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AI ETHICAL CONSIDERATIONS IN BUSINESS OPERATIONS

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Abstract

The rapid integration of Artificial Intelligence (AI) into business operations has profoundly reshaped decision-making, organizational productivity, and market strategies. However, the increasing dependence on AI systems has amplified ethical concerns regarding transparency, accountability, data privacy, algorithmic bias, and equity. This study investigates the primary ethical challenges arising from AI use in business and analyzes how companies navigate these issues while sustaining innovation and operational excellence. The research investigates ethical risks arising from automated decision-making systems, including potential discrimination, misuse of personal data, lack of explainability, and the impact of AI-driven automation on the workforce. In order to better understand current academic, professional, and public discourse on this topic, the study analyzes 50 YouTube videos related to AI ethics in business and survey with 25 questions including 87 participants. Findings reveal that transparency, equity, accountability, and human oversight are the leading ethical priorities in AI-driven businesses. The research concludes that embedding ethical standards within AI strategies is vital for building stakeholder trust, enabling responsible innovation, and advancing sustainable business growth in the digital economy.

Keywords: Artificial Intelligence, ethics, business operations, data privacy, responsible AI.

JEL code: O35

Introduction

Organizational procedures, decision-making frameworks, and strategic planning have undergone significant changes as a result of the quick spread of artificial intelligence (AI) in modern commercial settings. AI technologies, ranging from predictive analytics to autonomous decision-making systems, offer unprecedented opportunities for efficiency, innovation, and competitive advantage. However, alongside these transformative benefits, the deployment of AI raises a range of ethical concerns that have profound implications for

both organizations and society at large. Issues such as algorithmic bias, lack of transparency, misuse of personal data, discrimination, and accountability challenges have become central to discussions surrounding responsible AI implementation. Recent studies highlight that while AI adoption can streamline operations and reduce human error, it also introduces complex ethical dilemmas that, if unaddressed, may compromise trust, reputational integrity, and legal compliance (Floridi et al., 2018; Jobin et al., 2019). In the business context, these concerns are particularly significant because organizations are increasingly expected to operate not only efficiently but also responsibly, ensuring that technological innovations align with ethical, social, and legal norms. Ethical lapses in AI deployment can result in adverse consequences, including regulatory penalties, social backlash, and erosion of stakeholder trust, underscoring the need for systematic governance frameworks. Despite growing attention to AI ethics, much of the current research focuses on theoretical frameworks or high-profile corporate case studies, leaving a gap in understanding how ethical principles are discussed, interpreted, and operationalized in practical settings. This thesis addresses this gap by examining a dataset of 50 YouTube videos that represent contemporary discourse on AI ethics in business. Using a mixed-methods approach combining qualitative thematic analysis and quantitative content analysis, the study identifies the predominant ethical challenges highlighted by experts and practitioners, the strategies recommended for responsible AI deployment, and the ways in which ethical governance is framed within real-world business contexts. By integrating insights from digital media content, this research contributes to a practical and nuanced understanding of AI ethics, offering valuable guidance for managers, policymakers, and scholars. The study underscores that addressing AI ethical considerations is not merely a regulatory requirement but a strategic imperative, essential for sustaining innovation, ensuring fairness, and maintaining organizational legitimacy in the digital economy.

Research questions

To address these issues, the present study seeks to answer the following research questions:

1. What are the key ethical challenges associated with the adoption of Artificial Intelligence in business operations, and how are these

challenges represented and discussed by experts and practitioners in contemporary digital discourse?

2. What strategies and governance approaches are proposed or implied to address these ethical challenges, and how can they guide responsible AI implementation in organizational contexts?

Literature Review

The ethical implications of Artificial Intelligence (AI) in business operations have emerged as a critical area of scholarly inquiry and professional concern. As organizations increasingly adopt AI-driven systems for decision-making, process automation, customer engagement, and predictive analytics, the potential benefits are tempered by complex ethical risks that can influence organizational legitimacy, stakeholder trust, and social responsibility (Floridi et al., 2018; Jobin et al., 2019). Algorithmic bias is consistently highlighted in the literature as one of the most pressing ethical issues in AI. AI systems trained on historical data can inadvertently reproduce or amplify societal inequalities, leading to discriminatory outcomes in areas such as recruitment, credit scoring, customer profiling, and resource allocation (O’Neil, 2016; Mehrabi et al., 2019). For example, studies show that automated hiring algorithms may disadvantage candidates from underrepresented groups if historical data reflects past biases (Raji et al., 2020). Researchers emphasize that organizations must adopt strategies such as regular algorithm audits, diversification of training data, and fairness metrics to detect and mitigate bias, ensuring that AI-driven decisions are equitable and legally compliant (Binns, 2018; Cowgill et al., 2020). Transparency, often operationalized through Explainable AI (XAI), is crucial for ensuring that AI decisions can be understood and trusted by humans. Lack of transparency in AI systems poses ethical risks, including opacity in decision-making, diminished accountability, and potential legal challenges (Lipton, 2018; Doshi-Velez and Kim, 2017). In business settings, transparency is particularly important when AI affects stakeholders’ rights, such as customer profiling, employee evaluations, or financial decisions. Scholars argue that organizations must provide clear explanations of AI logic, decision criteria, and limitations, not only to comply with regulations but also to maintain stakeholder confidence (Guidotti et al., 2018; Wachter et al., 2017). Data privacy remains a central ethical concern in AI deployment. AI systems often rely on large volumes of personal, behavioral, and

organizational data, which raises questions about consent, data protection, and misuse of sensitive information (Shin, 2020; Zeng et al., 2021). The introduction of stringent privacy regulations, such as the General Data Protection Regulation (GDPR) in the European Union and the California Consumer Privacy Act (CCPA), has underscored the legal and ethical imperatives for organizations to handle data responsibly. Ethical AI governance requires the establishment of data minimization protocols, secure storage mechanisms, and transparent policies regarding data use, which collectively reduce the risks of breaches and misuse. The deployment of AI in decision-making shifts responsibilities from humans to machines, creating ethical concerns around accountability and responsibility (Dignum, 2019). Without clearly defined oversight mechanisms, errors or unethical decisions made by AI systems may lack a human actor to hold accountable. Literature emphasizes the importance of human-in-the-loop approaches, where humans retain ultimate decision-making authority in critical processes (Binns, 2018; Bryson, 2018). Additionally, organizations are encouraged to develop ethical codes, reporting procedures, and risk escalation frameworks that integrate AI oversight into corporate governance structures. Effective governance frameworks play a pivotal role in promoting responsible AI adoption. These frameworks integrate ethical principles such as fairness, transparency, accountability, privacy, and sustainability into organizational processes and decision-making (Morley et al., 2020; Jobin et al., 2019). Several guidelines, including those by the European Commission and the IEEE, provide principles for the development of ethical AI, emphasizing risk assessment, stakeholder consultation, and continuous monitoring (Floridi et al., 2018). Moreover, research underscores that governance must be interdisciplinary, combining inputs from ethics experts, data scientists, managers, and policymakers to ensure comprehensive oversight and alignment with societal norms (Crawford and Paglen, 2021). Recent empirical studies demonstrate how businesses implement ethical AI strategies in practice. Large technology firms, financial institutions, and multinational corporations have begun establishing AI ethics boards, bias detection teams, and transparency dashboards to operationalize ethical principles (McKinsey, 2021; PwC, 2022). Case studies reveal that organizations with proactive AI governance frameworks tend to achieve higher stakeholder trust, enhanced corporate reputation, and improved compliance with regulatory requirements. However, these practices vary widely, indicating a need for consistent standards and

guidelines across industries. Beyond academic and corporate reports, digital media platforms, particularly YouTube, provide a rich repository of discussions on AI ethics. Expert lectures, webinars, and professional presentations highlight real-world challenges, policy debates, and emerging strategies for responsible AI implementation. Studying these sources allows researchers to capture evolving trends, identify practical insights, and understand how ethical considerations are communicated to diverse audiences, bridging the gap between theory and practice. While the literature on AI ethics is extensive, most studies focus on theoretical frameworks, policy guidelines, or high-profile organizational case studies, leaving limited attention to how ethical principles are represented and operationalized in public digital discourse.

Methodology

This study employs a mixed-methods approach, combining qualitative thematic analysis, quantitative content analysis, and survey research to examine ethical considerations in AI adoption within business operations. A purposive sample of 50 YouTube videos produced by experts, academics, and professional organizations was selected based on relevance, credibility, language, and substantive content. Videos were transcribed, and key segments were extracted for analysis. Thematic analysis identified recurring ethical challenges, including algorithmic bias, transparency, data privacy, accountability, and human oversight, while content frequency analysis quantified the prevalence of these themes across the dataset. To complement the content analysis, a structured survey with 25 questions was administered to 87 participants, including students, professionals, and general audiences, to capture public perceptions of AI ethical concerns. Survey items mirrored the themes identified in the qualitative analysis, allowing for a direct comparison between expert discourse and participant perceptions. Reliability was ensured through intercoder agreement in the content analysis, and validity was enhanced by triangulating findings across the video content, survey responses, and existing literature. This methodology provides a comprehensive and systematic framework for exploring both the conceptual and practical discourse on AI ethics in business contexts.

Results

To understand how businesses address ethical challenges associated with artificial intelligence (AI), we analyzed 50 YouTube videos discussing AI applications in organizational contexts and survey with 25 questions including 87 participants. This investigation focused on identifying the frequency of key ethical themes mentioned in these discussions. By examining the relative prominence of each theme, we aimed to discover patterns in how companies perceive and prioritize ethical responsibilities in AI deployment. The findings provide insights into both the technical and human-centered dimensions of AI ethics in contemporary business practice.

Table 1. Demographic Characteristics of Survey Participants (N = 87)

Demographic Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	42	48.3
	Female	44	50.6
Age Group (years)	18–25	25	28.7
	26–35	32	36.8
	36–45	18	20.7
	46+	12	13.8
Education Level	High school diploma	10	11.5
	Bachelor’s degree	45	51.7
	Master’s degree	25	28.7
	Doctorate or higher	7	8.0
Occupation	Student	28	32.2
	Professional (private sector)	30	34.5
	Academic / Research	20	23.0
	Other	9	10.3

The survey included 87 participants, representing a diverse mix of gender, age, education, and occupational backgrounds. Gender distribution was relatively balanced, with 48.3% male and 50.6% female respondents (see Table 1). Regarding age, the majority of participants fell within the 26–35 age

group (36.8%), followed by 18–25 years (28.7%), 36–45 years (20.7%), and 46 years and above (13.8%). This distribution suggests that the survey captured perspectives across both early-career and mid-career adults, which is valuable given that perceptions of AI ethics may vary with professional experience and generational familiarity with technology. In terms of educational background, more than half of the participants held a Bachelor’s degree (51.7%), while 28.7% had a Master’s degree, 8.0% held a Doctorate or higher, and 11.5% had completed only high school. This indicates that the sample was generally well-educated, aligning with the focus on ethical awareness in AI contexts. Occupationally, participants were fairly diverse: 32.2% were students, 34.5% worked in the private sector, 23.0% were involved in academia or research, and 10.3% were classified as “other.” This diversity enhances the representativeness of the survey, providing insights from both emerging professionals and experienced individuals engaged with AI in business or research environments.

