno rast gradenj. Država je nase prevzela tveganje nihanja tržnih cen in vlagateljem jamčila visok donos za vsako proizvedeno enoto energije. To je bila nujna spodbuda, saj je bila tehnologija v obdobju do leta 2010 še izjemno draga. S tehnološkim razvojem in konkurenco na trgu ter ekonomijo obsega vlaganj v sončne elektrarne je prišlo do zniževanja cen nakupa fotovoltaičnih modulov, opreme in storitev temu pa je zamikom sledilo z zamikom državno zniževanje subvencioniranih zagotovljenih odkupnih cen električne energije iz obnovljivih virov energije. Po letu 2013 so zagotovljene cene za proizvodnjo iz sončnih elektrarn prišle na raven, da se je gradnja drastično zmanjšala.

Po usihanju fotovoltaičnega trga je s spremenjeno energetsko politiko Vlada Republike Slovenije, decembra 2015 sprejela regulacijo s t. i. letnim neto merjenjem električne energije z Uredbo o samooskrbi z električno energijo iz obnovljivih virov energije (Uradni list RS, št. 97/15, 32/18, 17/19, 197/20, 43/22, 8/26). Z uveljavitvijo uredbe o samooskrbi se je poudarek s neposrednih denarnih spodbud premaknil na količinsko izravnavo porabe in proizvodnje električne energije. Električno omrežje je dejansko začelo delovati kot brezplačen letni hranilnik energije. To je korenito spremenilo vlagateljsko logiko: donosnost ni bila več odvisna od prodaje presežkov, temveč od prihrankov pri nakupu elektrike.

Prenos evropskih usmeritev v slovenski red je prinesel zahtevo za ukinitev obdobja letnih poračunov električne energije. Novi model z mesečnim obračunom električne energije v letu 2025 in uvedba petih časovnih blokov za omrežnino (po metodologiji Agencije za energijo RS) vlagatelje sili v aktivno upravljanje lastne porabe.

1.2 Namen in cilj raziskave

Namen raziskave je preučiti dolgoročni vpliv zakonodajnih sprememb na gospodarsko upravičenost naložb v male sončne elektrarne (moči 10 kW). Raziskava išče odgovor na vprašanje, ali tehnološki napredek in upad cen sestavnih delov uspešno uravnotežita postopno opuščanje ugodnih sistemskih spodbud.

Cilji raziskave so izdelati ekonomsko analizo za naložbe v petih prelomnih letih (2005, 2010, 2015, 2020 in 2025) z ekonomskimi kazalniki.

1.3 Hipoteze

Na podlagi predhodnih študij in teoretičnih izhodišč energetske ekonomike (Bojnec, Papler, 2011, Bojnec, Papler, 2012, Papler, 2018, Papler, Blatnik, 2024) postavljamo naslednje hipoteze:

H1: Zakonodajne spremembe imajo vpliv na oblikovanje dinamike proizvodnih in prodajnih cen električne energije

H2: Tehnološki upad stroškov je spodbudil znižanje cen za naložbe v sončne elektrarne

H3: Regulacija ima močan vpliv na preobrazbo poslovnega modela in na ekonomske učinke naložbe.

2 Teoretična izhodišča

Osrednja predpostavka za analizo donosnosti sončnih elektrarn je nenehno zniževanje stroškov, ki ga prinašata večji obseg svetovne proizvodnje in tehnološki napredek. Po podatkih Mednarodne agencije za obnovljive vire energije (IRENA, 2024) so se svetovni povprečni stroški proizvedene električne energije iz sončnih elektrarn med letoma 2010 in 2023 znižali za približno 90 %.

Ta izjemen upad je v Sloveniji omogočil prehod iz obdobja, ko so bile naložbe povsem odvisne od državnih pomoči, v čas, ko je lastna proizvodnja postala gospodarsko povsem primerljiva z nakupom elektrike s trga. Raziskave (Schmidt in sodelavci, 2017) ob tem izpostavljajo, da se niso znižale le cene samih fotovoltaičnih celic, temveč so postali dostopnejši tudi spremljajoči stroški, kot so načrtovanje, namestitev in urejanje vse potrebne dokumentacije.

Kot navajajo Couture in sodelavci (2010), so zagotovljene odkupne cene najuspešnejši mehanizem za hiter prodor tehnologije, saj vlagatelju zagotavljajo dolgoročno stabilnost denarnega toka. V Sloveniji je to obdobje (2009–2014) zaznamovala Uredba o podporah električni energiji, proizvedeni iz obnovljivih virov energije, ki je temeljila na predpostavki, da mora država pokriti razliko med tržno ceno in dejanskimi stroški proizvodnje.

Raziskave (Gautier in sodelavci, 2018) kažejo, da model Net-metering (letno neto merjenje s količinsko izravnavo) deluje kot posredna spodbuda, pri kateri javno omrežje prevzame vlogo hranilnika energije. Zakonodaja v Sloveniji (Uredbo o samooskrbi z električno energijo iz obnovljivih virov energije, 2015) je s tem modelom poudarek z neposrednih denarnih izplačil prenesla na zmanjševanje lastnih stroškov, kar je korenito spremenilo vlagateljsko logiko gospodinjstev.

Najnovejša zakonodajna smer, ki jo narekujejo evropske uredbe (Direktiva EU 2019/944), prinaša prelom s prejšnjimi modeli. Namesto količinske izravnave, ki je omrežje obravnavala kot statičen hranilnik, novi model dejanskega obračuna (Net-billing) temelji na ločenem vrednotenju oddane in prejete energije.

3 Metodologija

Znanstveni pristop raziskave temelji na ekonomski analizi naložbe v sončno elektrarno instalirane moči 10 kW za gospodinjstvo v Sloveniji. Parametri dimenzioniranja sončne elektrarne temeljijo na predpostavkah povprečnega sončnega obsevanja v Sloveniji s 1.050 obratovalnih ur (kWh/kW) v čemer je upoštevan odklon od idealne lega stavbe na kateri je nameščena sončna elektrarna in naklon sončnih modulov na strehi. Upoštevana je degradacija fotovoltaičnih modulov z 1-odsotnim upadom učinkovitosti fotovoltaičnih modulov (do vrednosti 80 %). Upoštevani so stroški za zamenjavo razsmenika v 12. in 22. letu obratovanja elektrarne. Cene za izgradnjo in vzdrževanje sončne elektrarne so upoštevane na podlagi izkustvenih podatkov ponudnikov in investitorjev (Papler, 2012). Cene za

zagotovljeno električno energijo so upoštevane po Uredbi o podporah električni energiji, proizvedeni iz obnovljivih virov energije, po Uredbi o samooskrbi z električno energijo iz obnovljivih virov energije in po cene električne energije za gospodinjske odjemalce po podatkih portala Si-Stat, Statističnega urada RS (SURS, 2026). Z opisno statistiko analiziramo dinamiko proizvodnih in prodajnih cen električne energije.

Za vsak model sončne elektrarne zgrajen in vključen v distribucijsko električno omrežje, v opazovanem letu, smo izdelali simulacijo denarnega toka za življenjsko dobo elektrarne 25 let.

Model upošteva tri različne zakonodajne okvire: a) obdobje zagotovljenih cen, kjer prihodki temeljijo na prodaji celotne proizvedene energije po subvencioniranih cenah, b) obdobje letnega neto merjenja, kjer denarni tok predstavljajo prihranki od lastne proizvedene električne energije (zaradi neplačevanja stroškov nakupa energije in omrežnine), c) obdobje tržnega obračuna (2025), kjer se upošteva mesečni obračun proizvedene/oddane električne energije v omrežje in nov tarifni sistem za omrežnino (5 časovnih blokov).

Ključni ekonomski kazalniki so:

- Neto sedanja vrednost (NSV) je razlika med sedanjo vrednostjo prilivov in sedanjo vrednostjo odlivov ter prikazuje absoluten donos investicije; upošteva vse denarne tokove investicije, vrednost denarja v času in strošek kapitala. Izračunana pri 4-odstotni diskontni stopnji, ki odraža povprečne stroške kapitala za gospodinjstva.
- Interna stopnja donosnosti (ISD) predstavlja dejansko donosnost naložbe. Uporabljena za primerjavo donosnosti med obdobji ne glede na višino začetnega vložka.
- Enostavna doba vračanja naložbe (EVS) pove pričakovano število let, potrebnih za povrnitev začetnega investicijskega izdatka, ali z drugimi besedami, kako hitro bodo neto denarni tokovi, ki bodo posledica investicije, povrnili začetni vložek (Papler in Bojnec, 2022, str. 61).
- Diskontirana doba vračanja naložbe (DVS) je podobna metodi dobe vračanja vloženih sredstev. Razlika je v tem, da se uporabi diskontirane neto denarne tokove. Pokaže leto preloma po pokritju zahtevane donsonosti kapitala in dolgov.
- Kazalnik gospodarnosti ali ekonomičnosti (E) oblikuje odnos med psolobvnimi učinki in sttroški. Vrednost kazalnika ekonomičnst E naj bo večja od 1, kar pomeni, da poslujemo z dobičkom.
- Kazalnik donosnosti ali rentabilnosti naložbe (D) je kriterij, ki pokaže letni donos v odstotku od vlaganja kapitala. Razmerje med učinkom in vloženimi sredstvi. Kazalec pove koliko dobička ustvari vsak vložen EUR.
- Kazalnik donosnosti odhodkov ali rentabilnost vseh sredstev (Do) pokaže letni donos v odstotku od skupnih odhodkov za naložbo (Papler in Bojnec, 2012, str. 82).

4 Rezultati

4.1 Dinamika proizvodnih in prodajnih cen električne energije

Testiramo hipotezo H1: Zakonodajne spremembe imajo vpliv na oblikovanje dinamike proizvodnih in prodajnih cen električne energije z opisno statistiko.

Začetki slovenske fotovoltaike so vezani na sistem zagotovljenih cen, ki ga je upravljal Center za podpore Borzen. Pregled parametrov regulatornega mehanizma v sončno elektrarno moči 10 kW, ki ga je upravljal Center za podpore pri Borzenu (2005-2014), Eko sklad (2015-2024) in Borzen (2025) po obdobjih prikazuje tabela 1.

Tabela 1

Pregled parametrov regulatornega mehanizma v sončno elektrarno, moči 10 kW, po obdobjih

Leto naložbe	Glavni mehanizem	Prejeti znesek / Prihranek	Vir spodbude
2005	Zagotovljena cena	0,21489 EUR/kWh (fiksno)	Borzen
2010	Zagotovljena cena	0,41546 EUR/kWh (fiksno)	Borzen
2015	Letni obračun	0,16150 EUR/kWh (prihranek)	Eko sklad
2020	Letni obračun	0,15710 EUR/kWh (prihranek)	Eko sklad
2025	Mesečni obračun	Tržna cena / viški – 0,19750 do 0,21280 EUR/kWh (nakup)	Borzen

Vir: Borzen (2005, 2010, 2025), Eko sklad (2015, 2020)

S sprejetjem Uredbe o podporah električni energiji, proizvedeni iz obnovljivih virov energije (Uradni list RS, št. 37/09) je bila zagotovljena podporna shema z zagotovljenimi odkupnimi (ali obratovalnimi podporami in lastnim trženjem) za obnovljive vire za 15 let in za soproizvodnjo toplote in elektrike za 10 let. V Tabeli 2 je prikazana analiza cen za proizvedeno električno energijo v sončni elektrarni moči 10 kW glede na leto začetka obratovanja in vključitev v podporno shemo (do leta 2014) oz. prihranka za samooskrbno porabo električne energije za lastno gospodinjstvo z upoštevano ceno najštevilčnejše skupine za gospodinjstvo DC s porabo 2500 do 5000 kWh.

Tabela 2

Analiza cen za proizvedeno električno energijo v sončni elektrarni, moči 10 kW glede na leto začetka obratovanja

Parameter	2005 (Fit)	2010 (Subvenc.)	2015 (Net-metering)	2020 (Tržna/Net-metering)	2025 (Dinamična)	2026 Cena za gospodinjstvo DC – I. kvartal
Št. let obratovanja	22	17	12	7	2	-
Min. cena	0,19750	0,19750	0,15710	0,15710	0,19750	-
Max. cena	0,41546	0,41546	0,21280	0,21280	0,21280	-
Povprečna cena	0,35876	0,39072	0,17701	0,18739	0,20515	0,21280
Indeks s stalno osnovo (2026)	168,59	183,61	83,18	88,06	96,41	100,00
Gibanje cen glede na l. 2026	68,59	83,61	-16,82	-11,94	-3,59	0,00

Vir: Lastni

Pri sončni elektrarni zgrajeni leta 2005 se je po Sklepu o cenah in premijah za odkup električne energije od kvalificiranih proizvajalcev električne energije zagotavljala cena 0,21489 EUR/kWh, električne, od leta 2007 0,39957 EUR/kWh in od leta 2009 po sprejemu Uredbe o podporah električni energiji, proizvedeni iz obnovljivih virov energije 0,41546 EUR/kWh. Po 15 letih je prešla na tržno ceno. Povprečna cena je bila za 22 let obratovanja 0,35876 EUR/kWh, ki je v primerjavi s tržno ceno DC za 1. kvartal leta 2026 za 68,59 % višja.

Pri sončni elektrarni zgrajeni leta 2010 je bila cena po Uredbi o podporah električni energiji, proizvedeni iz obnovljivih virov energije 0,41546 EUR/kWh. Po 15 letih je prešla na tržno ceno. Povprečna cena je

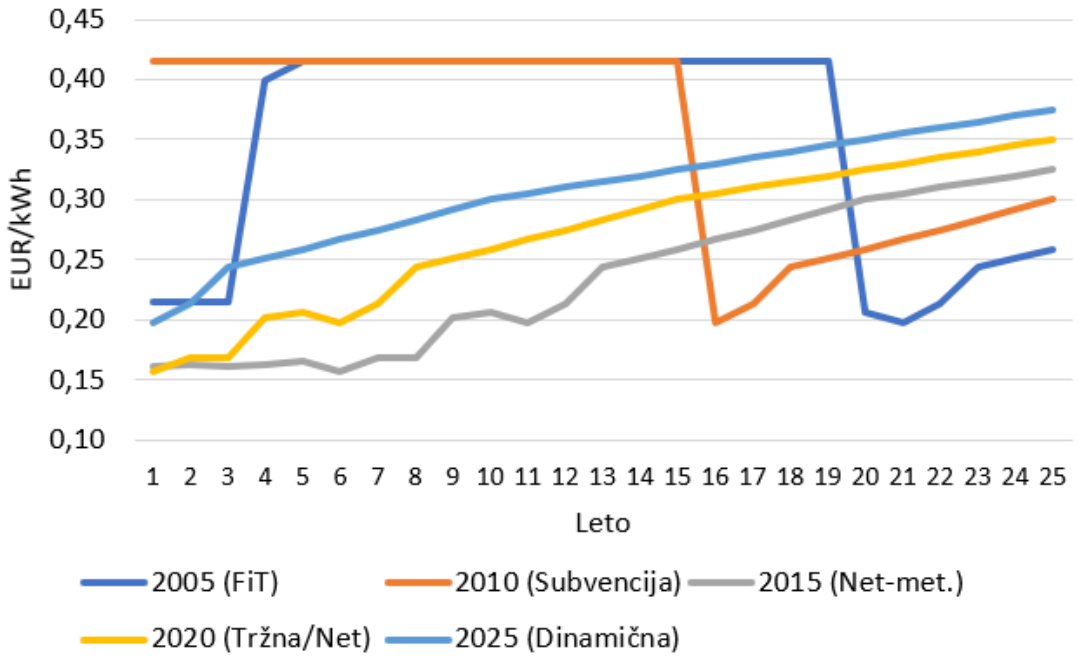
bila za 17 let obratovanja 0,39072 EUR/kWh, ki je v primerjavi s tržno ceno DC za 1. kvartal leta 2026 za 83,61 % višja (Tabela 2).

Po letu 2015 so cene za zagotovljen odkup električne energije nadomestili prihranki. Pri sončnih elektrarnah zgrajenih leta 2015 in leta 2020 po Uredbi o samooskrbi z električno energijo iz obnovljivih virov energije o podporah električni energiji, proizvedeni iz obnovljivih virov energije iz leta 2015, je cena prihrankov po podatkih Si-Stat, SURS za ceno DC za 1. kvartal leta 2026.

Od leta 2025 je cena električne energije za gospodinjstvo dinamična glede na nove pogoje tarifnega sistema in omrežnine v petih blokih in sprotnega mesečnega obračuna.

Slika 1

Referenčne cene za vrednotenje proizvedene energije iz sončnih elektrarn



Vir: Papler (2026)

V obdobju 2010–2018 je bila značilna stagnacija cen. Stabilne cene so bile okoli 0,16 EUR/kWh. Energetska kriza v obdobju 2021-2023 je povzročila ekstremna nihanja, ki bi brez vladnih zamejitev cene od 0,20 do 0,21 EUR/kWh potisnila preko 0,25 EUR/kWh. Nova realnost je nastopila v obdobju 2024–2025 z novo omrežninsko metodologijo se dejanska cena (z vsemi dajatvami) stabilizirala pri ceni 0,20–0,22 EUR/kWh, kar povečuje vrednost lastne proizvodnje električne energije iz sončnih elektrarn.

Analiza kaže, da se je država na padec cen tehnologije odzvala s postopnim umikanjem neposrednih plačil za proizvedeno energijo in prehodom na spodbude za postavitev aktivnih upravljalskih naprav. Te zdaj usmerjajo trg v večjo odgovornost (uporaba hranilnikov, prilagajanje porabe). Leto 2025 ne pomeni konca donosnosti, temveč konec obdobja, ko je elektrodistribucijsko omrežje brezplačno opravljalo vlogo sezonskega shranjevanja energije.

Ugotovitve:

- Zakonodajna podlaga: Uredbe o podporah električni energiji iz obnovljivih virov so vlagateljem zagotavljale fiksne prihodke za obdobje 15 let.

- Višina spodbud: V letu 2005 je zagotovljena odkupna cena znašala 0,21489 EUR/kWh do leta 2010 pa se je povečala na 0,41546 EUR/kWh (Borzen, 2010).
- Učinek: Visoka donosnost je povzročila izjemen naložbeni val, ki se je končal z drastičnim znižanjem in končno ukinitvijo podporne sheme za nove sončne elektrarne v letu 2014.

4.2 Znižanje cen za naložbe v sončne elektrarne

Testiramo hipotezo H2: Tehnološki upad stroškov je spodbudil znižanje cen za naložbe v sončne elektrarne z opisno statistiko in analizo trenda.

V opazovanem obdobju 2005–2010 so bili najizrazitejši padci cen tehnologije za fotovoltaiko. V obdobju 2005–2010 so stroški za 10 kW sončno elektrarno znašali med 5.500 EUR/kW in 3.500 EUR/kW. Visoka cena je bila posledica nerazvitega trga in visokih proizvodnih stroškov silicijevih celic. V obdobju 2015–2020 so z vzponom masovne proizvodnje stroški padli na 1.150 EUR/kW do 1.500 EUR/kW (Tabela 3). V obdobju 2024–2025 se je naložba v sončno elektrarno (brez hranilnika) gibala med 800 EUR/kW in 1.000 EUR/kW; naložba v sončno elektrarno s hranilnikom pa je bila 1.650 EUR/kW. Tehnološki napredek fotovoltaičnih celic z izkoristki nad 22 % je nevtraliziral inflacijske pritiske po letu 2022.

Tabela 3

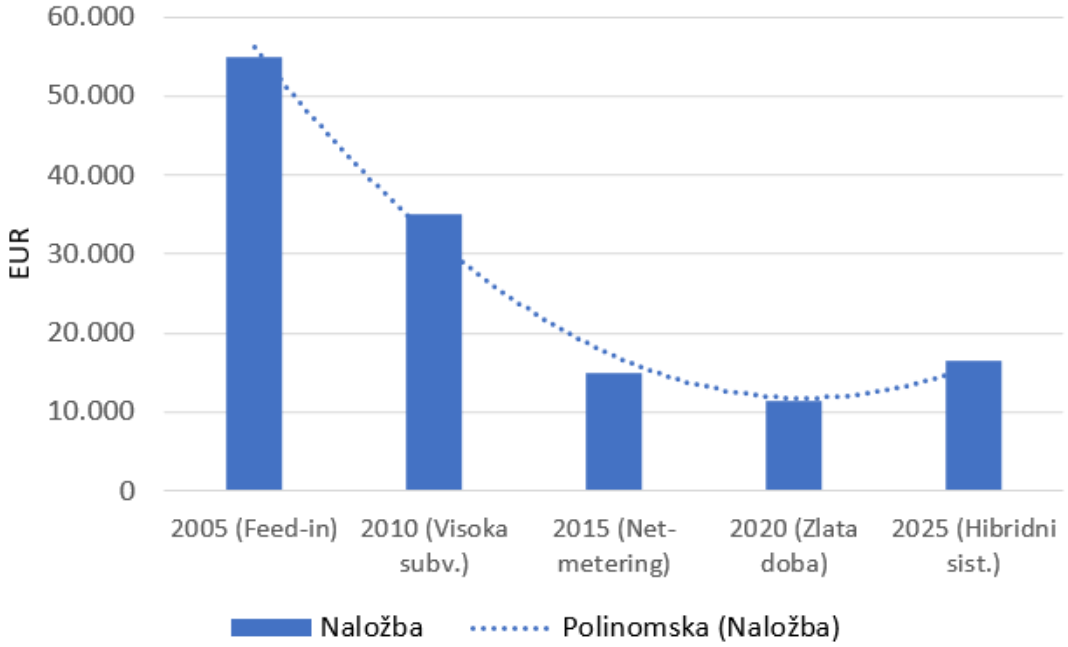
Gibanje cen za naložbo v sončno elektrarno moči 10 kW, po obdobjih

Parameter	2005 (Feed-in)	2010 (Subvenc.)	2015 (Net-metering)	2020 (Tržna/Net-metering) – Zlata doba	2025 (Hibridni sistem)	Opomba 2025
Naložba (EUR)	55.000	35.000	15.000	11.500	16.500*	*Sončna elektrarna 10 kW z vgrajenim hranilnikom
Spec. cena (EUR/kW)	5.500	3.500	1.500	1.150	1.650*	
Indeks s stalno osnovo (2020)	478,26	304,35	130,43	100,00	143,48	
Gibanje cen glede na l. 2020	378,26	204,35	30,43	0,00	43,48	

Slika 2 prikazuje vrednost naložbe v sončno elektrarno zgrajene in priključene v obratovanje v letih 2005, 2010, 2015, 2020 in 2025. Tehnološki upad stroškov za naložbo v sončno elektrarno se je od leta 2005 do leta 2020 znižal za 4,8-krat. Padanje cen prikazuje polinomska trendna črtkana črta.

Slika 2

Naložba v sončno elektrarno instalirane moči 10 kW v različnih časovnih obdobjih



Vir: Papler (2026)

4.3 Ekonomski učinki naložbe v sončno elektrarno

Z ekonomskimi metodami testiramo hipotezo H3: Regulacija ima močan vpliv na preobrazbo poslovnega modela ima ekonomske učinke naložbe.

4.3.1 Analiza denarnih tokov in finančni rezultati

S pomočjo metode denarnih tokov ugotavljamo finančno uspešnost 10 kW sončne elektrarne. Analiza temelji na predpostavki 25-letne življenjske dobe, upoštevanju 4 % diskontne stopnje in stroškov vzdrževanja (menjava razsmernika v 12. letu).

Diskontna stopnja uporabljena pri izračunu neto sedanje vrednosti projekta predstvalja alternativno obrestno mero s katero banke obrestujejo dolgoročne naložbe (Bizjak, 2008, str. 246). V našem primeru je izbrana diskontna stopnja 4 % kot povprečne cene kapitala za gospodinjstva.

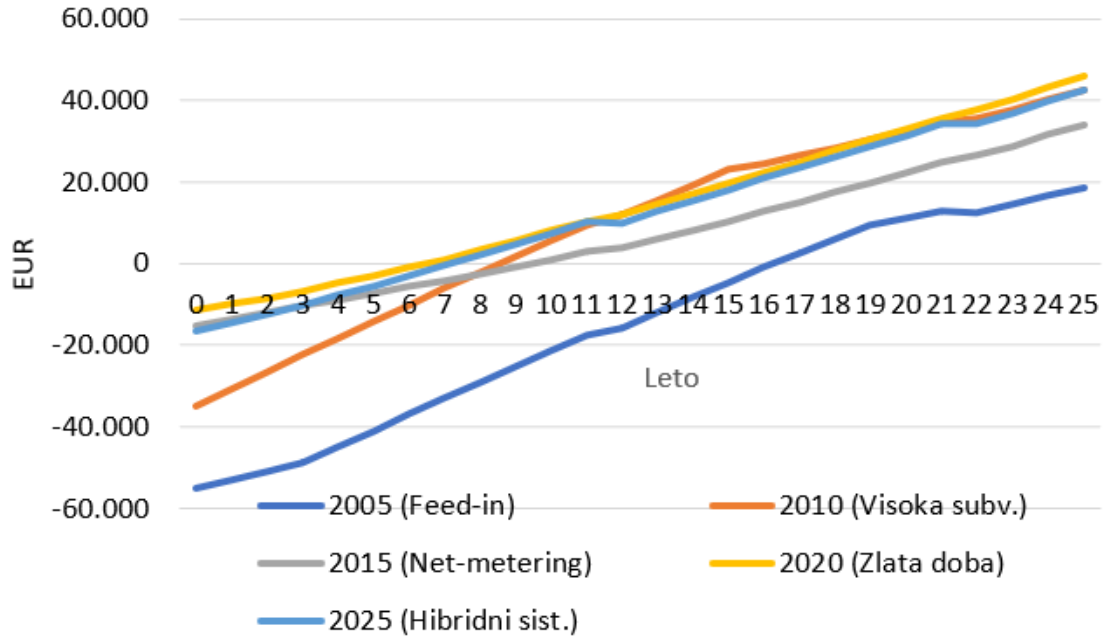
Slika 3 prikazujejo kumulativne neto denarne tokove (v EUR). Pri modelih za zagrajeno sončno elektrarno leta 2005 in leta 2010 so vir prihodka zagotovljene odkupne cene električne energije (Feed-in), pri modelih 2015–2025 pa prihranki pri stroških za nakup električne energije (Net-metering).

Leta 2005 (model zagotovljenih cen) je bila naložba ekstremno draga, a so jo podpirale izjemno visoke subvencionirane odkupne cene za dobo 15 let. Po 15. letu je sončna elektrarna obratovala po tržnih cenah. Leta 2010 je bil vrhunec subvencioniranih cen za zagotovljen odkup električne energije iz sončnih elektrarn. Po letu 2015 je sledil prehod na samooskrbo. Prihodki so obravnavani kot prihranki ("izognjeni stroški" na položnici). Leta 2020 je bilo najugodnejše razmerje med nizko ceno naložbe in ugodnim sistemom letnega poračuna oddaje viškov električne energije iz sončne elektrarne v distribucijsko omrežje (poletni meseci) in porabo električne energije iz omrežja (zimski meseci). Leta 2020 je bil vrhunec sistema (“zlata doba”) neto merjenja proizvedene električne energije iz sončne

elektrarne in oddane v distribucijsko omrežje ter ob potrebah uporabnika v obratni smeri. Model za leto 2025 vključuje 30 % neposredne porabe električne energije in prodajo viškov po tržni ceni.