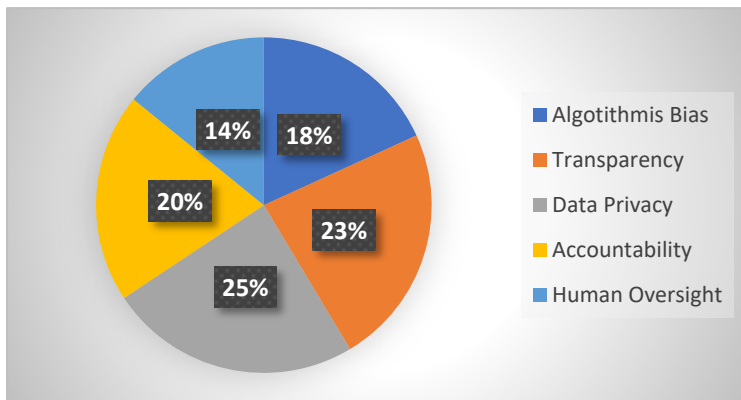


Figure 1: Frequency of AI Ethical Themes in Business

As illustrated in Figure 1, data privacy emerges as the most frequently discussed concern, accounting for 25% of the total references, highlighting businesses’ heightened attention to protecting sensitive information and ensuring regulatory compliance. Transparency follows closely at 23%, reflecting the growing demand for explainable AI and clear communication regarding decision-making processes in areas such as finance and human resources. Accountability, representing 20%, underscores the focus on governance frameworks and the assignment of responsibility for AI-driven decisions. Algorithmic bias appears in 18% of the discourse, signaling awareness of fairness and equity issues, while human oversight, at 14%, is the

least emphasized theme, suggesting a potential gap in balancing automated processes with ethical human judgment. The distribution demonstrates that while technical and compliance-related risks dominate the current conversation, human-centered considerations remain underrepresented, indicating the need for a more holistic approach to AI ethics in business operations.

Table 2: Comparative Analysis of Ethical Concerns in AI

Ethical Issue	YouTube (% of Mentions)	Survey (% Rating Very/Extremely Important)
Data Privacy	27.0	89.7
Transparency	22.0	87.4
Accountability	19.0	83.9
Algorithmic Bias	17.0	79.3
Human Oversight	15.0	71.3

Table 2 presents a comparative analysis of ethical concerns in AI as identified through YouTube content analysis and survey responses from 87 participants. The data reveal a strong convergence in the ranking of ethical priorities across both sources: data privacy, transparency, and accountability consistently emerge as the most prominent concerns, while algorithmic bias and human oversight are relatively less emphasized. Despite this alignment in trends, there is a notable difference in magnitude between the two datasets. Survey participants rated ethical issues as much more critical than they were mentioned in YouTube content. For example, data privacy was mentioned in 27% of YouTube videos but rated as very or extremely important by 89.7% of survey respondents. Similarly, transparency and accountability show a similar pattern of higher perceived importance in the survey compared to YouTube mentions. This difference suggests that while experts and organizations discuss these issues in online content, public perception tends to prioritize ethical concerns even more strongly, reflecting heightened awareness and sensitivity to AI-related risks in everyday contexts. Algorithmic bias and human oversight, though recognized in both datasets,

received comparatively lower attention, indicating areas that may benefit from increased visibility and education among both experts and the public. The comparative analysis demonstrates that ethical concerns in AI are consistently recognized across multiple channels, and the higher perceived importance in survey data underscores the relevance of these issues for practical AI governance and business decision-making.

Discussion

The findings of this study highlight that ethical concerns surrounding AI adoption in business operations are predominantly centered on data privacy, which emerged as the most frequently discussed theme. This aligns with existing research emphasizing the critical importance of protecting user data in increasingly data-driven business environments. The prominence of transparency and accountability further reflects the growing demand for explainable AI systems and clear governance structures, particularly in high-stakes decision-making contexts. The relatively high frequency of algorithmic bias indicates an increasing awareness of fairness and discrimination risks embedded in AI systems. This is consistent with current academic discourse, which identifies bias mitigation as a key challenge in the implementation of responsible AI. However, the comparatively lower emphasis on human oversight suggests a potential gap in the discourse. While automation and efficiency are prioritized, the role of human control, ethical judgment, and intervention may not be sufficiently addressed in practice. These findings suggest that while organizations are actively engaging with technical and regulatory aspects of AI ethics, there is still a need to strengthen the human-centered dimension of AI governance. Integrating ethical frameworks that balance automation with human responsibility will be crucial for the sustainable and trustworthy adoption of AI in business contexts.

Conclusion

The rapid adoption of artificial intelligence in business operations introduces both significant opportunities and complex ethical challenges. This study explored how these challenges are understood in contemporary digital discourse by analyzing 50 YouTube videos and surveying 87 participants. The findings demonstrate that data privacy, transparency, and accountability are the most prominent ethical concerns, reflecting organizations' strong focus on regulatory compliance and risk management. Algorithmic bias and

human oversight, while recognized, receive comparatively less attention. The relatively lower emphasis on human oversight indicates a potential gap in ensuring that ethical judgment, responsibility, and control remain central in AI-driven decision-making. Overall, this study underscores the necessity for a more comprehensive and holistic approach to AI ethics, one that addresses not only compliance and efficiency but also fairness, accountability, and human involvement. Embedding ethical principles into AI strategies is crucial for building trust, mitigating risks, and fostering sustainable innovation. Future research should: (a) examine how organizations operationalize these ethical frameworks in practice, (b) explore cross-cultural differences in AI ethics perceptions, (c) conduct longitudinal studies to track changes in discourse, and (d) investigate the implementation of human-in-the-loop systems across industries.

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CURRENT TRENDS IN MARKETING DIGITALIZATION AND THE IMPACT OF DIGITAL TRANSFORMATION ON MANAGEMENT SYSTEM EFFECTIVENESS: EVIDENCE FROM ARMENIAN ORGANIZATIONS

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Abstract

The research applies a conceptual-analytical and comparative methodology, integrating international empirical findings with contextual evidence from Armenian firms. The study explores key technological drivers such as artificial intelligence, big data analytics, cloud computing, CRM systems, and omnichannel platforms.

The findings indicate that digital transformation significantly enhances decision-making quality, operational efficiency, and customer engagement. However, Armenian organizations exhibit heterogeneous levels of digital maturity, resulting in uneven performance outcomes. The study develops an integrated conceptual framework linking digital transformation with management effectiveness through KPI-based systems and data-driven processes.

Keywords: marketing digitalization, digital transformation, management effectiveness, KPI systems, Armenia, data-driven decision-making.

JEL code: M31

Introduction

The rapid development of the digital economy has fundamentally transformed the structure and functioning of modern organizations. Digital technologies are no longer auxiliary tools but have become core components of business strategy and management systems (Ryan, D. 2020).

Marketing digitalization, in particular, plays a crucial role in enabling organizations to collect, process, and utilize data for strategic decision-

making. According to Kotler and Keller, modern marketing is increasingly data-driven, customer-centric, and technology-enabled.

Despite global advancements, emerging economies such as Armenia demonstrate transitional characteristics in digital transformation. Armenian organizations are gradually adopting digital tools; however, structural, financial, and institutional constraints limit the speed and depth of transformation (Kotler, P., & Keller, K. L. 2016).

Research Objective: To evaluate the impact of marketing digitalization on management system effectiveness in Armenian organizations.

Research Questions

- How does digital transformation influence managerial decision-making?
- What is the relationship between digital maturity and organizational performance?
- What barriers constrain digital transformation in Armenia?

2. Literature Review

Digital transformation has been widely studied as a multidimensional phenomenon integrating technology, strategy, and organizational change. (Davenport and Harris Davenport, T. H., & Harris, J. G. 2007). emphasize the strategic role of analytics in achieving competitive advantage. Similarly, (Wedel and Kannan Wedel, M., & Kannan, P. K. 2016). highlight the importance of marketing analytics in improving customer targeting and performance measurement.

Recent studies (McKinsey, 2022) show that companies implementing advanced digital marketing technologies achieve:

- 20–30% higher ROI
- 15–20% cost reduction
- 2x faster decision-making

However, most studies focus on developed markets, leaving a research gap regarding emerging economies such as Armenia. This study contributes by integrating:

- technological perspective
- managerial perspective
- regional (Armenian) context.

3. Methodology: The research adopts a **conceptual-analytical and comparative approach**, combining theoretical insights with empirical observations.

Research Methods

- Comparative analysis (Armenia vs international benchmarks)
- KPI-based performance evaluation
- Secondary data analysis (OECD, Statista, McKinsey reports)
- Case-based reasoning (Armenian banking, telecom, e-commerce sectors)

Analytical Model

Management Effectiveness = f (Digitalization, Data Quality, Speed, Accuracy, KPI Systems)

4. Results and Discussion

Analytical Introduction

This section presents findings based on the analysis of digital transformation trends in Armenian organizations. The results highlight structural changes in management systems, levels of digital maturity, and performance outcomes.

Table 1 Impact of Digital Transformation in Armenian Organizations¹

Factor	Traditional Firms	Digitally Advanced Firms	Impact
Decision-making	Experience-based	Data-driven	Higher accuracy
Speed	Low	High	Faster response
Efficiency	Moderate	High	Increased productivity
Risk Level	High	Reduced	Improved stability

The findings indicate that organizations implementing digital tools—such as CRM systems and advanced analytics platforms—demonstrate significantly enhanced managerial performance. In particular, data-driven decision-making improves accuracy, reduces uncertainty, and enables more proactive and strategically aligned planning processes.

The analysis further reveals that digitized organizations exhibit several key advantages over traditional firms, including faster responsiveness, more accurate decision-making, and reduced exposure to operational and strategic risks. These improvements are primarily driven by the integrated and systematic utilization of data across organizational processes.

¹ Source: Author’s own elaboration based on research results.

Empirical evidence from Armenian organizations confirms that companies adopting digital technologies significantly outperform their traditional counterparts. This performance gap is especially evident in sectors such as banking, telecommunications, and e-commerce, where firms demonstrate higher adaptability, improved decision quality, and greater operational efficiency.

These findings support the functional relationship:

$$\text{Efficiency} = f(\text{Data, Speed, Accuracy})$$

indicating that organizational efficiency is directly influenced by the quality of data, the speed of information processing, and the accuracy of decision-making.

Overall, digital transformation enhances managerial rationality and reduces uncertainty, thereby improving management system effectiveness. However, its impact is not uniform across sectors, as variations in digital maturity, resource availability, and technological capabilities lead to differing performance outcomes.

Table 2 Digital Maturity in Armenian Organizations²

Level	Description	Armenian Context	Performance
Initial	Minimal digitalization	SMEs	Low
Developing	Partial use of digital tools	Medium-sized firms	Moderate
Integrated	System-level integration	Banks, telecommunications	High
Advanced	AI-driven and automated systems	IT sector, tech startups	Very High

The Armenian market is characterized by **asymmetric digital maturity**, where organizations demonstrate significantly different levels of digital development. Large enterprises—particularly in the banking, telecommunications, and IT sectors—tend to operate at integrated or advanced levels of digitalization, benefiting from system-wide data integration and automation.

In contrast, small and medium-sized enterprises (SMEs) remain concentrated in the initial and developing stages, relying on limited digital tools and fragmented systems. This imbalance creates a **structural digital divide**,

² Source: Author’s own elaboration based on research results.

which constrains overall economic efficiency and reduces the potential for widespread productivity gains.

Furthermore, the level of digital maturity is directly correlated with organizational performance. Firms operating at higher maturity levels demonstrate improved decision-making quality, greater operational efficiency, and stronger competitive positioning. Conversely, low digital maturity is associated with slower processes, higher uncertainty, and reduced strategic flexibility.

The findings suggest that enhancing digital maturity across all organizational levels—particularly among SMEs—is essential for reducing structural disparities and achieving sustainable economic growth in Armenia.

Table 3 KPI-Based Performance Evaluation³

KPI	Traditional Firms	Digital Firms	Change
Conversion Rate	2–3%	5–8%	+2x
Customer Acquisition Cost (CAC)	High	Reduced	Decrease
Customer Lifetime Value (CLV)	Medium	High	Increase
ROI	10–15%	20–30%	Significant growth

The results confirm that digital marketing significantly enhances measurable business outcomes. Organizations that adopt data-driven strategies achieve more effective customer targeting, reduced customer acquisition costs, and increased overall profitability.

Empirical evidence from Armenian organizations further supports these findings. Companies utilizing digital marketing tools demonstrate higher levels of customer engagement, more efficient allocation of marketing resources, and improved return on investment (ROI). These performance improvements reflect the growing role of data analytics in optimizing marketing activities and strategic decision-making.

In practical terms, sector-specific applications highlight this impact. For instance, banks in Armenia increasingly rely on data analytics to deliver personalized financial services, thereby strengthening customer relationships

³ Source: Author’s own elaboration based on research results.

and retention. Similarly, e-commerce platforms employ advanced targeting and segmentation systems to enhance conversion rates and customer experience.

Overall, improvements in key performance indicators (KPIs) provide clear evidence that digital transformation generates tangible and measurable benefits. These findings underscore the critical role of digital marketing in enhancing organizational performance and competitiveness within the Armenian context.

Table 4. Comparative Analysis: Armenia vs. Developed Markets⁴

Indicator	Armenia	Developed Markets
Digital maturity	Medium	High
AI adoption	Low–Medium	High
Data utilization	Partial	Advanced
Automation level	Low	High

Armenia demonstrates strong growth potential but remains in a developmental stage compared to advanced economies. The gap is primarily driven by resource constraints, technological infrastructure, and skill shortages.

5. Challenges in Digital Transformation

The study identifies several critical barriers:

- Limited financial resources
- Insufficient technological infrastructure
- Lack of digital competencies
- Organizational resistance to change
- Regulatory and institutional limitations

These challenges significantly slow the adoption and effectiveness of digital transformation initiatives.

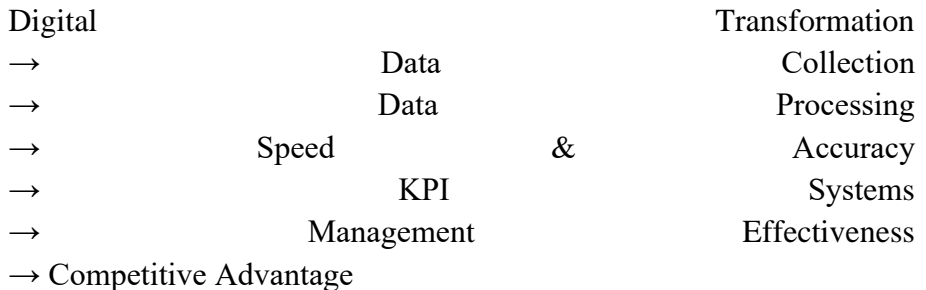
6. Practical Implications

To enhance management effectiveness, Armenian organizations should:

1. Implement phased digital transformation strategies
2. Adopt KPI-driven management systems
3. Invest in digital skills and workforce training

⁴ Source: Author’s own elaboration based on research results.

4. Establish data governance frameworks
5. Integrate AI and automation technologies
6. Conceptual Framework
7. Conceptual Framework



8. Scientific Contribution and Research Novelty

The scientific novelty of this study lies in the development of an integrated and context-specific framework that links marketing digitalization with management system effectiveness in an emerging economy, specifically Armenia.

First, the study proposes a **multi-dimensional model of management effectiveness**, where digital transformation is conceptualized as a function of data quality, processing speed, and decision-making accuracy. Unlike traditional approaches, which examine digitalization in isolation, this research integrates technological, managerial, and performance dimensions into a unified analytical framework.

Second, the research introduces a **contextualized digital maturity model tailored to Armenian organizations**, highlighting structural asymmetries between large enterprises and SMEs. This model provides a more nuanced understanding of digital transformation in transition economies, where uneven technological adoption significantly affects organizational performance.

Third, the study develops a **KPI-based evaluation system** that empirically demonstrates the measurable impact of digital marketing on organizational outcomes. By linking indicators such as conversion rate, customer acquisition cost (CAC), customer lifetime value (CLV), and ROI with digital adoption, the research provides quantifiable evidence of performance improvement.

Fourth, the paper offers a **comparative analysis between Armenia and developed markets**, identifying key gaps in AI adoption, automation, and data utilization. This comparative perspective contributes to the literature by positioning Armenia within the global digital transformation landscape.

Finally, the study contributes to academic and practical discourse by providing **empirical insights from an under-researched regional context**, thereby addressing a gap in existing literature, which predominantly focuses on developed economies.

Conclusion

The findings confirm that marketing digitalization is a key determinant of management system effectiveness. Digital transformation enhances decision-making quality, operational efficiency, and organizational competitiveness.

However, the impact is contingent upon the level of digital maturity. In Armenia, uneven digital development and structural barriers limit the full realization of digital transformation benefits.

Bridging the digital divide and implementing integrated digital strategies are essential for achieving sustainable economic growth and long-term competitiveness.

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RETHINKING UNIVERSITY TEACHING IN THE DIGITAL ERA: EVIDENCE FROM ARMENIAN AND RUSSIAN UNIVERSITIES

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Abstract

This article examines transformations in university lecturers' pedagogical activity amid the ongoing digitalisation of higher education. Drawing on post-non-classical science methodology, which integrates explanatory and interpretative approaches and treats participants' values, perceptions, and attitudes as valid research data, the study provides both theoretical and empirical justification for the growing centrality of pedagogical knowledge.

The empirical component involved comprehensive diagnostics—including focus groups, observations, and anonymous questionnaires—with over 70 lecturers from Armenian and Russian universities. Three main groups of challenges are identified: (1) designing curricula and educational-methodological support, where 72% feel unprepared to build student-centred digital learning environments; (2) organising students' independent work, hampered by insufficient feedback and counselling; and (3) fostering productive communication with students in digital environments, which remains labor-intensive and institutionally unrecognised.

The conclusion underscores that pedagogical knowledge has become a core component of university lecturers' professional activity in contemporary higher education—a finding with direct implications for policy, institutional practice, and the design of academic development programmes.

JEL code: I23, O33

Keywords: Digitalisation of higher education, Pedagogical knowledge, University lecturers, Student-centred learning, Digital learning environments, Academic development

Introduction

The rapid transformation of higher education, accelerated by digitalisation and the legacy of the pandemic, presents profound challenges for university teaching and its management (Jughuryan, Mkhitarian, & Avetisyan, 2024; *Basics of Professional Education Management*). Many university lecturers demonstrate a low level of readiness for these changes, owing to insufficiently developed skills for operating in digital educational environments and a lack of so-called “soft skills” – teamwork, creativity, and critical thinking. At a deeper level, they face the need to change the mental models that underpin their professional activity – models shaped by value orientations, attitudes, expectations, and social dispositions that manifest in concrete actions.

Despite substantial institutional investment in technological infrastructure and digital tool training, these efforts have proved insufficient. Post-pandemic teaching remains predominantly lecture-based, with technologies used largely for content transmission rather than pedagogical transformation. As Shirley (2024) argues, the mere incorporation of digital technologies does not guarantee meaningful change in teaching and learning processes. This observation underscores the urgent need to rethink university teaching beyond technological fixes.

A lecturer’s activity is multidimensional, comprising pedagogical (teaching and methodological), educational, research, and organisational-managerial components. Among these, pedagogical activity plays the leading role, integrating the others (Jughuryan & Mkhitarian, 2026; *Methodology of Scientific Research and Scientometrics*). Consequently, understanding how pedagogical activity is being transformed in the digital era is a central problem for higher education research.

Research gap and contribution. While a growing body of literature examines digital transformation in higher education, most studies focus on technological adoption, infrastructure, or student outcomes. Far less attention has been paid to the internal, value-laden process by which university lecturers reconfigure their pedagogical activity – including their professional identity, readiness for change, and the practical difficulties they encounter.

Moreover, the post-Soviet context of Armenia and Russia, where higher education systems share historical legacies but are undergoing distinct modernisation trajectories, remains underexplored in international debates. This study addresses that gap by providing empirical evidence on lecturers' value orientations, self-perceived readiness, and actual challenges, grounded in a post-non-classical science methodology.

Theoretical framework. Our research is situated within the post-non-classical stage of pedagogical science, where humanistic orientations become the starting point for scientific inquiry, making “research optics more stereoscopic” (Stepin, 2012). From this perspective, participants' values, perceptions, and attitudes are treated not as subjective noise but as valid data for understanding complex educational change. The theoretical framework integrates a functional approach to lecturers' professional activity, distinguishing five core groups of pedagogical tasks identified in prior research at leading Armenian universities:

1. Designing educational programmes in accordance with professional standards.
2. Developing educational and methodological support, including assessment tools.
3. Designing and organising productive independent work for students.
4. Collaborating with other lecturers in the design and implementation of the educational process.
5. Designing one's own professional career and self-education.

In the context of digitalisation, each of these tasks acquires new content, shaped by the need to construct non-linear, student-centred educational processes. Furthermore, entirely new tasks emerge – those related to the lecturer's understanding of the meaning of their activity, professional self-identification, and readiness for collegial and partnership work. Drawing on an extensive review of dissertation research, monographs, internet resources, and the authors' own experience teaching in Armenian, Russian, and European universities (including professional development programmes), we argue that readiness for change is a key determinant of successful pedagogical transformation.

Empirical approach. The empirical study was designed to answer three main questions:

- How do university lecturers perceive the necessity of change in the context of digitalisation?
- What value orientations underlie their attitudes towards these changes?
- What specific difficulties do they encounter in realising pedagogical tasks?

The study employed a mixed-qualitative design, comprising: (a) qualitative content analysis of scientific literature to identify documented connections between new digital tasks and pedagogical strategies; (b) thematic coding (based on Strauss & Corbin, 2000, but adapted for the purposes of this study) of semi-structured interviews with lecturers, to capture subjective value orientations; and (c) comprehensive diagnostics, including observation of real-time teaching, focus group discussions with humanitarian expertise of the results, and anonymous self-assessment questionnaires. This design allowed us to establish both lecturers' stated acceptance of change and the difficulties they actually experience.