Slika 3

Kumulativni denarni tok za naložbe v sončne elektrarne instalirane moči 10 kW zgrajene v letih 2005, 2010, 2015, 2020 in 2025



Vir: Papler (2026)

Iz slike 3 denarnih tokov je razvidno, da se je narava donosnosti korenito spremenila. Medtem ko so modeli 2005 in 2010 ustvarjali visoke denarne tokove neposredno iz državnih sredstev, modeli samooskrbe 2015 in 2020 prihranke pri neposrednih tekočih stroških v gospodinjstvih, model 2025 zahteva bistveno večjo stopnjo optimizacije. Pri njem je ključno tveganje razkorak med tržno ceno viškov in maloprodajno ceno nakupa.

4.3.2 Ekonomska analiza modelov naložb v sončne elektrarne

Za celovito primerjavo smo uporabili nabor ključnih ekonomskih kazalnikov, ki obravnavajo likvidnost, donosnost in učinkovitost uporabljenega kapitala. Pri izračunih so upoštevane neto naložbe (z odštetimi spodbudami), vsi operativni stroški ter časovna vrednost denarja s 4-odstotno diskontno stopnjo.

Tabela 4

Primerjalna analiza ekonomskih kazalnikov za sončno elektrarno moči 10 kW, po obdobjih

Ekonomski kazalniki	2005 (Feed-in)	2010 (Subvenc.)	2015 (Net-metering)	2020 (Tržna/Net-metering) – Zlata doba	2025 (Hibridni sistem)
Neto sedanja vrednost – NSV (EUR)	-7.355,64	17.240,36	14.231,15	22.902,44	13.362,30
Interna stopnja donosnosti – ISD (%)	2,60	9,15	10,74	16,70	10,88
Enostavna doba vračanja –EVS (št. let)	26,11	8,21	9,40	7,42	9,86

Diskontirana doba vračanja (DVS) (št. let)	27,16	8,54	9,78	7,72	10,25
Kazalnik ekonomičnosti ali gospodarnosti – E (-)	0,88	1,45	1,81	2,64	1,45
Kazalnik donosnosti ali rentabilnost naložbe – D (%)	-13,37	49,26	94,87	199,15	80,98
Kazalnik donosnosti vseh sredstev – Do (%)	-12,47	45,34	81,30	163,54	45,10

Vir: Lastni

Enostavna doba vračanja (EVS) naložbe neposredno zrcali tehnološki napredek. V letu 2005 je bila najdaljša enostavna doba vračanja naložbe (26,11 let) preko meje konca življenjske dobe naprave, kar je pomenilo visoko tveganje. S spodbudami subvencioniranih cen in padanjem cene naložb se je leta 2010 doba vračanja naložbe bistveno skrajšala (8,21 let). Leto 2020 predstavlja najugodnejšo dobo vračanja (7,42 let) zaradi izjemnih ugodnosti letnega neto merjenja, ki je ob uvedbi imel dve leti daljšo dobo (9,40 let). V letu 2025 se zaradi prehoda na mesečni obračun doba podaljša (9,86 let), kar pa je z vidika konfliktov v svetu, posledične energetske krize in naraščanje cen električne energije še vedno alternativna rešitev zagotavljanja električne energije.

Neto sedanja vrednost (NSV) prikazuje, koliko bogastva projekt ustvari nad zahtevano 4-odstotno donosnostjo: leto 2010 izstopa z najvišjo absolutno NSV (17.240 EUR), kar pojasnjuje takratno naložbeno mrzlico, ki so jo poganjale visoke zagotovljene odkupne cene. Leto 2020 dosega s simulacijo prihrankov najvišjo NSV (22.902,44 EUR), kar kaže na največjo učinkovitost naložbe (Tabela 4).

Leta 2025 Interna stopnja donosnosti (ISD) v višini 10,88 % potrjuje, da so sončne elektrarne kljub strožji zakonodaji še vedno donosnejše od večine konzervativnih finančnih naložb (npr. bančnih depozitov ali obveznic).

Kazalnik ekonomičnosti (E = Skupni prihodki / Skupnimi odhodki) kaže, da projekt v sončno elektrarno iz leta 2020 za vsak vložen evro vrne 2,64 evra, medtem ko projekt iz leta 2025 vrne 1,45 evra. Donosnost vseh sredstev (Do) najbolje ponazarja dolgoročno uspešnost: medtem ko je naprava iz leta 2005 v svoji dobi komaj povrnila 87,53 % čistega dobička glede na začetni vložek, naprava iz leta 2020 ustvari preko 163,54 % donosa.

5 Diskusija

Potrdili smo hipotezo H1, da imajo zakonodajne spremembe vpliv na oblikovanje dinamike proizvodnih in prodajnih cen električne energije.

Primerjava med leti 2005, 2010, 2015, 2020 in 2025 razkriva strukturni premik v razumevanju sončne elektrarne: iz finančnega instrumenta za doseganje državnih subvencij se je preoblikovala v nujno tehnologijo za obvladovanje stroškovne nestanovitnosti gospodinjstva.

Analiza potrjuje, da tehnološki napredek sam po sebi ni bil zadosten za stabilno rast trga; šele ugodne regulatorne rešitve (kot je bil Net-metering) so naložbo naredile dostopno širšemu krogu gospodinjstev. Podatki kažejo, da je bilo javno omrežje med letoma 2015 in 2024 ključen ekonomski akter, saj je vlagateljem brezplačno nudilo storitev sezonskega shranjevanja energije.

Prevladujoč vpliv zakonodajnih sprememb na tržno dinamiko je pokazal, da je bil zakonodajni okvir glavni povzročitelj nihanj; sistem letnega neto merjenja je predstavljal vrhunec privlačnosti za investitorje.

Potrdili smo hipotezo H2, da je tehnološki upad stroškov spodbudil znižanje cen za naložbe v sončne elektrarne.

Tehnološki upad stroškov je bil dejavnik izravnave spodbud. Upad cen opreme je nevtraliziral umik državnih pomoči.

Potrdili smo hipotezo H3, da ima regulacija močan vpliv na preobrazbo poslovnega modela in dosežene ekonomske učinke naložbe.

Primerjalna analiza potrjuje, da se je doba zagotovljenih donosov končala. Vlagatelj v letu 2025 mora postati dejavni udeleženec na trgu, ki svojo donosnost gradi na čim večji neposredni porabi v času ugodnejših tarifnih blokov, medtem ko je bil vlagatelj v preteklosti predvsem pasivni prejemnik sistemskih spodbud. Ta prehod k dejavnemu upravljanju energije je nujen za dolgoročno vzdržnost celotnega slovenskega elektroenergetskega sistema.

Preobrazba poslovnega modela sledi aktivnemu upravljanju porabe električne energije. Prehod iz pasivnega proizvajalca električne energije v sončni elektrarni zahteva aktivnega uporabnika. Ekonomska vzdržnost postaja odvisna od neposredne porabe in hrambe električne energije.

V letu 2025 ekonomska upravičenost ni več zagotovljena s strani države, temveč je v rokah vlagatelja. Inženirska logika kaže, da integracija hranilnikov in prilagajanje odjema (uporaba toplotne črpalke v času proizvodnje iz sonlne elektrarne) nista več le tehnična izbira, temveč ekonomska nujnost za ohranitev optimalne dobe vračanja sredstev za naložbo.

Podatki potrjujejo, da sončna elektrarna ostaja donosna naložba, vendar se je fokus iz "prodajalca energije" (2005) premaknil v "upravljalca stroškov" (2025).

Donosnost v letu 2025 je strukturno boljša kot v letu 2005. Čeprav so bili nominalni prihodki leta 2005 zaradi visokih subvencij višji, je bila kapitalna intenzivnost (visok začetni strošek) prevelika ovira. Današnji model (2025) temelji na nizkem vstopnem pragu in visoki stopnji samooskrbe, kar naložbo postavlja v varno območje ekonomičnosti, kljub strožjim obračunskim pravilom.

6 Zaključek

Analiza dveh desetletij razvoja fotovoltaike v Sloveniji je razkrila izjemno pot od dragih, subvencioniranih začetkov do današnje tržne zrelosti. Ugotovitve potrjujejo, da se slovenski elektroenergetski trg nahaja na prelomu, kjer sončna elektrarna neha biti le finančni instrument za prejemanje pomoči v obliki zagotovljenih cen iz novih “zelenih energetskih virov,” ampak postaja strateško orodje za aktivno obvladovanje stroškov gospodinjstva. Ključni dejavnik razvoja v obdobju 2005-2025 je bila nenehna tekma med padajočimi cenami tehnologije in regulatornimi vplivi v spreminjajoči zakonodaji, pri čemer se je izkazalo, da je tehnološki napredek v celoti nevtraliziral postopen umik visokih državnih spodbud.

Analiza podatkov v obdobju 2005–2025 kaže na zanimiv ekonomski paradoks. Čeprav se je čas dobe zagotovljenih donosov in brezplačnega sezonskega shranjevanja energije v omrežju končalo, so sončne elektrarne, kljub zmanjšani investicijski aktivnosti, še vedno privlačne in v času zahtevnih razmer, zanimive za vlagatelje. Z interno stopnjo donosnosti, ki se giblje okrog 10 %, fotovoltaika ostaja eden najboljših načinov za zaščito pred inflacijo in nihanjem cen energije na svetovnih trgih. Vendar pa uspeh naložbe v novem sistemu mesečnega obračuna in zapletenejših omrežninskih tarif v petih blokih, ni več samoumeven.

Največji preobrat po ukinitvi letnega obračuna po letu 2024, je prehod iz pasivnega v dejavnega odjemalca električne energije. Zgolj namestitev fotovoltaičnih modulov na streho stavbe ne zadošča več za optimalne prihranke, še posebej pri gospodinjstvih s toplotnimi črpalkami. Zaradi velike časovne neusklajenosti med poletno proizvodnjo in zimsko porabo električne energije, so rešitve z vgradnjo baterijski hranilnikov energije, ki so dobili v okviru regulatornih ukrepov močno podporo s subvencijami, ki jih nudi Borzen. Prav tako so postali pomembni sistemi za pametno upravljanje porabe električne energije.

Prihodnost samooskrbe iz sončnih elektrarn ni samo v tehničnem zagotavljanju električne energije, ampak v pametni sinergiji med proizvodnjo, hrambo in prilagajanjem odjema. Slovenija je uspešno prešla pot od subvencioniranih začetnih korakov do ekonomsko vzdržnega modela, ki vlagatelja spodbuja k odgovornejšemu ravnanju z energijo. Sončna elektrarna tudi po letu 2025 ostaja varna in donosna izbira, vendar zahteva vlagatelja, ki razume izrabo sončne energije za proizvodnjo električne energije in je pripravljen aktivno sodelovati pri upravljanju energije v lastnem gospodinjstvu.

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CORPORATE GOVERNANCE PRACTICES IN SMALL AND MEDIUM-SIZED ENTERPRISES: COMPARATIVE INSIGHTS ACROSS OWNERSHIP TYPES

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Abstract

Corporate governance has become a widely discussed and often controversial topic in both academic literature and the popular press. Corporate governance (CG) refers to the system of control mechanisms that organizations adopt to prevent or discourage managers from engaging in activities that may harm the interests of shareholders and stakeholders. Small and medium-sized enterprises (SMEs) play a significant role in economic development. Transparency represents an essential element of an effective corporate governance system. SMEs are widely considered an important driver of sustainable economic growth, employment generation, and the creation of a dynamic business environment. The main objective of this research is to examine the role of SMEs in the economic development of Albania. In addition, the study aims to evaluate the barriers faced by SMEs and their contribution to creating a positive environment for business development. SMEs are often regarded as an efficient mechanism for generating sustainable economic growth, increasing revenue, and reducing unemployment and poverty. In both developed and developing economies, small and medium-sized enterprises (SMEs) contribute significantly to economic growth by generating added value and fostering innovation. In Albania, SMEs have experienced continuous growth and play an increasingly important role in economic development. The study of SMEs, particularly in relation to corporate governance practices, is essential because these enterprises significantly influence everyday economic activity. The methodology adopted in this research is based on a qualitative approach relying primarily on secondary data analysis.

Keywords: Corporate Governance; Albanian SMEs; Transparency; Business Performance; Boards of Directors.

1 Introduction

The recent global financial crisis made corporate governance issues even more relevant to businesses and society. Corporate governance has become one of the most commonly used terms in the global business vocabulary. Today, small and medium-sized enterprises (SMEs) are vital for economic growth and development in both industrialized and developing countries, particularly in smaller economies such as Albania.

The global financial crisis increased awareness among companies, regulators, and society regarding the potential consequences of weaknesses in the functioning of boards of directors. Boards generally operate under two models: a unitary board structure or a two-tier board system. The board of directors is a crucial component of corporate governance, even within SMEs, although not all SMEs formally establish boards. SMEs provide the majority of employment opportunities and generate a substantial share of value added, turnover, and profits in many economies.

They also play a significant role in exports in developed economies. Small and medium-sized enterprises are widely recognized as important contributors to economic growth, job creation, and innovation (Hallberg, 2001).

In Albania, SMEs dominate the business structure, representing more than 99 percent of registered enterprises and employing approximately 80 percent of the workforce. Corporate governance refers to the framework of rules, relationships, systems, and processes through which authority is exercised and controlled within corporations (OECD, 2015). Effective governance improves transparency, reduces risk, enhances accountability, and facilitates access to external financing (World Bank, 2019). Ownership structures, once characterized as dispersed by Berle and Means (1932), became more concentrated toward the end of the twentieth century.