Study context and participants. The study was conducted during the 2025–2026 academic year, in parallel with professional development programmes for teaching staff. A total of 76 lecturers from Armenian and Russian universities participated: 15 from the International Scientific and Educational Centre (ISEC) of the National Academy of Sciences of the Republic of Armenia, 22 from Yerevan State University, 20 and 14 respectively from two St. Petersburg universities (Saint Petersburg State University and Saint Petersburg State University of Industrial Technologies and Design), and 5 from the Public Administration Academy of RA. Focus group discussions were supplemented by participant observation (recording interaction patterns and the value content of assignments) and humanitarian expertise of pedagogical activities – the latter aimed not at verdicts but at collaborative identification of difficulties. An anonymous questionnaire with two blocks (attitudes towards change and self-assessed difficulties) was administered, and responses were analysed using assessment matrices and open-ended commentary. Semi-structured interviews were subsequently conducted to clarify intermediate findings.

The remainder of the article presents the results of this empirical investigation, discusses the three main groups of difficulties identified, and proposes strategic directions for rethinking university teaching in the digital

era – with a particular focus on flexible curricula, robust digital educational environments, and reformed professional development programmes.

Results and Discussion

This section presents the main empirical findings, organised around three themes: (1) lecturers’ value-normative regulation and self-perceived readiness for change; (2) the specific difficulties encountered in pedagogical activity; and (3) the relationship between involvement in innovation and readiness to transform practice. Where relevant, findings are discussed in light of contemporary international research.

Value-normative regulation: between formal acceptance and actual practice

Focus group discussions revealed two distinct types of value-normative regulation among university lecturers: **ordinary-traditional** (based on routine, habit, and external compliance) and **moral-ethical** (grounded in internalised professional values and a sense of purpose). Although the declared value orientations of digital transformation – such as student-centredness, flexibility, and innovation – were recognised as important and significant by the overwhelming majority, they were perceived largely as *formal* regulators of behaviour rather than as genuine drivers of real pedagogical activity.

A striking finding concerns self-perceived readiness: **more than 90%** of respondents rated themselves as sufficiently or highly ready to implement pedagogical activities under conditions of uncertainty. This optimistic self-assessment, however, did not align with observed behaviour. During the first month of the pandemic-induced shift to distance learning, lecturers raised numerous organisational, psychological, and methodological concerns. While respondents later claimed these difficulties were “overcome fairly quickly”, the initial gap between confidence and competence is noteworthy. This discrepancy echoes recent findings by Naa-Solo Tettey (2025), who reported that 70% of faculty struggle to maintain student engagement in asynchronous courses despite high self-efficacy ratings. It also aligns with the concept of “digital metamorphosis” proposed by Mavroudi and Wagstaffe (2025), which requires not just skills but a fundamental introspection of educators’ values and beliefs about learning technologies.

Changing perceptions of pedagogical tasks and value orientations

More than a third (35%) of respondents noted that the number of organisational and controlling tasks in their pedagogical activity had expanded – a change that conflicts with their understanding of the purpose of university education. For 18% of lecturers, university education should orient students towards research activity, not merely practice-oriented skills. Conversely, **almost 45%** believed that, under new conditions, pedagogical activity should give greater attention to student support, autonomy, and professional self-development. This group called for designing variable class content that depends on students’ own goals.

These shifting perceptions were accompanied by changes in value orientations across three dimensions:

<u>Dimension</u>	<u>Reported value orientation</u>
Content-related	Presenting educational material in diverse forms (not only text but also video, visualisations); using “emotional knowledge” (thoughts and feelings captured in interviews, essays, compositions).
Organisational	Ensuring active student participation through individual, group, and collective activities; organizing interactive interaction within student groups; creating conditions for applied, research-based knowledge use.
Controlling	Developing student motivation for self-organisation, self-control, and self-education (e.g., accumulative assessment with peer-review elements); building systematic support and counselling at programme and discipline levels.

This understanding, held by a substantial group of lecturers, represents an effective prerequisite for transforming university education towards individual learning trajectories, competency development through research and project activities, and a shift in the lecturer’s professional role – from a “lecturer” to a “**navigator**” or **tutor** who provides reflection and orientation, enabling the student to become a genuine subject of trial activity across

research, management, and cultural practices (Jughuryan & Mkhitarian, 2025; *Science Organisation and Management*).

Three groups of difficulties in pedagogical activity

Comprehensive diagnostics (focus groups, observations, questionnaires, and humanitarian expertise) identified three interconnected clusters of difficulties.

1. Designing curricula and educational-methodological support

More than half of the respondents reported a deficit of knowledge and skills for working in the digital information environment (55%). Approximately half (50%) felt unable to develop bachelor's or master's programmes and corresponding discipline work programmes. Notably, 70% noted problems in developing control and assessment materials, and 72% were unprepared to design educational-methodological support that builds a student-centred educational process.

The digital transformation has also foregrounded the task of developing electronic training courses and modules. However, many existing e-courses consist only of presentations, lecture materials, and numerous assignments for independent work – without teacher explanations or recommendations. Assessment materials for intermediate certification rarely include necessary clarifications, feedback algorithms, or error commentaries. On distance learning platforms, students receive insufficient information about additional literature and sources that would motivate deeper disciplinary immersion and research.

2. Organising productive independent work for students

Difficulties here stem from two interrelated sources: lecturers' lack of readiness to implement student-centred processes, and students' underdeveloped general cultural and professional competencies for productive independent work. A supplementary survey of students (conducted by the authors) revealed that:

- 52% cannot independently navigate discipline content, distinguish essential from non-essential, or formulate a request for help.
- 30% are unable to organise their own time, find, and effectively use additional information sources.
- Students consistently reported a lack of feedback, systematic counselling, and algorithmic assistance from lecturers, leading to formal task completion and negative emotions (irritation, disappointment, anxiety).

These findings are consistent with international research on the dual role of digital technology as both facilitator and inhibitor (Fan, 2025), which notes that online environments can lead to de-systematisation, de-centralisation, and de-individualisation of teaching – precisely the problems observed here.

3. Organising productive communication with students

Communication difficulties became particularly acute during the pandemic. While lecturers have learned to use various electronic platforms, instant messengers, and email, the content of interaction remains problematic. On one hand, lecturers are unprepared to change their pedagogical position and master new interaction technologies; on the other, the system itself has not revised its understanding of what modern university pedagogical activity entails or how its complexity should be assessed.

Productive communication requires the ability to provide counselling and differentiated support based on students’ professional interests and needs. This activity is highly labour-intensive and significantly increases the lecturer’s academic workload – yet this increase is neither recorded nor compensated institutionally. As Finnegan and Murphy (2024) argue, lecturer identity in digital contexts is often misaligned with institutional expectations and contract structures, creating a hidden burden.

Exacerbating factors and the risk of professional alienation

Objective circumstances exacerbate all three groups of difficulties. 95% of respondents cited “lack of time, energy, and bodily resources” and the stressful situation of being involuntarily involved in change. This combination increases the risk of alienation from the very meanings of pedagogical activity – meanings that determine a lecturer’s readiness to facilitate student professional and personal development, autonomy, and identity formation. Such alienation undermines the transition to a personified educational process.

The moderating role of involvement in innovation

An important connection was identified between participation in innovative processes and readiness to change. Lecturers from Yerevan State University who were actively involved in implemented innovation events showed a qualitatively different profile: they understood the need for change and its essence, adapted more readily, and changed their activities in line with systemic challenges. This manifested as reduced anxiety about difficulties, greater acceptance of working situations, and a proactive stance. This finding

supports the ISTE Faculty Standards for Digital Teaching and Learning Competencies (2025), which emphasise that sustained engagement in innovation communities fosters the six key roles (Instructor, Coordinator, Leader, Researcher, Learner, Contributor) necessary for digital transformation.

Summary of discussion

The results demonstrate that the digital transformation of university teaching is not primarily a technological challenge but a **pedagogical and value-laden** one. Lecturers recognise the need for change and articulate sophisticated value orientations (content-related, organisational, controlling) that would support transformation. However, a profound gap exists between these orientations and actual practice, constrained by insufficient methodological preparation, inadequate institutional support for labour-intensive activities (counselling, feedback, differentiated instruction), and the absence of workload recognition. Overcoming these difficulties requires moving beyond individual lecturer effort towards systemic changes in curriculum design, digital environments, and professional development – as will be elaborated in the Conclusions.

Conclusions

The analysis of difficulties encountered by university lecturers in the context of digital transformation – specifically in curriculum design, organisation of students' independent work, and productive communication in digital environments – points to several interrelated strategic directions for overcoming them. These directions are grounded not only in the empirical findings of this study but also in recent international research on digital pedagogy and institutional change.

First, moving beyond the traditional “educational pipeline” model. The findings reveal that rigid curricula and fixed learning trajectories are a primary source of lecturer difficulty, particularly in designing student-centred educational-methodological support (72% of respondents reported being unprepared for this task). To address this, institutions should develop **flexible, modular educational programmes** that enable individualised learning pathways. This includes introducing elective module pools, dynamic scheduling models, and micro-credentials – structural innovations that have gained empirical support in recent initiatives such as Digivisio2030 (2024–2025) and the work of Ciolan (2023) on modular

curricula. Such approaches not only support student-centred learning but also require a fundamental reconsideration of academic workload distribution and institutional organisation, including recognition of the labour-intensive counselling and feedback activities that lecturers currently perform without formal acknowledgment.

Second, strengthening digital educational environments as pedagogical spaces. Beyond their technological function, digital environments must enable meaningful pedagogical interaction, co-construction of knowledge, continuous feedback, and personalisation of learning processes. Our study found that current e-courses often reduce to repositories of presentations and assignments without explanatory or reflective support. As Polupan (2018) argued, interactive intellectual environments should integrate teaching, learning, and assessment practices. More recent work by Fan (2025) on the dual role of digital technology – as both facilitator and inhibitor – underscores the need for intentional pedagogical design to counteract de-systematisation and de-individualisation. Therefore, developing a comprehensive digital educational environment means prioritising pedagogical affordances over technical features, and ensuring that platforms support rather than undermine lecturer-student relationships.

Third, transforming professional development systems for academic staff. Existing training models, which focus predominantly on digital tool proficiency, have proven insufficient. Our findings show that despite high self-perceived readiness (>90%), lecturers face profound difficulties in designing student-centred materials (72%), developing assessment tools (70%), and organising productive independent work – difficulties rooted in pedagogical knowledge deficits, not technical ones. Consequently, professional development must be reoriented toward **pedagogical knowledge, reflective practice, and value-based understanding of teaching.** The ISTE Faculty Standards for Digital Teaching and Learning Competencies (2025) provide a useful framework, emphasising six roles (Instructor, Coordinator, Leader, Researcher, Learner, Contributor) that integrate technical and pedagogical dimensions. Similarly, Gqoli and colleagues (2025) advocate for blended training combining technical proficiency with pedagogical innovation, grounded in the TPACK framework. Such programmes should include ongoing evaluation and opportunities for lecturers to engage in communities of practice – a factor

that, in our study, distinguished more adaptable lecturers (e.g., those involved in innovation events at Yerevan State University) from their less engaged peers.