In transition economies such as Albania, institutional development and regulatory enforcement are still evolving. Several theoretical frameworks are commonly used to analyze corporate governance, including agency theory and transaction cost theory. Transparency is an essential element of a well-functioning corporate governance system. Similarly, risk management and effective internal control systems are crucial components of sound governance. Consequently, governance mechanisms within SMEs are often limited or informal. The global financial crisis highlighted the importance of transparency and effective risk management within corporate governance systems.

In general, definitions of corporate governance in the literature emphasize accountability as a key principle. Corporate disclosure to stakeholders is the main mechanism through which transparency is achieved. This paper aims to analyze corporate governance structures in Albanian SMEs and evaluate their impact on financial sustainability and competitiveness. Modern society operates through corporate entities such as companies, clubs, joint ventures, and partnerships. The objective of this study is to examine the implementation and impact of corporate governance practices in SMEs as an important component of the Albanian economy, focusing on how governance mechanisms influence transparency, accountability, and business performance.

2 Theoretical Frameworks

Modern society operates through corporate entities-companies, clubs, cooperatives, institutions, joint ventures etc. Corporate entities are incorporated to meet the needs pf their members. The board is the linchpin between the members and the management of the enterprise. The financial stakeholders include financial institution and other sources of non-equity (that is non-shareholder) funding. A number of theoretical frameworks have evolved to explain clearly corporate governance. Concretely: Agency theory, transaction cost theory, stakeholder theory. Clearly corporate governance checks and balances can only serve to detect, not cure unethical practices. For example, from a finance or agency theory perspective, the corporate governance problem involves aligning managers' interests with those of their shareholders. Corporate governance as we know is the process of supervision and control intended to ensure the company's management acts in accordance with the interests of shareholders (Parkinson, 1994).

Academic research increasingly highlights the importance of corporate governance in improving transparency, accountability, and long-term organizational performance. In transition and developing economies, governance structures are particularly significant because institutional frameworks and regulatory enforcement are still evolving. Recent studies (e.g., Bulău et al., 2024; Grigorescu, 2025) have examined how governance mechanisms influence managerial behavior, financial stability, and organizational effectiveness. These studies indicate that well-structured governance systems, including

internal control mechanisms and oversight processes, contribute to stronger risk management and improved decision-making within organizations. In addition, recent research has emphasized the relationship between governance practices, ethical management, and organizational resilience, suggesting that firms adopting stronger governance frameworks are better positioned to address economic uncertainties and maintain sustainable growth. These insights support the relevance of analyzing governance practices in small and medium-sized enterprises, particularly in economies undergoing structural transformation such as Albania.

3 Methodology

This study adopts a qualitative research approach based on secondary data analysis to examine corporate governance practices in Albanian SMEs. Qualitative research allows for an in-depth exploration of governance structures, challenges, and their implications for organizational performance in the context of a transition economy (Creswell & Poth, 2018).

Qualitative research typically involves collecting and analyzing non-numerical data, such as documents, reports, and textual materials, in order to understand concepts, experiences, and institutional processes. This approach allows researchers to explore governance practices and identify patterns that may not be visible through purely quantitative methods.

3.1 Data Sources

Data were collected from multiple sources to ensure triangulation and improve the reliability of findings:

- Various reports from the World Bank and INSTAT, which provided macro-level data on SME structures, ownership patterns, and governance practices in Albania (World Bank, 2019; INSTAT, 2023).
- Corporate governance documents, including the OECD Principles of Corporate Governance and various governance codes for unlisted companies, which offered benchmarks for assessing governance standards and institutional expectations (OECD, 2015).
- Literature in the field of corporate governance, including studies on Albanian SMEs, SME behavior, inclusivity, policy responsiveness, and governance in European transition economies, which provided theoretical and empirical insights into governance practices in similar contexts (e.g., Božič et al., 2018; Bîrlădeanu, 2025).

3.2 Governance Dimensions in SME Albania

Changes in the business environment further complicate attempt to identify uniform standard of governance. Some recent trends include the increased prominence of activist investors; environmental, social and governance advocacy; private equity firms, and proxy advisory firms in the governance space. In SME and in the various company the governance system that a company adopts is not independent of its environment. A variety of factors inherent to the business setting shape the governance system. These factors are critical and include societal and cultural values, as well as the efficiency of local capital markets, among others.

These variables as it presented on Table 1 are commonly used in SME governance studies to evaluate oversight, strategic orientation, and operational effectiveness.

Governance theories are conceptual tools developed from systematic observation, critical reasoning, and analytical thinking. Effective corporate governance is vital for all organizations, but it is particularly significant for SMEs due to their smaller scale and concentrated decision-making. This study emphasizes four governance dimensions frequently discussed in SME research:

1. Ownership: Concretely how decision making authority is distributed (OECD, 2015).
2. Family Management: The role of family members in the strategic and operational leadership of a company.
3. Board Structure/Function: The role of boards in management of everyday activity. All directors have equal responsibility as the member of the board.
4. The Control System: Is important part in everyday business of SME. The control of financial statements, operational etc has a great impact in the business of the society.

Table 1

Four dimensions provide a framework for evaluating governance in SMEs.

Variable	Definition / Description	Source
Ownership	Distribution of decision-making authority and control rights among shareholders, shaping strategic direction and accountability.	OECD, 2015
Family Management	Involvement of family members in strategic and operational leadership, influencing commitment, continuity, and potential conflicts of interest.	Božič, Pogačar, & Bokal, 2018
Board Structure/Function	Composition and responsibilities of boards in overseeing daily operations and guiding strategic decisions; all board members share equal governance responsibility.	World Bank, 2019
Control System	Mechanisms for monitoring financial statements, operational activities, and compliance; essential for transparency and sustainable management.	INSTAT, 2017; OECD, 2015

Note: These variables are commonly used in SME governance studies to evaluate oversight, strategic orientation, and operational effectiveness.

4 Analysis of Facts of SME in Albania (2019-2023)

The main characteristic of SME development in Albania is their high concentration in the majour's country's, urban centers. Approximately 50% of these enterprises are located in the Tirana and Durrës regions, while approximately 35% are distributed across Fier, Korçë, Vlorë, and Elbasan. The remaining 15% are situated in smaller cities such as Berat, Dibër, Gjirokastër, Lezhë, and Shkodër. Newly established businesses tend to focus on key sectors of the economy, including services, transport, and commerce. Within the overall structure of enterprises by economic activity, trade and services remain dominant, accounting for roughly 85% of registered enterprises.

As presented in Table 2 SMEs in Albania are the backbone of the economy, dominating in number, employing the majority of the workforce, generating most of the business turnover, and contributing significantly to investments. The trends between 2019 and 2023 indicate **s**light but steady growth in both employment and turnover, underscoring the increasing role of SMEs in economic development.

Table 2

SME performance indicators in Albania, 2019-2023.

Indicator	2019	2023	Source
Share of SMEs in total enterprises	99.8%	99.9%	INSTAT (2020; 2025)
Share of SME employment	81.6%	82.5%	INSTAT (2020; 2025)
Share of SME turnover	78.9%	81.3%	INSTAT (2020; 2025)
Share of SME investments	68.2%	n/a	INSTAT (2020)

Source: INSTAT Albania.

5 How Boards Add Value in Small Companies, Including SME

Small companies tend to be "entrepreneurial" in nature, whereas large companies are more "administrative." Although small-company boards share many functions and attributes with large-company boards, they add value in very different ways (Mintzberg, 1973; OECD, 2015).

Boards of large companies can plan first and then act according to the plan, while boards of entrepreneurial firms need to be in continual motion. By definition, these boards seek growth by pursuing opportunities regardless of the resources currently controlled. Their needs are highly unpredictable, operating in turbulent business environments with both significant opportunities for success and risks of failure (Daily et al., 2003; Zahra & Pearce, 1989).

Alongside operating in an unpredictable environment, these companies typically have fewer experienced managers and more limited internal resources than large firms.Consequently, it is not surprising that SMEs exhibit a different pattern of board activity compared to large corporations, with boards often taking on more hands-on advisory and strategic support roles (OECD, 2015; World Bank, 2019).

5.1 How Boards Operate in Small Companies

The entrepreneurial needs of the small company drive three important aspects of board life that determine whether the board functions properly: how the board operates, the selection of directors, and the compensation of directors.

The smaller board size in SMEs also affects the role of committees and the way boards operate both during and between meetings (OECD, 2015; Daily et al., 2003).

5.1.1 Role of Committees and Board Meetings

The use of board committees has become widespread, so most companies—large and small—now have three basic committees: audit, compensation, and nominating. The governance committee is responsible for identifying, evaluating, and nominating new directors when board seats need to be filled (World Bank, 2019).

Board meetings are presided over by the chair or chairman, who is responsible for scheduling meetings, planning agendas, and distributing materials in advance. Small company boards, on average, meet less often than large company boards (approximately five times annually versus seven), as firms aim to reduce governance-related costs such as travel expenses and meeting fees (OECD, 2015).

In addition, the less predictable nature of small firm operations results in more frequent informal interaction between CEOs and directors outside formal meetings. This is facilitated by the smaller number of directors and more flexible governance structures (Daily et al., 2003). The structure of the

board of directors is generally described in terms of its key attributes, including size, demographic and professional composition, independence from management, number of committees, and director compensation (Božič et al., 2018).

Outside directors in small companies are more actively involved in providing direct support to management compared to those in large firms. They typically contribute in three main areas: access to financing, provision of specialized business knowledge, and facilitation of contracts and external relationships (Bîrlădeanu, 2025; OECD, 2015).

Table 3

Directors' Activities: Small vs. Large Companies

Governance Activity	Small Companies (SMEs)	Large Companies
Number of board meetings per year	5. Range 4–12 meetings per year.	7. Range. 2–13 meetings per year
Length of a typical board meeting	5. Range 1–2 hours	3. Range. 1–9 hours
Number of board committees	Usually 2–3 committees	Usually 3–5 committees
Number of board committee meetings per year	5-6 meetings	10–13 meetings

In building an effective small-company board, chief executive officers and directors should keep in mind two fundamentals: the primacy of shareholders' interests and the uniqueness of smaller firms. In small company's directors often are quite proactive in helping formulate strategy. In the words of one small company director, "I have seen major value added in small organization grow their business and to head off into new directions. This can involve exposing management to new technologies, new services, or new businesses."

6 Discussion/Conclusion

The governance system adopted by a company is not independent of its external environment. A variety of factors inherent in the business environment influence governance structures, including cultural values, regulatory frameworks, and the efficiency of financial markets.

The objective of this study was to examine the importance of corporate governance practices in SMEs and their contribution to improving transparency, accountability, and long-term organizational sustainability. Corporate governance has increasingly been recognized as a crucial framework for guiding managerial behavior, strengthening oversight mechanisms, and protecting the interests of stakeholders (OECD, 2015; Tricker, 2019).

In this context, the study explores key governance characteristics commonly observed in SMEs and discusses how the adoption of more structured governance mechanisms—such as internal control systems and external auditing—may enhance managerial effectiveness and support sustainable business development. By analysing these governance dimensions, the paper aims to contribute to the broader academic discussion on the role of corporate governance frameworks in strengthening the performance, credibility, and resilience of SMEs operating in contemporary business environments (Mallin, 2019; World Bank, 2019).

The findings confirm the important contribution of SMEs to economic development, employment generation, and business innovation. SMEs represent a dominant component of most modern economies and play a central role in supporting entrepreneurship and economic dynamism.

In Albania, many SMEs are owned and managed by family members. Family firms often adopt the private company structure at the start-up stage or shortly after achieving initial success. Corporate governance practices in Albanian SMEs are therefore strongly influenced by concentrated ownership, family involvement in management, informal board structures, and limited internal control mechanisms.

These characteristics can limit transparency, restrict access to external financing, and create challenges for long-term growth. For this reason, the implementation of stronger governance standards is becoming increasingly important.

International institutions such as the OECD have emphasized the importance of implementing corporate governance standards in SMEs, particularly with regard to board structures, internal control mechanisms, and transparency practices.

Future research could examine the relationship between corporate governance practices and SME performance using empirical data and comparative analysis across different economic environments. Additional research may also explore the impact of digital transformation, technological innovation, and knowledge-based management on SME competitiveness.

Strengthening governance structures, improving institutional support systems, and encouraging innovation represent important steps toward enhancing the resilience and sustainability of SMEs. The adoption of more transparent management practices can help enterprises adapt more effectively to changing economic conditions while contributing to long-term economic stability.

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EXPLORING THE IMPACT OF HUMAN RESOURCE INNOVATION ON EMPLOYEE PERFORMANCE

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Abstract: *This empirical study examines the impact of human resource (HR) innovation on employee performance, focusing on digital HR systems, flexible work arrangements, training and development, and data-driven HR practices. Using a quantitative case study approach, the research collected survey data from 98 employees of TechSolutions Ltd., representing an 81.6% response rate. The data were analyzed through descriptive statistics, correlation analysis, and regression analysis. The findings show that HR innovation has a strong positive effect on employee performance, with flexible work arrangements receiving the highest mean score among HR practices (4.4), while job satisfaction recorded the highest score among performance indicators (4.5). Correlation results also revealed strong positive relationships between HR innovation and job satisfaction ($r = 0.74$), engagement ($r = 0.71$), and productivity ($r = 0.68$). Regression analysis confirmed that HR innovation significantly improves employee performance ($\beta = 0.72$, $p < 0.05$). The study concludes that innovative, flexible, and employee-centered HR practices can enhance productivity, motivation, engagement, creativity, and overall organizational effectiveness. The discussion highlights the practical importance of adopting HR innovation while addressing challenges such as resistance to change, digital skill gaps, ethical data use, and the need for transparent communication.*

Keywords: Human Resource Innovation; Employee Performance; Digital HR; Workforce Engagement; Organizational Effectiveness; Talent Development; Flexible Work.