Overall contribution and implications. This study demonstrates that the effectiveness of digital transformation in higher education depends not on the mere adoption of technologies, but on the **reconfiguration of pedagogical activity, professional identity, and value orientations** of university lecturers. The gap between declared value orientations (which are often formal and regulatory) and actual pedagogical practice must be closed through systemic institutional support, not individual effort alone. In this context, **pedagogical knowledge emerges as a core component of academic professionalism** – extending beyond the teaching profession and becoming increasingly relevant in a knowledge-based society characterised by intensive interpersonal interaction, knowledge production, and continuous learning.

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TECHNOLOGY IS READY, CUSTOMERS ARE NOT: BEHAVIORAL BARRIERS TO DIGITAL BANKING IN ARMENIA

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Abstract: The rapid digitalization of the banking sector over the past two decades both globally and in Armenia has significantly expanded opportunities for efficiency, accessibility and financial inclusion. In Armenia, strong digital infrastructure, high smartphone penetration, certain economic regulations and active competition among banks have created favorable conditions for digital banking further technological development and adoption by customers.

However, despite this technological readiness, customer behavior has not evolved at the same pace. Many users continue to rely on physical branches and traditional service channels, even when more convenient and less time-consuming digital alternatives are available. This indicates a persistent gap between technological capability and actual usage.

This paper argues that the primary constraint is not technological, but behavioral. Based on behavioral economics and innovation diffusion theory, the study examines how cognitive biases, perceived risk, trust and habit persistence influence financial decision-making. It also introduces the concept of a “flattening” of the traditional innovation adoption curve in digitally saturated environment.

The findings suggest that digital banking transformation should be understood as a behavioral transition rather than a purely technological process. The study provides conceptual insights into more effective customer behavior management strategies in commercial banks.

Keywords: Digital banking, customer behavior, behavioral economics, trust, innovation adoption, Armenia, financial decision-making, customer experience (CX), brand experience (BrandX).

JEL code: M31

Research aims: The primary aim of this research is to examine the behavioral factors that influence the adoption of digital banking services in

the Republic of Armenia and to identify the key challenges faced by commercial banks in managing customer behavior during digital transformation.

The study specifically aims to:

- analyze the role of behavioral biases in financial decision-making;
- explore the impact of trust and perceived risk on digital banking adoption;
- examine the applicability of innovation diffusion theory in the modern digital environment;
- identify the gap between technological readiness and customer behavior;
- provide conceptual implications for customer behavior management in banking.

Research novelty: This research contributes a novel integrated behavioral perspective on digital banking adoption by combining insights from behavioral economics, innovation diffusion theory and customer experience management within a modern digital environment.

First, the study contributes to existing literature by highlighting a shift in how innovation spreads over time. Classical models (Rogers, 2003) describe adoption as a gradual transition from early adopters to the majority. However, this research suggests that in today’s digital environment, this process is no longer as smooth or predictable. Rapid technological change, constant exposure to new solutions, and information overload make customers more cautious in their decisions. As a result, adoption becomes slower and increasingly influenced by behavioral factors such as trust and perceived risk. This shift is described as a “flattening of the adoption curve.”

Second, the research reframes digital banking adoption as a behavioral rather than technological challenge. While prior studies often focus on infrastructure, usability, or technological acceptance, this study emphasizes the discrepancy between technological readiness and actual customer behavior. It demonstrates that even in environments with high digital accessibility, adoption remains constrained by cognitive biases, emotional responses, and habit persistence.

Third, the study contributes a conceptual framework for customer behavior management through the integration of customer experience (CX) and brand experience (BrandX). Unlike traditional approaches that treat CX

primarily as a service quality or usability factor, this research positions CX as a mechanism for reducing friction in interaction, while BrandX is conceptualized as a long-term driver of trust, familiarity, and behavioral commitment. This dual perspective provides a more comprehensive understanding of how financial institutions can actively influence customer behavior in digital environments.

Finally, the research adds contextual value by applying these concepts to the Armenian banking sector, where high levels of digital infrastructure coexist with behavioral resistance to adoption. By incorporating empirical observations on multi-banking behavior and declining loyalty, the study highlights the increasing importance of behavioral differentiation in competitive financial markets. Together, these contributions provide a more nuanced understanding of digital banking transformation and establish a foundation for behaviorally informed strategies in financial services.

Introduction

Digital transformation has become a central driver of socio-economic development in the modern era. In the banking sector, this transformation is particularly evident through the expansion of mobile applications, online platforms and digital financial services. These developments have created significant opportunities for improving operational efficiency and expanding access to financial services.

At the same time, customer behavior has not evolved at the same pace as technological innovation. This gap between technological capability and actual usage remains a critical challenge for financial institutions.

This issue is often illustrated by a statement commonly attributed to Henry Ford: *“If I had asked people what they wanted, they would have said faster horses.”* The statement reflects the tendency of individuals to interpret new possibilities through the lens of familiar experiences. In a similar way, banking customers often continue to rely on traditional channels even when more efficient digital alternatives are available.

In the current digital environment, however, the situation is further complicated by the increasing speed of innovation and the growing volume of information. Customers are continuously exposed to new technologies, which can lead not to faster adoption, but to greater selectivity and caution.

This raises a key research question: **why do customers resist digital banking even when the technology is already available and functional?**

This study is based on the hypothesis that the adoption of digital banking services is constrained more by behavioral factors such as trust, perceived risk, and cognitive biases, than by technological availability. Drawing on behavioral economics and innovation diffusion theory, the research examines how customer decision-making is shaped by psychological and emotional factors rather than purely rational evaluation.

Methodologically, the study combines a review of theoretical literature with the analysis of secondary data on digital infrastructure and banking trends, as well as primary research, including brand tracking surveys and targeted customer behavior surveys conducted in the Armenian market. This multi-source approach allows for both conceptual and empirical examination of digital banking adoption.

The findings suggest that digital banking transformation should be understood not only as a technological shift but also as a behavioral transition. The study contributes to the literature by highlighting the growing gap between technological capability and customer readiness, and by proposing behaviorally informed approaches to customer management in commercial banks.

Findings

1. Behavioral Nature of Financial Decision-Making

Traditional economic theory assumes that individuals act rationally, making decisions that maximize utility based on available information (Simon, 1955; Varian, 2014). However, research in behavioral economics demonstrates that decision-making is often influenced by cognitive biases and emotional factors (Kahneman, 2011; Thaler, 2015).

As Ariely (2008) suggests, individuals are “predictably irrational,” meaning that their behavior follows systematic patterns that deviate from purely rational models. In financial context, these deviations are particularly visible due to the presence of uncertainty, perceived risk and emotional involvement.

Several behavioral mechanisms are especially relevant to the emerging digital banking:

- **Status quo bias**, leading individuals to prefer familiar banking methods;
- **Loss aversion**, resulting in heightened sensitivity to potential financial errors;

- **Risk perception**, particularly related to cybersecurity and system reliability;
- **Trust**, which remains a fundamental component of financial relationships.

These factors help explain why customers may hesitate to adopt digital banking services despite their functional advantages.

2. Innovation Adoption and the Changing Diffusion Dynamics

The adoption of new technologies is commonly explained through Rogers’ Diffusion of Innovations theory (Rogers, 2003), which categorizes individuals into innovators, early adopters, early majority, late majority and laggards (see Figure 1).

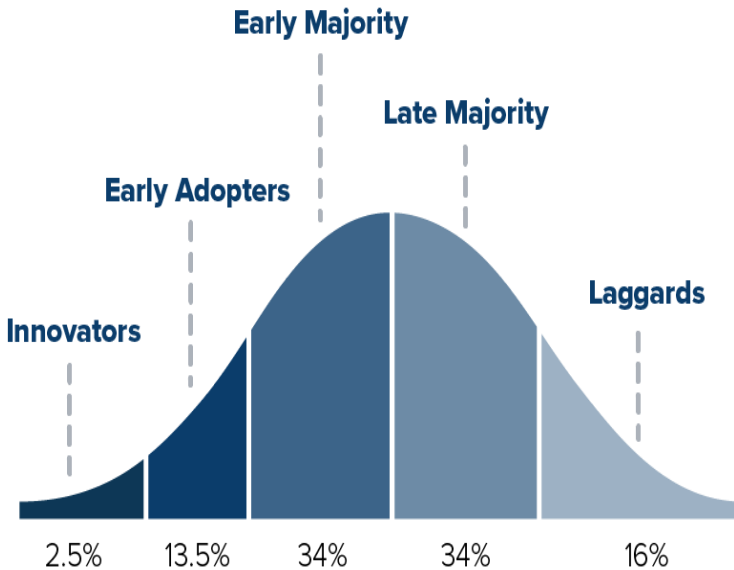


Figure 1. Innovation adoption lifecycle by based on Everett Rogers’ diffusion of innovation model

Adoption doesn’t happen uniformly. Each segment of the market responds to innovation differently, depending on their risk tolerance, access to information and trust in change. While early adopters focus on what’s possible, the early majority wants proof that an innovation works in real-world conditions and addresses their specific needs with easier solutions. What excites visionaries rarely convinces pragmatists.

A key insight into this model is that the majority of the population belongs to the early and late majority segments, which are typically more

cautious and risk-averse. These groups require higher levels of trust, social validation and perceived reliability before adopting new technologies.

In the contemporary digital environment, the dynamics of this process appear to be evolving. The rapid pace of innovation and the constant exposure to new technologies from one side and the overload of ads in all touchpoints have increased cognitive load and reduced the likelihood of immediate adoption. As a result, the transition from early adopters to the majority becomes slower and less predictable.

This phenomenon can be described as a **flattening of the adoption curve** (see **Figure 2**), where diffusion becomes more gradual and dependent on behavioral factors rather than purely technological ones.

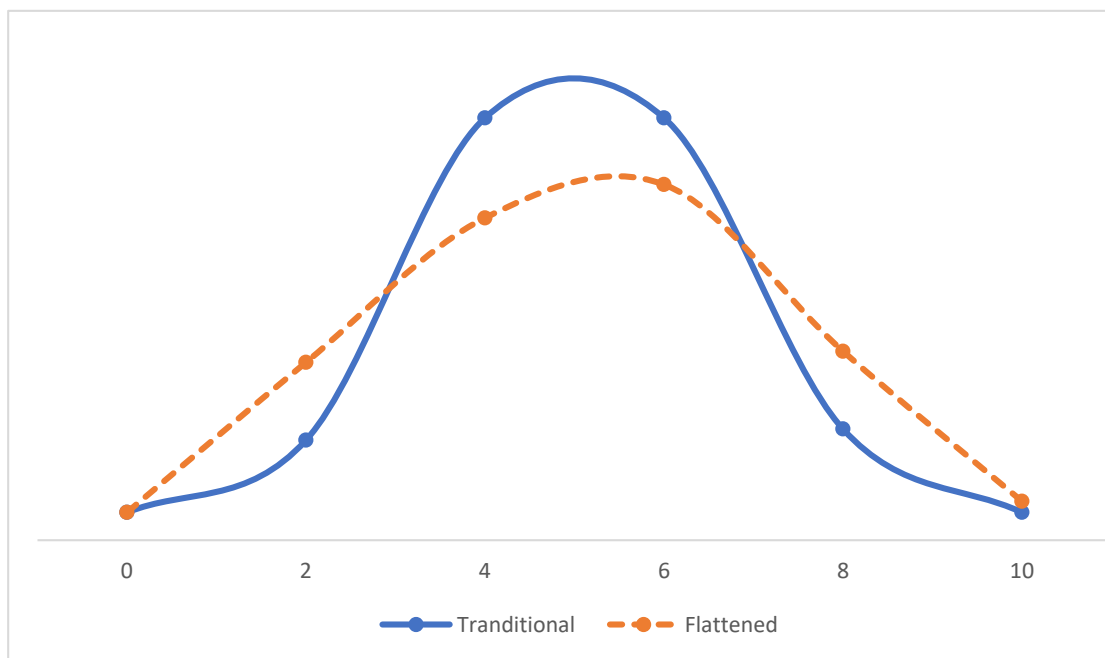


Figure 2. Comparison of traditional innovation diffusion and flattened adoption curve in digitalizing environment

In the Armenian context, digital banking infrastructure has been developing for more than a decade. Mobile banking applications were first introduced in the early 2010s, with more rapid expansion in recent years. Today, a significant share of banking services including payments, transfers, and product activation, can be performed through mobile applications.