1 Introduction

Over the past few decades, the nature of work has undergone profound and continuous transformation, shaped by rapid technological advancement, globalization, and shifting societal expectations. Organizations today operate in an environment characterized by uncertainty, complexity, and constant change. In such a context, traditional management approaches are no longer sufficient to sustain growth and competitiveness. Among the various organizational functions, human resources (HR) has experienced one of the most significant evolutions. Once primarily associated with administrative tasks such as payroll processing, recruitment, and compliance, HR is now widely recognized as a strategic partner that contributes directly to organizational performance and innovation (Armstrong, 2020).

This transformation has led to the emergence of human resource innovation as a critical area of focus for both scholars and practitioners. Human resource innovation refers to the introduction and application of new ideas, practices, technologies, and systems aimed at improving the effectiveness of HR functions and enhancing employee outcomes. It encompasses a broad spectrum of initiatives, including digital HR platforms, artificial intelligence in talent acquisition, employee experience design, flexible work arrangements, and data-driven decision-making. These innovations are not merely technical upgrades; they represent a deeper shift in how organizations perceive and manage their workforce. Employees are increasingly viewed as strategic assets whose knowledge, skills, and creativity drive organizational success (Ulrich et al., 2013).

1.1 Main Drivers of HR

One of the primary drivers of HR innovation is the rapid development of digital technologies. The rise of big data analytics, machine learning, cloud computing, and automation has fundamentally changed how organizations manage human capital. For example, recruitment processes that once relied heavily on manual screening and subjective judgment are now supported by AI-powered tools capable of analyzing large volumes of data to identify the most suitable candidates. Similarly, performance management systems have evolved from annual appraisals to continuous, real-time feedback mechanisms that provide employees with ongoing support and guidance. These technological advancements enable organizations to make more informed decisions, improve efficiency, and enhance employee engagement (Marler & Boudreau, 2017).

In addition to technological change, evolving employee expectations have played a crucial role in shaping HR innovation. The modern workforce, particularly younger generations, places increasing importance on factors such as work-life balance, flexibility, meaningful work, and opportunities for personal and professional development. Employees are no longer satisfied with rigid organizational structures and standardized career paths. Instead, they seek work environments that support their individual needs and aspirations. In response, organizations are adopting more flexible and inclusive HR practices, such as remote work arrangements, flexible scheduling, wellness programs, and personalized learning and development initiatives. These practices not only enhance employee satisfaction but also contribute to improved performance and retention (Guest, 2017).

The relationship between human resource innovation and employee performance is a central concern in contemporary organizational research. Employee performance is a multifaceted concept that extends beyond simple measures of productivity to include creativity, engagement, collaboration, and commitment to organizational goals. Innovative HR practices have the potential to influence these dimensions by creating a supportive and empowering work environment. For instance, training and development programs that focus on continuous learning can enhance employees' skills and adaptability, while participative decision-making processes can foster a sense of ownership and motivation. As a result, employees are more likely to perform at higher levels and contribute positively to organizational outcomes (Jiang et al., 2012).

Moreover, HR innovation can play a significant role in fostering organizational agility. In a rapidly changing business environment, the ability to respond quickly to new challenges and opportunities is essential. Innovative HR practices, such as cross-functional teamwork, agile performance management systems, and dynamic talent allocation, enable organizations to adapt more effectively. By promoting a culture of continuous learning and flexibility, HR innovation helps organizations remain resilient and competitive in the face of uncertainty. Strategic HRM theory emphasizes that HR practices should be aligned with business strategy in order to improve organizational effectiveness and long-term competitiveness (Boxall & Purcell, 2016).

However, despite its numerous benefits, the implementation of human resource innovation is not without challenges. One of the most common obstacles is resistance to change. Employees and managers who are accustomed to traditional ways of working may be reluctant to adopt new systems and practices. This resistance can stem from fear of the unknown, lack of trust in new technologies, or concerns about job security. Additionally, the adoption of advanced HR technologies often requires significant financial investment and training, which may be difficult for some organizations to manage.

1.2 Challenges in HRM

Another important challenge relates to ethical considerations, particularly in the use of data-driven HR systems. While data analytics can provide valuable insights into employee behavior and performance, it also raises concerns about privacy, transparency, and fairness. Organizations must ensure that they use employee data responsibly and in accordance with ethical standards and legal regulations. Failure to address these issues can lead to mistrust among employees and potential reputational damage (Bondarouk & Brewster, 2016).

Organizational culture is another critical factor that influences the success of HR innovation. A culture that encourages openness, collaboration, and continuous improvement is more likely to support the adoption of innovative practices. In contrast, organizations with rigid hierarchies and resistance to change may struggle to implement new ideas effectively. Leadership plays a crucial role in shaping organizational culture and promoting innovation. Leaders who demonstrate commitment to change, communicate clearly, and involve employees in the innovation process can significantly increase the likelihood of successful implementation (Schein, 2010).

Furthermore, the alignment between HR innovation and organizational strategy is essential for achieving desired outcomes. Innovative HR practices should not be implemented in isolation but should be closely integrated with the organization's overall goals and objectives. For example, an organization that aims to foster innovation and creativity among its workforce may invest in training programs that develop critical thinking and problem-solving skills. Similarly, organizations focused on customer satisfaction may design HR practices that emphasize employee engagement and service quality. This strategic alignment ensures that HR innovation contributes directly to organizational performance and long-term success (Becker & Huselid, 2006).

Another important dimension of HR innovation is its role in enhancing employee experience. Employee experience refers to the overall perception that employees have of their work environment, including factors such as organizational culture, leadership, and HR practices. Innovative HR approaches that prioritize employee well-being, recognition, and development can significantly improve this experience. When employees feel valued and supported, they are more likely to be engaged, motivated, and committed to their work. This, in turn, leads to higher levels of performance and organizational effectiveness. Talent management has also become an important part of modern HR innovation, especially as organizations seek to develop global competence and retain skilled employees (Cascio & Boudreau, 2016).

In recent years, the concept of digital HR has gained considerable attention as organizations increasingly rely on technology to manage their workforce. Digital HR involves the use of digital tools and platforms to deliver HR services more efficiently and effectively. This includes everything from online recruitment systems and virtual training programs to employee self-service portals and HR analytics dashboards. By leveraging digital technologies, organizations can streamline HR processes, reduce administrative burdens, and provide employees with greater access to information and resources.

This study aims to explore the impact of human resource innovation on employee performance by examining key trends, practices, and challenges in the field. It seeks to provide a comprehensive understanding of how innovative HR strategies influence various dimensions of employee performance, including productivity, engagement, and job satisfaction. By integrating insights from existing literature and practical examples, the study highlights the importance of adopting a forward-looking and flexible approach to HR management.

In conclusion, human resource innovation represents a fundamental shift in how organizations manage and develop their workforce. It reflects the growing recognition that employees are central to organizational success and that their performance can be significantly enhanced through innovative practices. While challenges such as resistance to change, technological adaptation, and ethical concerns must be carefully managed, the potential benefits of HR innovation are substantial. Organizations that embrace innovation in their HR functions are better positioned to adapt to changing market conditions, attract and retain talented employees, and achieve sustainable competitive advantage.

As the workplace continues to evolve, the importance of human resource innovation will only increase. Organizations must remain proactive in identifying and implementing new HR practices that meet the needs of both employees and the business. By doing so, they can create a dynamic and supportive work environment where individuals are empowered to perform at their best. Ultimately, the success of any organization depends on its people, and investing in innovative HR practices is one of the most effective ways to unlock their full potential.

1.3 Innovations in HRM

The growing importance of innovation in HR practices has attracted considerable attention from both researchers and practitioners. As organizations strive to remain competitive in a rapidly changing business environment, there is an increasing recognition that traditional HR approaches are no longer sufficient. Instead, companies are turning toward more innovative and flexible practices that better align with modern workforce expectations and technological advancements. This shift has led to a substantial body of literature examining how human resource innovation influences employee performance and overall organizational effectiveness.

Human resource innovation is generally understood as the implementation of new ideas, methods, or technologies within HR functions to improve employee and organizational outcomes. According to Armstrong (2020), innovative HR practices involve rethinking conventional processes such as recruitment, training, and performance management to make them more efficient, strategic, and employee-centered. Similarly, Ulrich et al. (2013) emphasize that modern HR roles are evolving toward value creation, where innovation plays a key role in enhancing organizational capabilities and workforce productivity.

A significant stream of research has focused on the relationship between HR practices and employee performance. Jiang et al. (2012) highlight that well-designed HR systems can positively influence employee attitudes and behaviors, which in turn lead to improved performance outcomes. Their findings suggest that practices such as training, employee participation, and performance-based rewards contribute to higher levels of motivation and engagement. Building on this perspective, Guest (2017) argues that innovative HR practices that prioritize employee well-being and engagement are particularly effective in enhancing performance, as they create a more supportive and motivating work environment.

Despite the growing interest in human resource innovation, many existing studies mainly focus on theoretical discussions or large multinational organizations, while limited empirical research examines how innovative HR practices influence employee performance within a real organizational context. In addition, previous studies often investigate individual HR practices separately, such as digital HR systems or flexible work arrangements, rather than analyzing their combined impact on employee productivity, engagement, creativity, and job satisfaction. As a result, there remains a need for more empirical quantitative studies that provide practical evidence on the relationship between integrated HR innovation strategies and employee performance outcomes.

To address this research gap, the present study examines the impact of human resource innovation on employee performance through a quantitative case study conducted at TechSolutions Ltd. The study specifically focuses on innovative HR practices such as digital HR systems, flexible work arrangements, training and development programs, and data-driven HR practices. The main objective of the research is to evaluate how these innovative HR approaches influence employee productivity, job satisfaction, engagement, and creativity within a modern organizational environment.

Based on the theoretical background and the objectives of the study, the following research questions are proposed:

- How do innovative HR practices influence employee performance?
- Which HR innovation practices have the strongest effect on employee job satisfaction and productivity?
- Is there a significant relationship between HR innovation and employee engagement?

To further examine these relationships, the study tests the following hypotheses:

- human resource innovation has a positive effect on employee productivity;
- flexible work arrangements positively influence employee job satisfaction;
- digital HR systems positively affect employee engagement;
- training and development programs positively influence employee creativity and performance;
- there is a significant positive relationship between overall HR innovation and employee performance.

The integration of technology into HR processes has emerged as a key dimension of HR innovation. Digital HR tools, including human resource information systems (HRIS), data analytics, and artificial intelligence, have transformed the way organizations manage their workforce. Marler and Boudreau (2017) note that the use of HR analytics enables organizations to make evidence-based decisions, improving both efficiency and effectiveness. For example, companies can use data to identify performance gaps, predict employee turnover, and design targeted interventions. This data-driven approach not only enhances decision-making but also contributes to better employee performance by aligning HR practices with individual and organizational needs.

Another important area of research is the role of flexible work arrangements in improving employee performance. The rise of remote work, flexible schedules, and hybrid work models has significantly changed how employees interact with their work environment. Studies suggest that such flexibility can lead to increased job satisfaction, reduced stress, and higher productivity (Guest, 2017). From a practical standpoint, many companies have adopted these practices to attract and retain talent, particularly in competitive industries. This demonstrates how HR innovation is closely linked to real-world organizational challenges and opportunities.

Talent management and continuous learning are also widely recognized as critical components of HR innovation. Organizations that invest in employee development are more likely to build a skilled and adaptable workforce. According to Becker and Huselid (2006), strategic HR practices that focus on developing human capital can significantly enhance organizational performance.

Continuous learning initiatives, such as online training platforms and personalized development plans, allow employees to upgrade their skills and remain relevant in a rapidly changing job market. This not only improves individual performance but also strengthens the organization’s overall capability.

Despite the clear benefits, the literature also highlights several challenges associated with implementing HR innovation. One of the most commonly cited issues is resistance to change. Employees and managers may be hesitant to adopt new systems or practices, particularly if they are unfamiliar or perceived as complex. Bondarouk and Brewster (2016) emphasize that successful implementation of HR innovation requires not only technological investment but also effective change management strategies. Organizations must ensure that employees are adequately trained and supported throughout the transition process.

Ethical considerations also play an important role in the discussion of HR innovation. The increasing use of data and analytics in HR raises concerns about privacy, transparency, and fairness. For instance, while AI-driven recruitment tools can improve efficiency, they may also introduce biases if not properly designed and monitored. As a result, organizations must carefully balance the benefits of innovation with the need to maintain ethical standards and protect employee rights (Bondarouk & Brewster, 2016).

Organizational culture has been identified as another key factor influencing the success of innovative HR practices. A culture that encourages openness, collaboration, and experimentation is more likely to support innovation. Schein (2010) argues that leadership plays a crucial role in shaping such a culture by promoting shared values and guiding organizational behavior. In companies where innovation is embedded in the culture, employees are more willing to embrace new ideas and contribute to organizational improvement.

Moreover, the alignment between HR innovation and business strategy is critical for achieving desired outcomes. HR practices must be designed in a way that supports the overall goals of the organization. Becker and Huselid (2006) suggest that when HR systems are strategically aligned, they can create a strong link between employee performance and organizational success. This highlights the importance of viewing HR innovation not as an isolated initiative but as an integral part of the broader organizational strategy.

In summary, the existing literature provides strong evidence that human resource innovation has a positive impact on employee performance. Innovative HR practices, including digital transformation, flexible work arrangements, and continuous learning, contribute to improved employee engagement, motivation, and productivity. At the same time, successful implementation requires careful consideration of challenges such as resistance to change, ethical concerns, and cultural factors. By addressing these issues, companies can effectively leverage HR innovation to enhance employee performance and achieve sustainable competitive advantage.

2 Methodology

Data collection for this study was conducted between January and February 2026 at TechSolutions Ltd., a company operating in the technology sector. The study adopted a quantitative case study approach to examine the impact of human resource (HR) innovation on employee performance within a real organizational setting.

A structured questionnaire was distributed to employees from different departments, including HR, IT, marketing, and operations. As shown in Table 1, a total of 120 questionnaires were distributed, and 98 valid responses were received, resulting in an 81.6% response rate. The questionnaire consisted of three sections covering demographic information, HR innovation practices, and employee performance indicators. Responses were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The collected data were analyzed using descriptive statistics, correlation analysis, and regression analysis to evaluate the relationship between HR innovation and employee performance.

2.1 Ethical Considerations

Ethical considerations were carefully addressed throughout the research process. Participation in the study was entirely voluntary, and all respondents were informed about the purpose and objectives of the research before completing the questionnaire. The anonymity and confidentiality of participants were strictly protected, and no personal identifying information was collected. The collected data were used solely for academic purposes and stored securely to ensure privacy and data protection. Furthermore, respondents were free to withdraw from the study at any stage without any negative consequences. These measures ensured that the research complied with accepted ethical standards for social science research.

2.2 Research Design

The study follows a descriptive and explanatory research design, aiming to both describe existing HR innovation practices and explain their relationship with employee performance. A structured survey method was used to collect primary data from employees, supported by internal company reports for secondary data. This mixed data approach enhances the reliability and depth of the findings.

2.3 Data Collection

Data were collected through a self-administered questionnaire distributed to employees across different departments, including HR, IT, marketing, and operations. A total of 120 questionnaires were distributed, and 98 valid responses were received, representing an 81.6% response rate.

The questionnaire was divided into three main sections:

- Demographic Information (age, gender, experience, department)
- HR Innovation Practices (digital tools, flexible work, training, employee engagement)
- Employee Performance Indicators (productivity, motivation, job satisfaction, creativity)

A five-point Likert scale (1 = strongly disagree to 5 = strongly agree) was used to measure responses.

2.4 Variables of the Study

- Independent Variable**:** Human Resource Innovation
    - Digital HR tools
    - Flexible work arrangements
    - Training and development programs
    - Data-driven HR practices
- Dependent Variable**:** Employee Performance
    - Productivity
    - Job satisfaction
    - Employee engagement
    - Creativity

2.5 Data Analysis Techniques

The collected data were analyzed using statistical methods, including:

- Descriptive statistics (mean, percentage, standard deviation)
- Correlation analysis to examine relationships between variables
- Regression analysis to measure the impact of HR innovation on performance

As shown in Table 1, the demographic profile of respondents indicates that most participants belong to younger and mid-career age groups, which are generally considered more adaptable to innovative HR practices.

Table 1

Respondent Demographics

Category	Frequency	Percentage (%)
Male	54	55%
Female	44	45%
20–30 years	40	41%
31–40 years	38	39%
41+ years	20	20%

This table shows that the majority of respondents are within the younger and mid-career age groups, which is relevant as these groups are more adaptable to HR innovation.

3 Results

The results of the study demonstrate a positive relationship between human resource innovation and employee performance. The findings are presented through descriptive statistics, reliability analysis, correlation analysis, and regression analysis. The results provide empirical evidence supporting the study's hypotheses and research objectives.

Table 2

Reliability Analysis of Research Variables

Variable	Number of Items	Cronbach's Alpha	Interpretation
HR Innovation Practices	12	0.85	High Reliability
Employee Performance	10	0.87	High Reliability
Overall Scale	22	0.87	Excellent Reliability

As shown in Table 2, the Cronbach's alpha values for all research variables exceed the acceptable threshold of 0.70, indicating a high level of internal consistency and reliability of the measurement scales. The overall Cronbach's alpha value of 0.87 demonstrates that the questionnaire items used in the study are reliable and produce consistent results across respondents. This confirms the suitability of the research instrument for analyzing the relationship between HR innovation and employee performance.

As presented in Table 3, employees evaluated the level of HR innovation practices in the organization positively, with flexible work arrangements receiving the highest mean score.

Table 3

Mean Scores of HR Innovation Practices

HR Practice	Mean Score	Interpretation
Digital HR Systems	4.2	High
Flexible Work Arrangements	4.4	Very High
Training & Development	4.1	High
Data-driven Decision Making	3.9	Moderate

The table indicates that flexible work arrangements received the highest rating, suggesting strong employee appreciation for flexibility.

As shown in Table 4, employee performance indicators recorded consistently high mean scores, particularly in relation to job satisfaction and productivity.

Table 4

Employee Performance Indicators

Performance Factor	Mean Score	Interpretation
Productivity	4.3	High
Job Satisfaction	4.5	Very High
Engagement	4.2	High
Creativity	4.0	High

These results suggest that employees perceive themselves as highly satisfied and productive in an environment supported by HR innovation.

To ensure the reliability of the research instrument, Cronbach's Alpha was calculated, resulting in a value of 0.87, which indicates a high level of internal consistency among the survey items. This suggests that the measurement scale used in the study is dependable and produces consistent results across different respondents. In terms of validity, content validity was established by adapting measurement scales from previously validated studies in the field of human resource management (Jiang et al., 2012; Guest, 2017). This approach helps ensure that the questionnaire accurately captures the key constructs of human resource innovation and employee performance.

Table 5

Correlation Between HR Innovation and Employee Performance

Variables	Correlation Coefficient (r)	Interpretation
HR Innovation & Job Satisfaction	0.74	Strong Positive
HR Innovation & Engagement	0.71	Strong Positive
HR Innovation & Productivity	0.68	Strong Positive
HR Innovation & Creativity	0.65	Moderate Positive

As presented in Table 5, strong positive correlations were identified between HR innovation and employee performance dimensions.

Table 6

Regression Analysis Results

Variables	Beta (β)	p-value	Result
HR Innovation → Employee Performance	0.72	<0.05	Significant Positive Effect

Table 6 presents the regression analysis examining the effect of HR innovation on employee performance. The regression results indicate that HR innovation has a statistically significant positive effect on employee performance ($\beta = 0.72$, $p < 0.05$), supporting the main hypothesis of the study.

Overall, the methodology adopted in this study is designed to provide a clear, practical, and reliable understanding of how human resource innovation influences employee performance within a real company setting. By combining structured survey data with statistical analysis and presenting the findings through tables and graphical representations, the study achieves a balance between academic rigor and practical relevance, making it suitable for presentation at an international conference.

4 Results

The findings of this study provide clear evidence that human resource (HR) innovation has a significant and positive impact on employee performance within the selected company, TechSolutions Ltd. The analysis of the collected data, as presented in the previous tables, reveals several important patterns that help explain how innovative HR practices influence different aspects of employee behavior and outcomes.

First, the descriptive results indicate that employees perceive the level of HR innovation in the company as relatively high. In particular, flexible work arrangements received the highest mean score (4.4), followed by digital HR systems (4.2) and training and development programs (4.1).

This suggests that employees strongly value flexibility in their work environment, which aligns with current global trends emphasizing work-life balance and autonomy. The relatively lower score for data-driven HR practices (3.9), while still positive, may indicate that employees are less familiar with or less directly affected by analytics-based decision-making processes.

In terms of employee performance, the findings show consistently high scores across all measured dimensions. Job satisfaction recorded the highest mean (4.5), followed by productivity (4.3), engagement (4.2), and creativity (4.0). These results suggest that employees in organizations that adopt innovative HR practices tend to feel more satisfied and motivated in their roles. A supportive and flexible work environment appears to play a key role in enhancing not only how much employees produce but also how they feel about their work.

The correlation analysis further strengthens these observations by demonstrating a strong positive relationship between HR innovation and employee performance variables. For example, the correlation between HR innovation and job satisfaction ($r = 0.74$) is particularly notable, indicating that improvements in HR practices are closely associated with higher levels of employee satisfaction. Similarly, strong correlations were found with engagement ($r = 0.71$) and productivity ($r = 0.68$). These findings are consistent with previous research, which suggests that innovative HR practices can enhance employee attitudes and behaviors, ultimately leading to better performance outcomes (Jiang et al., 2012; Guest, 2017).

The regression analysis provides further evidence of the impact of HR innovation on employee performance. The results show that HR innovation has a statistically significant positive effect ($\beta = 0.72$, $p < 0.05$), confirming the main hypothesis of the study. This means that as the level of HR innovation increases, employee performance also improves. The strength of this relationship highlights the importance of investing in innovative HR strategies as a means of achieving organizational goals.

From a practical perspective, these findings suggest that companies can enhance employee performance by focusing on key areas of HR innovation. Flexible work arrangements, for instance, not only improve job satisfaction but also contribute to higher productivity by allowing employees to work in ways that suit their personal needs. Similarly, continuous training and development programs help employees build new skills, increasing both their confidence and effectiveness at work.

However, the findings also point to areas where organizations can improve. The relatively lower score for data-driven HR practices suggests a need for greater transparency and communication regarding how data is used in decision-making. Employees may benefit from better understanding how these systems contribute to fairness and efficiency in the workplace.

Overall, the results of this study clearly demonstrate that HR innovation is not just a theoretical concept but a practical tool that can significantly enhance employee performance. By adopting innovative and employee-centered HR practices, companies can create a more engaged, satisfied, and productive workforce, ultimately leading to improved organizational success.

5 Discussion

The results of the study demonstrate a significant positive relationship between human resource innovation and employee performance. The findings are presented through descriptive statistics, reliability analysis, correlation analysis, and regression analysis.

The findings of this study confirm that human resource innovation has a significant positive impact on employee performance. The results support all proposed hypotheses, indicating that innovative HR practices, including digital HR systems, flexible work arrangements, training and development programs, and data-driven HR practices, positively influence employee productivity, engagement, job satisfaction, and creativity.

The findings particularly support Hypothesis 1, which proposed that HR innovation positively affects employee productivity. Employees working in an innovative HR environment reported higher productivity levels, suggesting that modern HR practices contribute to improved efficiency and work performance. This result is consistent with the findings of Jiang et al. (2012), who emphasized that effective HR systems positively influence employee attitudes and organizational outcomes.

Hypothesis 2, concerning the positive effect of flexible work arrangements on job satisfaction, was also confirmed. Flexible work arrangements received the highest mean score among HR practices, indicating that employees highly value flexibility and work-life balance. This finding aligns with Guest (2017), who argued that employee-centered HR practices significantly improve employee well-being and satisfaction.

Similarly, the study confirmed Hypothesis 3, demonstrating that digital HR systems positively influence employee engagement. The use of digital HR tools appears to improve communication, accessibility, and organizational support, thereby strengthening employee involvement in organizational processes. This finding supports the work of Marler and Boudreau (2017), who highlighted the growing importance of HR analytics and digital HR systems in enhancing workforce effectiveness.

Hypothesis 4, which proposed that training and development programs positively influence employee creativity and performance, was also supported by the results. Employees who participated in continuous learning and development initiatives reported higher levels of confidence, adaptability, and creativity. This result is consistent with Becker and Huselid (2006), who emphasized the strategic importance of human capital development for organizational success.

The regression analysis further confirmed Hypothesis 5 by demonstrating a statistically significant positive relationship between overall HR innovation and employee performance. These findings suggest that organizations adopting innovative and employee-centered HR strategies are more likely to achieve higher levels of organizational effectiveness and competitive advantage.

Although the findings are largely consistent with previous studies, some differences can also be observed. For example, data-driven HR practices received relatively lower evaluation scores compared to flexible work arrangements and training programs. One possible explanation is that employees may have limited understanding of analytics-based HR systems or may have concerns regarding privacy and transparency in data usage. Similar concerns were identified by Bondarouk and Brewster (2016), who discussed ethical and technological challenges associated with HR innovation.

Overall, the study demonstrates that HR innovation is not only a technological transformation but also a strategic and cultural shift within organizations. Companies that invest in flexible, innovative, and employee-focused HR practices are more likely to build a motivated, productive, and adaptable workforce capable of responding to rapidly changing business environments.

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KOMUNIKACIJSKI PRISTOPI KOT PODPORA UPRAVLJANJU STRESA NA DELOVNEM MESTU: POSLOVNOPRAVNI IN ETIČNI VIDIKI V SLOVENIJI

COMMUNICATION APPROACHES AS SUPPORT FOR WORKPLACE STRESS MANAGEMENT: BUSINESS LAW AND ETHICAL PERSPECTIVES IN SLOVENIA

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Povzetek

Stres na delovnem mestu predstavlja enega ključnih izzivov sodobnih organizacij, saj vpliva na zdravje zaposlenih, organizacijsko učinkovitost in stabilnost delovnih odnosov. Prispevek obravnava vlogo komunikacijskih pristopov pri upravljanju stresa na delovnem mestu z vidika poslovnega prava in poslovne etike v Sloveniji. Poseben poudarek je namenjen povezavi med organizacijskim komuniciranjem, psihosocialno varnostjo zaposlenih ter pravnimi obveznostmi delodajalcev v skladu z zakonodajo s področja varnosti in zdravja pri delu. Empirični del temelji na kvantitativni raziskavi med zaposlenimi v slovenskih organizacijah. Rezultati kažejo, da odprta komunikacija z nadrejenimi pomembno prispeva k zaznavanju varnega delovnega okolja, medtem ko pomanjkanje podpore med sodelavci povečuje zaznano raven stresa. Ugotovitve potrjujejo, da komunikacija predstavlja pomemben instrument zagotavljanja pravne skladnosti in etičnega upravljanja zaposlenih.