From a regulatory perspective, the environment further supports digital adoption. Cashless transactions are actively promoted, and salary

payments for formally employed individuals are predominantly processed through bank accounts. These conditions create a structurally favorable environment for the transition toward digital banking.

However, adoption levels remain moderate. By the end of 2025, the number of mobile banking users is estimated at approximately 800,000⁵, representing around 40–45% of the target population. This contrasts with smartphone penetration, which is estimated at 70–85% of the adult population.

This discrepancy suggests that the key limitation is not access to technology, but the behavioral readiness of customers to actively use digital banking services.

3. Perceived Risk vs. Actual Risk

An important barrier to digital banking adoption is the discrepancy between perceived and actual risk. Customers often evaluate new technologies based on familiarity rather than objective security.

For example, the introduction of biometric payment systems by Amio bank, such as face-recognition-based transactions, which is a significant innovation not only in the country but in the region, has sometimes been met with skepticism and concern. Some users interpret such technologies as intrusive or unsafe, despite the fact that biometric authentication can be more secure than traditional password-based systems.

This pattern reflects a broader behavioral tendency: individuals tend to overestimate risks associated with unfamiliar technologies while underestimating risks associated with familiar ones. Similar reactions have historically accompanied the introduction of major innovations, including electrical appliances and mobile communication technologies. Thus, perceived risk is not solely a function of technological design, but a behavioral construct shaped by experience, trust and cognitive framing.

4. Trust and Digital Transformation

Trust plays a central role in financial decision-making. As Botsman (2017) argues, trust can be considered the “currency” of the modern digital economy. In traditional banking, trust is built through physical presence, interpersonal interaction and long-term relationships. In digital banking, however, trust must be transferred to technological systems and interfaces.

⁵ Author assessment based on relevant nationwide survey data (brand tracking research)

This transition is not automatic. Customers may trust banks as institutions while simultaneously distrusting digital channels. This creates a gap that can significantly slow the adoption of digital services.

In addition to behavioral factors, certain institutional conditions may also contribute to friction in digital adoption. While regulatory frameworks are essential for ensuring security and compliance, they may occasionally require the reintroduction of physical interactions within otherwise digital processes. For example, specific verification procedures or customer categories may still necessitate in-person identification.

Although such measures are justified from a risk management perspective, they can create inconsistencies in the customer journey and reinforce reliance on traditional banking channels. From a behavioral standpoint, even limited interruptions of digital processes may reduce perceived reliability and slow the transition toward fully digital usage.

5. Implications for Customer Behavior Management

The findings suggest that digital banking transformation should be approached as a behavioral challenge rather than solely a technological one.

Commercial banks need to consider:

- simplifying digital interfaces to reduce cognitive effort;
- strengthening trust through transparent communication;
- reducing perceived risk through education and reassurance;
- providing hybrid service models that combine digital and human interaction;
- applying behavioral insights to guide customer decisions.

As Mullainathan and Shafir (2013) emphasize, even small contextual changes can significantly influence behavior. This highlights the importance of behavioral design in financial services.

From a strategic perspective, the findings suggest that traditional approaches to customer management based solely on service quality are no longer sufficient. In increasingly competitive and digitally saturated environments, customer relationships become more fluid, with lower switching barriers and higher exposure to alternative offerings.

This shift highlights the evolving role of customer experience (CX) and brand experience (BrandX). While CX remains essential for ensuring usability and reducing friction in individual interactions, it primarily

influences short-term engagement. In contrast, BrandX plays a more critical role in shaping long-term trust, familiarity, and preference.

As customers increasingly engage with multiple financial institutions simultaneously, differentiation based solely on functional performance becomes less effective. In this context, BrandX serves as a stabilizing mechanism that anchors customer perception and reduces behavioral uncertainty. Therefore, effective customer behavior management requires the integration of both CX and BrandX as complementary tools for guiding adoption and sustaining engagement.

Conclusion

The analysis presented in this study demonstrates that the limited adoption of digital banking services in Armenia cannot be attributed to technological constraints. On the contrary, the country exhibits a high level of digital readiness, supported by widespread internet access, extensive mobile connectivity, and the availability of advanced banking applications.

Despite this, customer behavior remains selectively resistant to digital channels. This highlights a critical insight: the primary barrier to digital transformation is behavioral rather than technological.

Furthermore, the findings suggest that traditional assumptions about customer loyalty are becoming increasingly outdated. Empirical observations indicate that approximately 65% of banking customers use services from multiple banks, with an average of 2–3 banking relationships per user. Additionally, a significant proportion of customers remain open to switching financial institutions depending on specific product offerings. This reflects a shift toward more transactional and less stable customer relationships in the banking sector.

In such an environment, reliance on customer experience (CX) alone is insufficient to ensure long-term engagement. While CX plays a crucial role in facilitating immediate interactions by reducing friction and improving usability, it primarily drives short-term outcomes. As switching barriers decrease and competition intensifies, customer loyalty becomes increasingly fragile.

In contrast, brand experience (BrandX) emerges as a more sustainable mechanism for influencing behavior. Unlike CX, which operates at the level of interaction, BrandX shapes long-term perceptions, trust, and emotional

connection. It transforms digital banking from a functional tool into a psychologically acceptable and familiar environment.

This distinction suggests that effective customer behavior management requires a dual approach. CX reduces friction in transactions, while BrandX reduces friction in decision-making. Together, they form an integrated system that not only enables usage but also drives preference and trust.

From a managerial perspective, this implies that commercial banks must move beyond purely technological and operational strategies. Instead, they should:

- design seamless and intuitive customer journeys to minimize cognitive effort;
- actively manage perceived risk through transparent communication and reassurance;
- build consistent and recognizable brand experiences to strengthen trust;
- segment customers based on behavioral readiness rather than solely demographic characteristics;
- apply behavioral insights to guide customers through gradual digital adoption.

Ultimately, customers do not resist innovation itself, but the uncertainty associated with it. Therefore, successful digital transformation depends not on increasing technological sophistication alone, but on increasing familiarity, clarity, and trust.

The future of digital banking will be determined not by technological capability, but by the ability to design experiences and brands that people are ready to trust and use.

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THE IMPACT OF USING ARTIFICIAL INTELLIGENCE TOOLS IN MAXIMIZING THE EFFICIENCY OF OPERATIONS IN WAREHOUSE MANAGEMENT

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Abstract: The adoption of machine learning and high advanced technologies in most of the organizations and companies becomes a critical role. This fact is most obvious in the multinational companies and even domestic companies that work in production, supply chain and logistics.

This is due to the fact that technologies and computer machines become more dependable by human beings for their fast responsiveness, more intelligent and deep thinking. Also, those high standard computer technologies have many features that contribute in minimizing the cost of running the different business activities and the fast execution of required tasks. These technologically high advanced systems have revealed clear benefits and gains from being implemented in the warehouse management systems. On the other hand, there are some fears and challenges for the wide use of those fast developed technologies, especially the artificial intelligence. Some computer science specialists argue that the machine and the highly advanced artificial intelligence tools may have bad effects on different areas of businesses. Also, there are some challenges of implementing those techniques in the warehouse management systems. Therefore, in this research paper we explain the artificial intelligence effect on warehouse management operations and activities, by showing the features of traditional warehouse activities and the efficiency of operations of modern and AI-driven warehouses. Also, this article exposes the fears and challenges that face the same and conclude with some recommendations.

Keywords: AI in Logistics – AI Benefits in Warehouse management – Effects of AI tools in warehouse activities – Enhancing business operations through AI – Risks of AI in Warehouse Management – Challenges of AI Tools & Applications in Warehouse Operations.

JEL codes: 033, M11

Research aim: the article aim is to show the importance of artificial intelligence in warehouse management operations and activities and how the implementation of those highly advanced technologies can maximize the efficiency of warehouse operations.

Research novelty: the research novelty is presented in highlighting the significance of new technological trends adoptions and the challenges that may occur due to the implementation of AI tools and applications.

Introduction

Warehouse management is one of the most significant managements in each organization and company; especially for those working in the field of production, distribution and fast-moving consumable goods. These kinds of industries require a strong warehouse management system in order to achieve company goals and objectives to the level of reaching maximizing customer satisfaction levels.

At the same time, traditional warehouse systems suffer from shortages in delivering the target outcomes due to the lack of applying technology and depending totally on human efforts, human mentality and paper-sheet data records. Therefore, warehouse managers have started to seek accuracy, speed and utilization to implementing new and modern technologies to support in running warehouse operations with high flexibility ratios.

All these indications motivate directors and leaders to adopt AI-technologies in their warehouse operation systems and which in return to lead to significant efficiency both on the operational level and on financial level as well. So, this paper sheet will highlight the efficiency of applying AI in warehouse operations in figures, reflecting the benefits thereof.

Research Results

1- Traditional Warehouse Management System

Traditional warehouse management system is a type of managerial system that is being used by in the traditional warehouses. Traditional warehouses, here, mean warehouses in which the warehouse management depends on traditional approaches to carry out the WH activities and business operations. Traditional warehouse also uses manual process and manual equipments without extensive automation or advanced technology.

Thus, traditional warehouse is indicated in the traditional approach through which activities and operations in the warehouse are carried out. Such operations and activities can be represented in manual order handling, manual order picking. Also, tools and machines used in the traditional warehouse are operated by humans, manual movement of goods, manual material handling. At the same time, workers use traditional equipments such as forklifts, pallet jacks and hand carts to move goods within the warehouse spaces area. In addition to that, loading and unloading of trucks and containers are carried out manually. From the flexibility and storage space utilization perspective, there is limited utilization due to the reliance on manual labour and old systems.