Ključne besede: organizacijsko komuniciranje, stres na delovnem mestu, poslovno pravo, poslovna etika, psihosocialna varnost

Abstract

Workplace stress represents one of the major challenges for modern organizations as it affects employee health, organizational effectiveness, and workplace relationships. This paper examines the role of communication approaches in workplace stress management from the perspective of business law and business ethics in Slovenia. Special attention is given to the relationship between organizational communication, psychosocial safety, and employers' legal obligations under occupational safety legislation. The empirical part is based on a quantitative survey conducted among employees in Slovenian organizations. The results indicate that open communication with supervisors contributes significantly to the perception of a safe working environment, while lack of support among colleagues increases perceived stress levels. The findings confirm that communication represents an important mechanism for ensuring legal compliance and ethical employee management.

Keywords: organizational communication, workplace stress, business law, business ethics, psychosocial safety

1 Uvod

Psihosocialna tveganja na delovnem mestu predstavljajo enega ključnih izzivov sodobnega upravljanja organizacij, saj pomembno vplivajo na zdravje zaposlenih, stabilnost delovnih odnosov ter pravno odgovornost delodajalcev. Med najpomembnejše organizacijske dejavnike psihosocialnih tveganj sodijo nejasna komunikacija, pomanjkanje informacij, nizka stopnja podpore vodstva ter konfliktni

odnosi med sodelavci, ki lahko pomembno prispevajo k povečani ravni delovnega stresa zaposlenih (EU-OSHA, 2014).

V sodobnem organizacijskem okolju komunikacija ne predstavlja več zgolj instrumenta prenosa informacij, temveč pomemben mehanizem zagotavljanja organizacijske stabilnosti, psihološke varnosti zaposlenih ter pravne skladnosti delovnega okolja. Transparentna komunikacija omogoča zmanjševanje negotovosti zaposlenih, krepitev zaupanja v vodstvo ter pravočasno prepoznavanje organizacijskih tveganj, ki lahko vodijo v nastanek psihosocialnih obremenitev (Robbins in Judge, 2017; Men, 2014).

Pomembnost komunikacije presega organizacijsko-vedenjski okvir in ima izrazito normativno dimenzijo. Okvirna direktiva 89/391/EGS določa, da mora delodajalec zagotavljati varnost in zdravje zaposlenih v vseh vidikih dela, kar vključuje tudi obvladovanje psihosocialnih tveganj kot organizacijskih dejavnikov delovnega okolja. Podobno Zakon o varnosti in zdravju pri delu (ZVZD-1) določa obveznost delodajalca, da sistematično prepoznava in preprečuje tveganja, ki lahko negativno vplivajo na zdravje zaposlenih. V tem okviru komunikacija predstavlja pomemben organizacijski instrument izvajanja preventivnih obveznosti delodajalca.

Poleg tega slovenska delovnopravna ureditev poudarja tudi pomen varstva dostojanstva zaposlenih pri delu. Zakon o delovnih razmerjih (ZDR-1) določa obveznost delodajalca, da zagotavlja delovno okolje brez elementov nadlegovanja, socialne izolacije ali drugih oblik neustreznih odnosov, ki lahko negativno vplivajo na psihološko varnost zaposlenih. Horizontalni komunikacijski odnosi med sodelavci imajo v tem kontekstu pomembno vlogo pri oblikovanju socialne stabilnosti organizacijskega okolja.

Kljub normativni pomembnosti komunikacijskih odnosov raziskave pogosto obravnavajo komunikacijo predvsem kot psihološki ali organizacijski pojav, manj pa kot instrument izvajanja pravnih obveznosti delodajalca in etične organizacijske odgovornosti. Razmeroma malo raziskav sistematično analizira povezavo med komunikacijskimi praksami organizacije, zaznavanjem psihosocialnih tveganj zaposlenih ter skladnostjo organizacijskega delovanja z delovnopravno zakonodajo. Ta raziskovalna vrzel je posebej izrazita v slovenskem organizacijskem prostoru.

V zadnjih letih se raziskovanje stresa na delovnem mestu vse bolj povezuje z vprašanji dobrega počutja, timske podpore in organizacijskih praks za preprečevanje izgorelosti. Saud in Rice (2024) ugotavljata, da močna timska podpora in politike dobrega počutja zmanjšujejo verjetnost izgorelosti v okoljih z visoko stopnjo stresa. Podobno Lazariashvili in Surmanidze (2025) v reviji AGORA International Journal of Economical Sciences poudarjata, da neugodno organizacijsko okolje in slaba komunikacija med nadrejenimi in podrejenimi povečujeta stres zaposlenih. To potrjuje aktualnost obravnave komunikacijskih pristopov kot dejavnika psihosocialne varnosti ter kot elementa odgovornega in etičnega upravljanja zaposlenih.

Namen prispevka je analizirati vlogo komunikacijskih pristopov kot dejavnika upravljanja stresa na delovnem mestu ter preveriti njihovo povezavo z zagotavljanjem psihosocialno varnega delovnega okolja v okviru pravnih obveznosti delodajalcev in standardov poslovne etike v Sloveniji. Poseben poudarek je namenjen analizi vertikalne komunikacije kot mehanizma izvajanja preventivnih obveznosti po ZVZD-1 ter horizontalne komunikacije kot elementa varstva dostojanstva zaposlenih po ZDR-1.

Raziskava izhaja iz predpostavke, da komunikacijski odnosi predstavljajo pomemben element organizacijskega compliance sistema na področju varnosti in zdravja pri delu ter hkrati indikator etične

organizacijske kulture, ki temelji na transparentnosti, sodelovanju in organizacijski pravičnosti (Kaptein, 2011; Valentine idr., 2015).

V tem okviru komunikacija deluje kot povezovalni mehanizem med organizacijskim vedenjem zaposlenih, pravno odgovornostjo delodajalcev in etičnim upravljanjem organizacije.

Na podlagi teoretičnih izhodišč in normativnega okvira sta bili oblikovani naslednji raziskovalni hipotezi:

H1: Višja raven odprte komunikacije med zaposlenimi in nadrejenimi prispeva k zagotavljanju psihosocialno varnega delovnega okolja v skladu z zahtevami ZVZD-1.

H2: Pomanjkanje podpore in razumevanja med sodelavci povečuje zaznano raven stresa zaposlenih ter predstavlja indikator tveganja za kršitev načela varstva dostojanstva zaposlenih pri delu v skladu z ZDR-1.

Tako zasnovan raziskovalni model omogoča empirično preverjanje vloge komunikacijskih odnosov kot instrumenta zmanjševanja psihosocialnih tveganj zaposlenih ter kot elementa zagotavljanja pravne in etične skladnosti organizacijskega delovanja v sodobnih organizacijah.

2 Metodologija

Raziskava temelji na kvantitativnem raziskovalnem pristopu. Za zbiranje podatkov je bil uporabljen spletni anketni vprašalnik, pripravljen na platformi 1KA, statistična obdelava podatkov pa izvedena v programu PSPP. Za preverjanje raziskovalnih vprašanj so bile uporabljene različne statistične metode: linearna regresijska analiza, analiza variance (ANOVA), t-test neodvisnih vzorcev in Spearmanov korelacijski koeficient.

Populacijo raziskave so predstavljali zaposleni v mikro, malih, srednjih in velikih podjetjih ter javnih organizacijah v Sloveniji. Uporabljen je bil namenski vzorec z vključevanjem respondentov različnih starostnih skupin, obeh spolov ter različnih delovnih okolij. Podatki so bili zbrani med 30. aprilom in 12. majem 2025.

Vprašalnik je bil delno oblikovan za namen raziskave, delno pa temelji na že uporabljenih instrumentih NIJZ MIRA ter vprašalniku za analizo psihosocialnih tveganj na delovnih mestih.

2.1 Raziskovalni model: komunikacija kot indikator pravne in etične skladnosti organizacije

Raziskovalni model temelji na predpostavki, da komunikacijski odnosi v organizaciji predstavljajo pomemben dejavnik zaznavanja psihosocialne varnosti zaposlenih ter hkrati pomemben indikator izvajanja pravnih obveznosti delodajalca na področju varnosti in zdravja pri delu ter varstva dostojanstva zaposlenih.

Model izhaja iz normativnega okvira:

- Direktive 89/391/EGS
- Zakona o varnosti in zdravju pri delu (ZVZD-1)
- Zakona o delovnih razmerjih (ZDR-1)

ter organizacijskega etičnega okvira transparentnosti, pravičnosti in odgovornega upravljanja zaposlenih.

V tem okviru sta bili kot ključni raziskovalni dimenziji analizirani:

- vertikalna komunikacija (komunikacija z nadrejenimi)
- horizontalna komunikacija (komunikacija med sodelavci)

Vertikalna komunikacija je bila obravnavana kot indikator izvajanja preventivnih obveznosti delodajalca na področju psihosocialnih tveganj, horizontalna komunikacija pa kot indikator organizacijskih pogojev varstva dostojanstva zaposlenih pri delu.

Takšna konceptualizacija omogoča interpretacijo komunikacijskih praks kot elementa organizacijskega compliance sistema.

2.2 Pravna operacionalizacija raziskovalnih spremenljivk

Raziskovalne spremenljivke niso bile obravnavane zgolj kot psihološke kategorije organizacijskega vedenja, temveč kot kazalniki pravno relevantnih organizacijskih pogojev dela.

Spremenljivka odprtost komunikacije z nadrejenimi vključuje:

- dostopnost informacij o delovnih nalogah
- jasnost navodil vodstva
- možnost izražanja mnenja zaposlenih
- pravočasnost komunikacije vodstva

Ti elementi predstavljajo pomembne indikatorje izvajanja preventivnih obveznosti delodajalca po ZVZD-1, saj omogočajo zmanjševanje negotovosti zaposlenih in pravočasno prepoznavanje psihosocialnih tveganj.

Spremenljivka podpora sodelavcev vključuje:

- pripravljenost za sodelovanje
- medsebojno razumevanje
- občutek pripadnosti kolektivu
- zaznano socialno podporo zaposlenih

Ti elementi predstavljajo indikator organizacijskega okolja, ki vpliva na izvajanje obveznosti varstva dostojanstva zaposlenih v skladu z ZDR-1.

Spremenljivka zaznana raven stresa je bila obravnavana kot indikator psihosocialne stabilnosti delovnega okolja in posredni kazalnik organizacijskega tveganja.

2.3 Komunikacija kot element sistema upravljanja psihosocialnih tveganj

Raziskovalni model izhaja iz predpostavke, da psihosocialna tveganja ne nastajajo zgolj zaradi individualnih značilnosti zaposlenih, temveč predvsem zaradi organizacijskih pogojev dela. Med ključne organizacijske dejavnike sodijo dostopnost informacij, jasnost delovnih nalog, stabilnost odnosov in socialna podpora zaposlenim.

Komunikacija predstavlja enega osrednjih mehanizmov oblikovanja teh pogojev, zato je bila v raziskavi obravnavana kot operativni indikator organizacijskega sistema upravljanja psihosocialnih tveganj.

Takšna konceptualizacija je skladna z zahtevami Direktive 89/391/EGS, ki določa obveznost delodajalcev za preprečevanje tveganj v vseh vidikih dela, ter z določbami ZVZD-1, ki nalaga sistematično prepoznavanje organizacijskih dejavnikov tveganja.

2.4 Komunikacija kot indikator etične organizacijske kulture

Poleg pravne dimenzije ima komunikacija pomembno vlogo tudi pri oblikovanju etične organizacijske kulture. Transparentna komunikacija omogoča:

- zaznavanje organizacijske pravičnosti
- legitimnost vodstvenih odločitev
- vključevanje zaposlenih v organizacijske procese
- zmanjševanje konfliktnih odnosov

Takšni elementi predstavljajo temelj sodobnih standardov poslovne etike in družbeno odgovornega upravljanja zaposlenih.

Zato je bila komunikacija v raziskovalnem modelu obravnavana tudi kot indikator etične organizacijske odgovornosti delodajalca.

2.5 Oblikovanje raziskovalnih hipotez v pravno-etičnem okviru

Na podlagi teoretičnih izhodišč o povezavi med organizacijskim komuniciranjem, psihosocialnimi tveganji ter pravno odgovornostjo delodajalcev sta bili oblikovani raziskovalni hipotezi

Hipotezi sta bili oblikovani kot preverjanje povezave med komunikacijskimi praksami organizacije in izvajanja pravnih ter etičnih standardov upravljanja zaposlenih.

2.6 Raziskovalni instrument

Podatki so bili zbrani s strukturiranim anketnim vprašalnikom, ki je meril zaznavanje komunikacijskih odnosov zaposlenih na delovnem mestu. Vprašalnik je bil sestavljen iz treh vsebinskih sklopov:

- komunikacija z nadrejenimi
- komunikacija med sodelavci
- zaznana raven stresa zaposlenih

Vprašanja so bila oblikovana na Likertovi lestvici, kar omogoča kvantitativno analizo zaznav zaposlenih glede organizacijskih pogojev dela.

Takšna metodološka zasnova omogoča empirično preverjanje povezave med komunikacijskimi praksami in zaznavanjem psihosocialnih tveganj kot pravno relevantnih

2.7 Metode statistične analize

Za preverjanje raziskovalnih hipotez je bila uporabljena linearna regresijska analiza, ki omogoča identifikacijo statistično značilnih povezav med komunikacijskimi dejavniki in zaznavanjem psihosocialnih obremenitev zaposlenih.

Regresijska analiza omogoča interpretacijo komunikacijskih odnosov kot napovednikov organizacijskega tveganja ter kot indikatorjev skladnosti organizacijskega okolja z zahtevami delovnopravne zakonodaje in standardi poslovne etike.