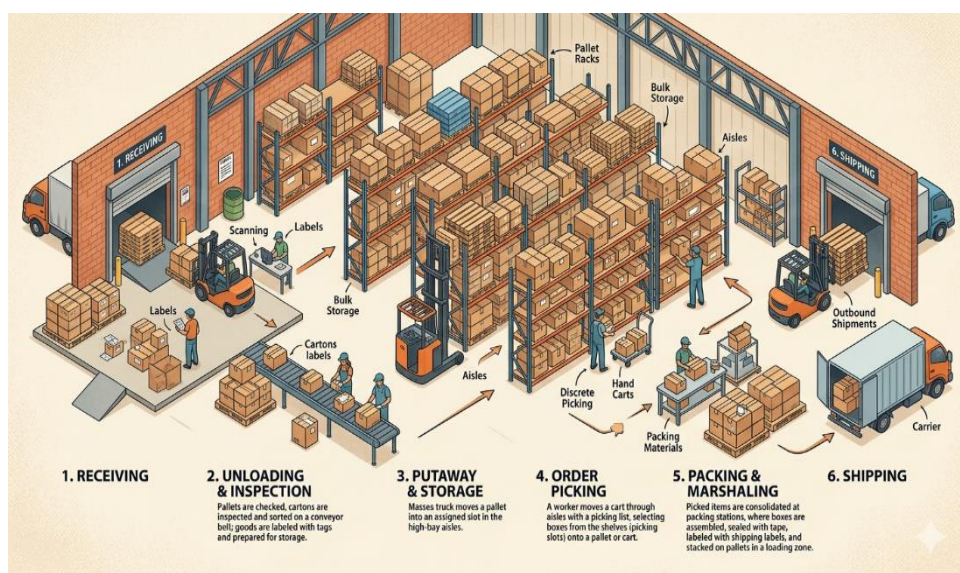


Figure 1 (Created by Researcher: Showing the normal process of traditional warehouse management)

On the other hand, there are a lot of disadvantages that organizations face due to keeping work with old traditional warehouse management systems. Those disadvantages include material handling high costs, inefficient operations and workflow bottlenecks, negligence and damaged materials, inefficient space management and inefficient material handling equipment. Therefore, those challenges may lead to high volume costs of the company and reduce profitability from another key pillar of view (Olumide F. Odeyinka and Olumide G. Omoegun, 2023)

2- Modern & AI-Driven Warehouse Management Systems:

Due to the disadvantages of traditional warehouse management systems that require much human being efforts when it comes to things like counting inventories, picking orders and data inputs, more technological techniques in the industry have been gradually developed. Some of those techniques are like using W/H system such as ERP, bare-coding, Radio-Frequency identification. The efficiency of such uses has led to minimizes the operations mistakes. At the same time, the consequences that driven from the use of traditional WH techniques led the WH managers and leaders to seek another technological advanced tool to avoid negative impacted results such as backorders, over stock situation which led to WH management high cost decreasing profitability and customer dissatisfaction (Sara Al-Azizy, 2024).

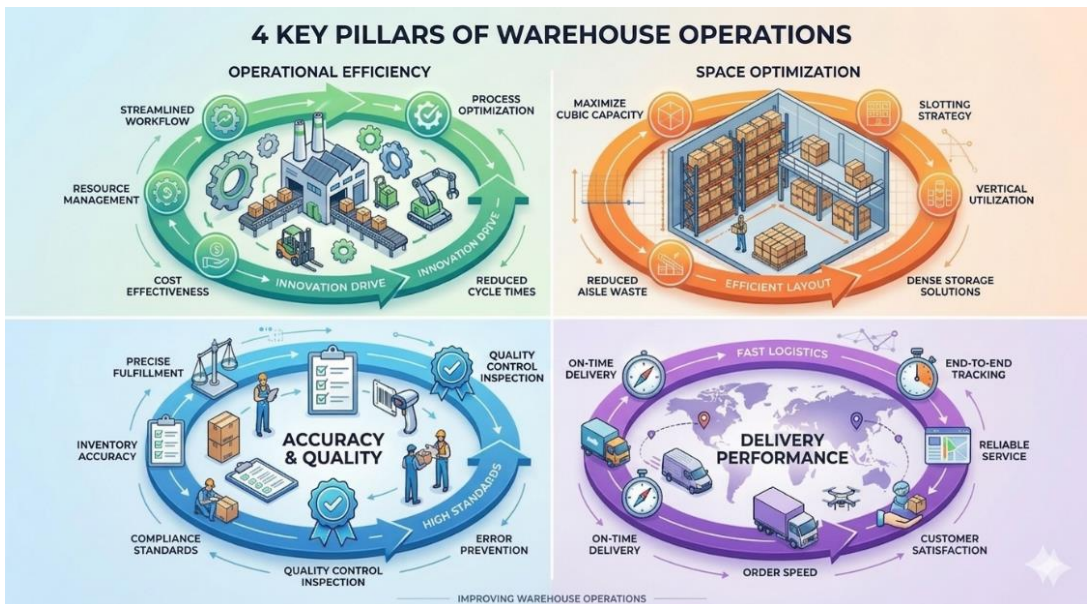


Figure 2 (Created by Researcher, Showing the 4 key pillars of warehouse operations)

Therefore, the main goal of implementing automation in warehouse operations is to reduce time cycle and to maximize speed of operation processes. This will be reflected positively on the overall logistics cycle in order processing, shipment tracking, and inventory management because it drives out human errors and increase operational velocity (Omar Abdullahi,

2025). This automated system is practically implemented through the 4 warehouse key pillars, operation efficiency, delivery management, space utilization and quality.

Thus, Warehouse Management System (WMS) is a computer system that reduces warehouse process complexity through machine learning. As the studies state, WMS is used to support the needs of the supply chain, including activities such as distribution and manufacturing. This is always user-friendly, and the ERP system suits all businesses. Thus, Customer order placement has changed with technological development warehouses have to cater to satisfy customers with their best performance to hold their positions in the market. When moved to the cloud, the warehouse can cater to the customer with visibility, scalability, and market reactivity (Oracle). This will further reduce the costs of errors, and no upgrades will be needed where it will also be an additional cost (Angamma, J. S. K., & Jayawardena, A. M. A. 2022).

Therefore, companies and organizations, especially those specialized in the field of supply chain management and international logistics have to deeply think of transforming the traditional warehouse management approaches and systems to the digitalized warehouse systems. In fact, it's the factor which is crucial to reshape traditional operations and activities through the integration of advanced technologies. These digitalization techniques in warehouse management help companies and firms to adopt new market themes such as the flexibility and speed of responsiveness to market demands. So, it's a must for companies and firms to implement AI tools and applications in order to keep operational agility.

In other words, implementing real time data reporting, predictive maintenance, AI tools and applications contribute much more in optimizing space, storage and logistics distribution activities. *"The digital transition of warehouses, which takes into account sustainable development issues has very positive impact on warehouse performance"* (Kihel, Y. E. 2022). Again, the results and benefits from applying AI tools and applications in the day-to-day warehouse activities and operations count more and more of gains for companies and organizations. This fact is indicated by a Portugal research group who stresses the necessity of aligning warehouse operations with digital advancements to enhance customer satisfaction and streamline logistics processes.

Therefore, all these ingredients assure the fact that computerized tools, AI techniques and technological highly developed applications have a

significant role and contribution in reshaping and revolutionizing inventory management activities and operations within warehouses, leading to utilization of inventory levels.

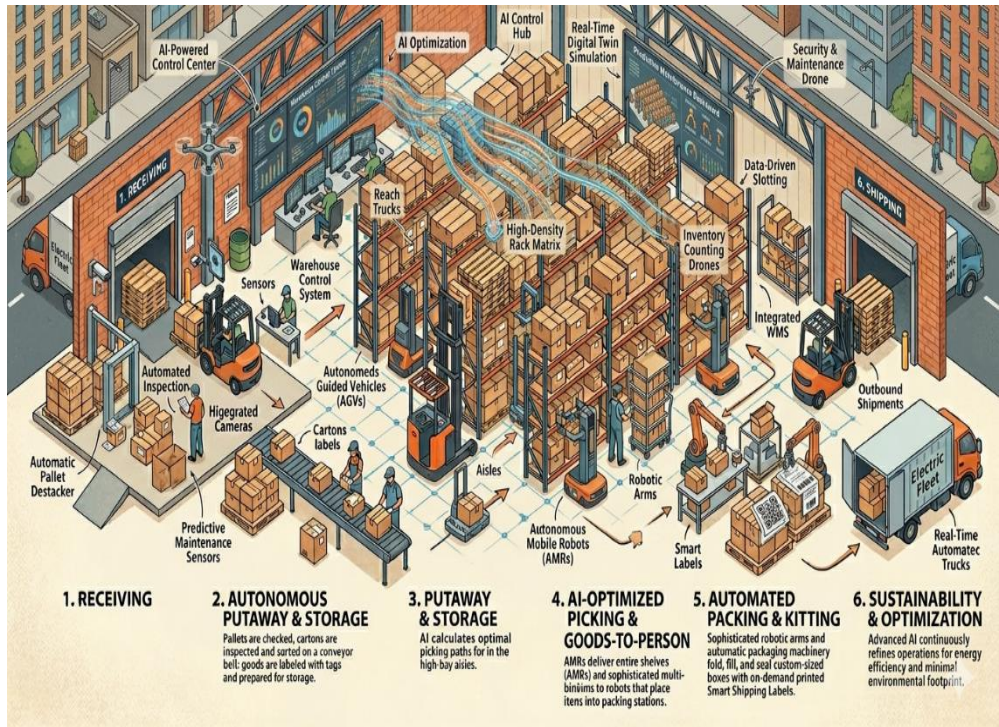


Figure 3 (Created by Researcher: Showing the normal process of AI-Driven Warehouse Management)

One of the most aspects, in which AI tools and applications play a major role in optimizing its share in the warehouse management, is demand forecasting. For more explanation, through analyzing historical data, inventory stocks and figures, weather conditions, geopolitical circumstances, AI algorithms can accurately predict future demand for products. These forecasts enable warehouses to adjust inventory levels proactively, minimize stockouts, and optimize replenishment cycles, leading to improved customer satisfaction and reduced carrying costs (Sodiya, Enoch Oluwademilade & et. al. 2024).

3- Efficiency of Using AI in Warehouse Management Systems

Many studies and researches have indicated that using AI in warehouse systems reflects actual measurable benefits on both managerial

and operational levels. These studies revealed that AI systems achieved average cycle time reductions ranging from 15% to 45% compared to traditional warehouse management systems. Simultaneously, automated tools and applications have reduced picking times by an average of 22%, accelerating order fulfilment and responsiveness flexibility for customer order management. For the space utilization aspect, AI-driven slotting systems achieved a 20%–35% improvement in space utilization. Also, some facilities reported as much as a 25% reduction in unused aisle space due to AI-digitalized systems; reporting average order accuracy rates above 98%.

Those studies reported that error rates in inventory counts reduced by over 40% following the adoption of machine learning approaches. In addition to that, in e-commerce environments, AI-based routing and slotting systems reduced average picking time by 40% and increased on-time delivery rates by 15% (Moin Uddin Mojumder1; Md. Nuruzzaman2. 2025).