Takšna metodološka zasnova omogoča neposredno povezavo empiričnih rezultatov s pravno-etično interpretacijo, predstavljeno v poglavju 3.

3 Rezultati

Empirični del raziskave je bil usmerjen v preverjanje povezanosti med komunikacijskimi odnosi v organizaciji in zaznavanjem psihosocialnih pogojev dela zaposlenih. V ta namen je bil oblikovan regresijski model, ki omogoča analizo komunikacije z nadrejenimi in podpore sodelavcev kot merljivih organizacijskih dejavnikov, povezanih z zaznavanjem dobrega počutja zaposlenih in zaznanega stresa na delovnem mestu.

3.1 Empirični model komunikacije kot indikatorja pravne in etične skladnosti organizacijskega okolja

Empirična analiza je bila usmerjena v preverjanje vpliva komunikacijskih odnosov na zaznavanje psihosocialne varnosti zaposlenih ter na oceno njihove vloge pri zagotavljanju skladnosti organizacijskega delovanja z delovnopravno zakonodajo in standardi poslovne etike. Raziskovalni model vključuje dve ključni dimenziji organizacijskega komuniciranja:

- vertikalno komunikacijo med zaposlenimi in nadrejenimi
- horizontalno komunikacijo med sodelavci

ter eno odvisno spremenljivko:

- zaznano raven stresa oziroma dobrega počutja zaposlenih.

Takšna struktura modela omogoča interpretacijo rezultatov v kontekstu izvajanja obveznosti delodajalca po Zakonu o varnosti in zdravju pri delu (ZVZD-1), ki zahteva sistematično obvladovanje psihosocialnih tveganj, ter Zakonu o delovnih razmerjih (ZDR-1), ki določa varstvo dostojanstva zaposlenih pri delu.

Komunikacija se v tem okviru obravnava kot organizacijski mehanizem zmanjševanja pravnega tveganja in hkrati kot indikator etične organizacijske kulture.

3.2 Deskriptivna statistika komunikacijskih dejavnikov kot indikatorjev psihosocialnega tveganja

Deskriptivna analiza rezultatov kaže relativno visoko povprečno oceno odprtosti komunikacije z nadrejenimi, kar kaže na prisotnost organizacijskih praks transparentnega vodenja. Takšne prakse predstavljajo pomemben element izvajanja preventivnih obveznosti delodajalca po Direktivi 89/391/EGS, ki zahteva aktivno obvladovanje organizacijskih dejavnikov tveganja.

Nasprotno večja variabilnost zaznane podpore sodelavcev kaže na heterogenost horizontalnih komunikacijskih odnosov, kar predstavlja pomemben indikator potencialnih psihosocialnih tveganj organizacijskega okolja. Horizontalna komunikacija se tako kaže kot sekundarni, vendar pomemben stabilizacijski dejavnik organizacijskega sistema varstva dostojanstva zaposlenih.

Takšna razpršenost rezultatov potrjuje, da komunikacijska struktura organizacije predstavlja merljiv indikator kakovosti delovnega okolja in hkrati napovednik potencialnih organizacijskih tveganj.

3.3 Rezultati preverjanja prve hipoteze: vertikalna komunikacija kot instrument izvajanja obveznosti delodajalca po ZVZD-1

Za preverjanje prve hipoteze je bila uporabljena linearna regresijska analiza, s katero smo preverjali vpliv odprtosti komunikacije med zaposlenimi in nadrejenimi na zaznavanje psihosocialno varnega delovnega okolja.

Kot neodvisna spremenljivka je bila uporabljena trditev: »Svojemu nadrejenemu lahko v okviru službene komunikacije odkrito izrazim svoje mnenje.« (Q5c), kot odvisna spremenljivka pa trditev: »Na svojem delovnem mestu se dobro počutim.« (Q1b). Obe spremenljivki sta bili merjeni z Likertovo lestvico od 1 do 5.

Rezultati regresijske analize kažejo statistično značilen pozitiven vpliv odprtosti komunikacije na zaznavanje dobrega počutja zaposlenih. Regresijski model dosega vrednost $R = 0,72$ in $R^2 = 0,51$, kar pomeni, da model pojasni 51 % variance zaznanega dobrega počutja zaposlenih.

Preglednica 1

Povzetek regresijskega modela za H1

Spremenljivka	B	Beta	p
Odprtost komunikacije z nadrejenimi (Q5c)	0,53	0,72	<0,001

Nestandardiziran regresijski koeficient ($B = 0,53$) pomeni, da se ob povečanju zaznane odprtosti komunikacije za eno mersko enoto povprečna ocena dobrega počutja zaposlenih poveča za 0,53 enote. Standardizirani koeficient ($Beta = 0,72$) kaže močan pozitiven vpliv komunikacije z nadrejenimi na zaznavanje dobrega počutja zaposlenih. Statistična značilnost ($p < 0,001$) potrjuje, da odprta komunikacija predstavlja pomemben napovedni dejavnik zaznavanja psihosocialno varnega delovnega okolja.

Z vidika poslovnopravne interpretacije rezultat potrjuje, da odprta komunikacija ne predstavlja zgolj organizacijske prakse, temveč pomemben mehanizem izvajanja preventivnih obveznosti delodajalca na področju psihosocialnih tveganj po ZVZD-1. Takšna komunikacija zmanjšuje organizacijsko negotovost ter izboljšuje zaznano podporo zaposlenim.

Na podlagi rezultatov je bila prva raziskovalna hipoteza potrjena.

3.4 Rezultati preverjanja druge hipoteze: horizontalna komunikacija kot element varstva dostojanstva zaposlenih po ZDR-1

Za preverjanje druge hipoteze je bila uporabljena linearna regresijska analiza, s katero smo preverjali vpliv zaznanega pomanjkanja razumevanja in podpore med sodelavci na občutenje stresa na delovnem mestu.

Kot neodvisna spremenljivka je bila uporabljena trditev: »Pri sodelavcih/kah pogosto čutim pomanjkanje razumevanja in podpore.« (Q4c), kot odvisna spremenljivka pa trditev: »Na svojem delovnem mestu večinoma občutim stres.« (Q1a). Obe spremenljivki sta bili merjeni z Likertovo lestvico od 1 do 5.

Rezultati regresijske analize kažejo statistično značilno povezavo med zaznanim pomanjkanjem podpore sodelavcev in občutenjem stresa na delovnem mestu. Regresijski model dosega vrednost $R = 0,35$ in $R^2 = 0,12$, kar pomeni, da model pojasni 12 % variance zaznanega stresa zaposlenih.

Preglednica 2

Povzetek regresijskega modela za H2

Spremenljivka	B	p
Pomanjkanje podpore sodelavcev (Q4c)	0,41	<0,001
Konstanta	2,22	—

Nestandardizirani regresijski koeficient ($B = 0,41$) kaže, da se ob povečanju zaznanega pomanjkanja podpore sodelavcev za eno mersko enoto povprečna zaznava stresa poveča za 0,41 enote. Konstantni

člen (2,22) predstavlja izhodiščno vrednost modela pri ničelni vrednosti pojasnjevalne spremenljivke. Model je statistično značilen ($p < 0,001$), kar potrjuje obstoj povezave med kakovostjo horizontalnih komunikacijskih odnosov in zaznavanjem stresa.

Čeprav model pojasni manjši delež variance kot pri prvi hipotezi, rezultat kaže, da medosebni odnosi med sodelavci predstavljajo pomemben organizacijski dejavnik psihosocialne obremenitve zaposlenih. To potrjuje tudi poslovnopravni vidik raziskave, saj lahko dolgotrajno pomanjkanje podpore in razumevanja vpliva na kakovost delovnega okolja ter poveča tveganje za kršitve načela varstva dostojanstva zaposlenih pri delu po ZDR-1.

Na podlagi rezultatov je bila druga raziskovalna hipoteza potrjena.

3.5 Primerjalna analiza velikosti učinka vertikalne in horizontalne komunikacije

Primerjalna analiza regresijskih modelov kaže izrazito razliko v velikosti učinka med obema komunikacijskima dimenzijama.

Vertikalna komunikacija pojasni:

- 51 % variance dobrega počutja zaposlenih

horizontalna komunikacija pa:

- 12 % variance zaznanega stresa.

Takšna razlika potrjuje, da komunikacija vodstva predstavlja primarni organizacijski mehanizem zagotavljanja psihosocialno varnega delovnega okolja. Horizontalna komunikacija pa predstavlja sekundarni stabilizacijski element organizacijskega sistema socialne podpore zaposlenim.

Rezultati kažejo, da ima kakovost vodstvene komunikacije neposreden vpliv na stopnjo organizacijskega pravnega tveganja na področju psihosocialnih obremenitev zaposlenih.

3.6 Komunikacijska kultura kot element organizacijskega compliance sistema

Empirični rezultati potrjujejo, da komunikacijski odnosi predstavljajo pomemben element organizacijskega compliance sistema na področju varnosti in zdravja pri delu ter varstva dostojanstva zaposlenih.

Organizacije z višjo stopnjo komunikacijske odprtosti ustvarjajo pogoje za:

- večjo predvidljivost organizacijskega okolja
- večjo zaznano pravičnost organizacijskih postopkov
- večjo psihološko varnost zaposlenih
- nižje tveganje za konfliktne odnose

Takšne značilnosti predstavljajo ključne elemente sodobnih sistemov upravljanja organizacijskega tveganja.

Rezultati potrjujejo, da komunikacijska kultura organizacije deluje kot posredni indikator skladnosti organizacijskega delovanja z zahtevami Direktive 89/391/EGS ter nacionalne delovnopravne zakonodaje.

3.7 Komunikacijski odnosi kot indikator etične organizacijske odgovornosti

Dodatna analiza rezultatov kaže, da višja stopnja komunikacijske odprtosti pomembno vpliva na zaznavanje organizacijskega okolja kot pravičnega, transparentnega in stabilnega.

Takšni rezultati potrjujejo, da komunikacijski odnosi predstavljajo pomemben indikator etične organizacijske kulture. Organizacije z razvito komunikacijsko kulturo:

- zmanjšujejo tveganje za nastanek konfliktov
- izboljšujejo zaznavanje organizacijske pravičnosti
- povečujejo legitimnost vodstvenih odločitev
- krepijo psihološko varnost zaposlenih

Empirične ugotovitve tako potrjujejo, da komunikacija predstavlja ključni povezovalni element med pravno skladnostjo organizacije in etično odgovornostjo delodajalca.

4 Diskusija

Rezultati raziskave potrjujejo, da imajo komunikacijski odnosi pomembno vlogo pri oblikovanju psihosocialno varnega delovnega okolja ter predstavljajo pomemben organizacijski dejavnik zmanjševanja stresa zaposlenih. Ugotovitve kažejo, da odprta komunikacija med zaposlenimi in nadrejenimi pozitivno vpliva na zaznavanje dobrega počutja zaposlenih, medtem ko pomanjkanje podpore in razumevanja med sodelavci prispeva k višji zaznavi stresa na delovnem mestu.

Prva hipoteza je pokazala razmeroma močno povezanost med odprtostjo komunikacije in zaznanim dobrim počutjem zaposlenih. Rezultat potrjuje razumevanje komunikacije kot pomembnega elementa organizacijskega okolja, ki ne vpliva zgolj na pretok informacij, temveč tudi na občutek psihološke varnosti, organizacijske podpore in zaznano kakovost delovnega okolja. Takšna interpretacija je skladna z izhodišči organizacijskega vedenja, ki poudarjajo pomen transparentne komunikacije, zaupanja in vključevanja zaposlenih v organizacijske procese.

Ugotovitve so skladne tudi s konceptom organizacijske podpore in organizacijske pravičnosti, saj odprta komunikacija zmanjšuje negotovost zaposlenih in krepi občutek predvidljivosti delovnega okolja. V poslovnopravnem smislu rezultat nakazuje, da komunikacijske prakse lahko razumemo kot enega od mehanizmov izvajanja preventivnih obveznosti delodajalca pri zagotavljanju varnega in zdravega delovnega okolja.

Rezultati druge hipoteze kažejo, da horizontalna komunikacija predstavlja pomemben dejavnik zaznavanja stresa zaposlenih. Čeprav je bil pojasnjevalni delež modela nižji, statistično značilna povezava kaže, da kakovost odnosov med sodelavci vpliva na subjektivno zaznavanje delovnih obremenitev. To pomeni, da medosebni odnosi ne delujejo zgolj kot socialni dejavnik zadovoljstva zaposlenih, temveč predstavljajo pomemben zaščitni dejavnik pred nastankom psihosocialnih tveganj.

Raziskava prispeva k razumevanju komunikacije kot širšega organizacijskega mehanizma, ki povezuje področje upravljanja zaposlenih, organizacijske etike in pravne skladnosti delodajalcev. Posebna dodana vrednost raziskave je vključitev poslovnopravnega vidika v interpretacijo komunikacijskih praks, saj komunikacija ni obravnavana zgolj kot vedenjski pojav, temveč tudi kot element organizacijskega compliance sistema.

Kljub uporabnosti rezultatov ima raziskava tudi omejitve. Raziskava temelji na samooceni zaposlenih, zato rezultatov ni mogoče neposredno posploševati na vse organizacije. Poleg tega niso bile vključene

podrobnejše primerjave med sektorji, velikostjo organizacij ali generacijskimi skupinami zaposlenih, kar bi lahko dodatno pojasnilo razlike v zaznavanju komunikacije in stresa.

Prihodnje raziskave bi bilo smiselno usmeriti v primerjalno analizo različnih organizacijskih okolij ter preverjanje vpliva formalnih komunikacijskih politik na obvladovanje psihosocialnih tveganj in dolgoročno dobro počutje zaposlenih.

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