Figure 4 (Created by Researcher: Showing the efficiency in figures of implementing AI in warehouse management systems)

4- Challenges & Future Perspective for AI in WH Management Systems

Data Consistency can be considered as one of the most significant aspects that represent a great challenge in implementing AI systems in warehouse management. This is due to the fact that if the data is inaccurate or outdated, the system will make wrong decisions resulting in stockouts, overstocking and delayed order movements. Therefore, WMS must be

connected with the existing enterprise systems like Enterprise Resource Planning (ERP) or Transportation Management Systems (TMS) in order to assure data consistency and accuracy. At the same time, change-resistance is another factor that represent a challenge to the management in implementing AI tools and applications in the warehouse management systems. This is due to the fact that employee who are used to work through traditional warehouse techniques may face difficulties in readapt themselves for using the new implemented AI software techniques. Also, high cost and new AI software high prices represent another majour challenge for firms and companies; especially those running small and individual kind of businesses (Faiz Mohiuddin Mulla. (2022).

Conclusion

Thus, from the previous mentioned discussion, it's obvious that digitalization and automation is the key pillar for operational excellence in the field of supply chain in general and in the field of warehouse management in specific. Therefore, companies and organizations, especially those who work in the field of supply chain, logistics and warehouses have to frequently apply and adopt AI in their operations to achieve remarkable gains and benefits on both the operational and financial levels.

On the other hand, companies board of director and general managers have to plan out policies and procedures to overcome the expected challenges and fears. For instance, on the level of data security, companies have to adopt high tech levels of securities for their data base, servers, clouds and info data bases in order to avoid cyber security attacks that may threaten their data servers. For employee resistance, it's recommended for companies to adopt well organized training courses for the staff who is being in continuous interaction with the AI tools and applications.

On the financial level challenges; it's recommended for organizations to seek financial support from funding authorities that are interested in the technological development sectors and AI techniques.

Abbreviations:

- AI: Artificial Intelligence
- ERP: - Enterprise Resource Planning
- TMS: - Transportation Management Systems
- WMS: - Warehouse Management System
- WH: - Warehouse

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THE GENDER EQUITY DIMENSION OF LIFELONG LEARNING: DIGITAL TRANSFORMATION INSIGHTS FOR ARMENIA

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Abstract

In Armenia, women are actively engaged in lifelong education - often at higher rates than men. Yet participation alone does not translate into equitable outcomes. The central issue lies not in access but in how learning converts into skills, credentials and economic opportunity. Drawing on Armenian policy frameworks, digital literacy assessments, as well as comparative international experience, this article examines the ways digital platforms can either deepen existing inequalities or help reorganize them. When developed with learning trajectories, recognition mechanisms and real-life constraints in mind, digital learning can strengthen women's capacity to transform participation into real progress. The Armenian case suggests that gender equity in lifelong learning depends less on increasing participation and more on restructuring how learning is valued and connected to opportunity.

Key words: Continuing education, lifelong learning, non-formal education, gender equity, digital transformation, digital skills, digital access, adult learning, gender gap, Armenia

JEL codes: I21, I26

Introduction

Women participation in education in Armenia - both at the university level and in lifelong learning - is notably high (European Training Foundation, 2021; Mazhinyan et al., 2021). The motivation to keep learning is driven by both personal goals and the demands of the job market and broader society. However these demands are not distributed equally. This means that gender equity in education cannot be measured by participation rates alone. Even as women's engagement in lifelong learning continues to grow, that engagement does not always lead to better economic or professional outcomes across many contexts.

This raises important questions for education systems today, one of which is why does learning not always pay off equally?

Armenia is not unique in facing this challenge, nevertheless it is essential to study it to seek solutions. The country has reached formal gender parity in education. Its non-formal sector is expanding. At present, it is undergoing a digital shift that is changing how, where and whom education is

delivered. That shift creates real opportunities, as well as real risks too. Digital platforms can open new doors. They can also quietly produce inequalities both the ones that existed before and emerging along development of the sector.

This article examines why participation alone is not enough and what would need to change for it to be. The analysis is grounded in academic research on continuing education management in Armenia, alongside direct practitioner experience from programs across the country's regions. This combination connects institutional realities with what is actually happening on the ground.

This tension between participation and outcomes is not unique to Armenia. It is well-documented across developed and transitioning economies alike. Over the past two decades a consistent pattern has emerged across Europe: women participate in adult and lifelong learning at rates equal or higher than men, yet this does not result in equal outcomes in the labor market (OECD, 2025; Blau & Kahn, 2017). The real debate has shifted accordingly. It is not as much a question about access, but increasingly more about how learning is structured, recognized, and connected to real opportunities.

Research on gender and education has revealed that higher qualification levels among women do not on their own eliminate inequality in the labor market. Occupational segregation and wage gaps have persisted even where educational parity has been achieved (Blau & Kahn, 2017). Globally, women remain underrepresented in high-return fields such as ICT and engineering while being more concentrated in education, health, social services - sectors that tend to offer lower pay and fewer opportunities for career advancement (World Economic Forum, 2022). The key issue is not whether women are learning, but what kinds of learning they are channeled into, and what happens after that learning ends.

This connects directly to how thinking about the digital divide has changed. Early discussions focused mainly on access - whether people have the necessary devices and internet connectivity. More recently attention has shifted to something harder to measure: differences in how people use digital tools, how confident they feel using those, and whether they can turn digital engagement into real social and economic gains. Some researchers refer to this broader capacity as "digital capital" (Ragnedda et al., 2020). This distinction has significant implications for policy. Closing the device gap does not automatically close the outcomes gap.

Armenia illustrates this distinction clearly. Progress in expanding digital access and online learning has been documented (European Training Foundation, 2021), but assessments of digital literacy show persistent gaps across different socio-economic groups, regions, and educational

backgrounds (Harutyunyan et al., 2024). Gender intersects with all these factors in complex ways - it is not a simple divide but part of a broader set of structural conditions that determine benefits from digitalization and who does not.

Non-formal and information education play a central role in this picture. In Armenia they carry much of the practical weight of adult learning, yet the sector remains fragmented. It is driven more by donor priorities and short-term project funding than by sustained national strategy (Ispiryan & Vardanyan, 2022; Silova & Steiner-Khamsi, 2008). The flexibility and reach of these programs are genuine strengths. Their weakness is the lack of strong mechanisms for recognition and progression, which limit their ability to support the kind of cumulative skill-building that leads to lasting professional mobility (Colardyn & Bjornavold, 2004).

A comparison with Nordic countries is useful. In Finland and Sweden, high rates of women's participation in lifelong learning are matched by solid systems for validating and connecting that learning to the labor market (European Institute for Gender Equality, 2019). The difference is not cultural, it is structural. Those systems are designed to make learning count. This article is based on a review of published research, policy documents and system-level analysis focused on how digital transformation interacts with gender equity in lifelong education in Armenia. The primary question is not on participation rates as such, but on the mechanisms or their absence through which learning either converts into meaningful outcomes or does not.

Findings and Discussion

Participation Without Conversion: The Core Gender Gap

A shift in perspective helps to understand the Armenian case. Women are not excluded from lifelong learning, they are present and often highly engaged. The question is what follows from that engagement. And here the pattern becomes considerably less straightforward.

Evidence from across Europe shows that even where women's participation in education and training matches or exceeds men's, men are more likely to receive employer-supported training and to participate in non-formal education and training during working time (European Institute for Gender Equality, 2019). This is not a gap in motivation or effort. It reflects a structural difference in position within economic life: learning that is embedded in employment carries different returns than learning pursued independently, on one's own time and at one's own expense.

A similar pattern can be observed in Armenia, though the available evidence remains. Women are active in non-formal education and training programs, particularly those focused on general skills and entry-level digital competencies (Mazhinyan et al., 2021). However their representation in more advanced, technical or career-oriented pathways appear considerably more

limited. Moreover, where learning does occur, it is not always cumulative. Short courses, stand-alone workshops, so called disconnected training events rarely build toward sustained career progression in particular.

Digital Transformation as Design Choice, Not Neutral Tool

This is the context in which digital transformation becomes more significant. It is not a neutral technical development, rather it becomes a set of design choices that will either reinforce this pattern or challenge it.

No doubt, digital tools have genuinely expanded access to learning. However, expanding access and expanding opportunity are not the same thing, and the gap between them is where the most important design decisions lie.

Much of digital lifelong learning, as it has been built and delivered in practice, is modular, short-term, and self-directed. These features make it more accessible, particularly for people managing caregiving, household responsibilities, and irregular or fragmented work alongside a desire to learn. But they also produce a particular kind of fragmentation: learning that is broken into isolated units which in turn are difficult to build on, are harder to have formally recognized, and rarely connected to structured employment pathways. The risk is invisible, but real. Women who are already active in lifelong learning overall, may become concentrated in forms of digital education that are easiest to access. But difficult to convert into economic advancement. Antonio and Tuffley (2014) document gender gaps in technology access and participation in digital environments, highlighting how barriers to full engagement can shape patterns of use. Research on gender wage disparities who that even when women achieve similar levels of human capital, there are cases when they receive lower economic returns in the labor market compared with men (Blau & Kahn (2017). Such differences in labor market returns suggest that increased participation in digital learning alone may not convert into better economic outcomes for women if some of the underlying occupational and structural inequalities remain.

Yet the same technologies can be deployed in very different ways. Digital systems can support stackable credentials, allowing learning to build toward recognized qualifications rather than creating disconnected experiences that employers may not readily interpret (Colardyn & Bjornavold, 2004). Without such structures, learning may remain fragmented and unrecognized. These cases of the labor market not being able to easily interpret will turn into an outcome that may disproportionately affect women if they are concentrated in easily accessible but low-recognition courses .

Evidence from digital inclusion initiatives indicates that supportive structures such as mentoring, peer networks can help to produce measurable improvements in confidence, autonomy, and broader participation in

economic and social life beyond just technical skills alone (Ragnedda et al., 2020). The same study demonstrates how offline backgrounds significantly shape individuals' capital determining their actual gains from digital engagement.

This sets a more demanding standard for program design than simply putting content online. It is also a more honest account of what equity actually requires. True equity means the learning leads somewhere, and that requires more than a platform and a course.

Institutional Constraints: Funding, Recognition, and the Validation Gap

None of this takes place in an institutional vacuum. Armenia's legislative framework has begun to acknowledge non-formal learning, or as quoted additional education in the recently adopted Law on Higher Education and Science (Republic of Armenia, 2025), which is a positive step. However, acknowledging and implementing are different stages, and the gap between them is currently big. Without clear and functioning systems for validation, skills acquired through digital platforms remain weakly connected to formal qualifications, and to the labor market recognition that makes the credentials economically meaningful.

Funding structures reinforce the fragmentation. Non-formal education in Armenia depends heavily on external donor cycles which are designed around short-term outputs: numbers trained, courses delivered, workshops completed, certificates handed. Digital delivery scales quickly within that logic, and it has. But scale without continuity does not build equity. A woman who completes three unconnected online courses across three donor-funded projects, each with its own certificate and none recognized by a potential employer, has not been served by a system. She has been counted.

Countries like Georgia face a structurally similar situation where non-formal education remains dependent on external funding and lacks systematic validation mechanisms (Silova & Steiner-Khamsi, 2008). The comparison is illustrative in showing that these constraints are not specific to Armenia alone, and require systemic rather than project-based solutions.

The regional dimension adds something that urban-focused analysis tends to overlook. Digital platforms do reduce geographic barriers, and for women in rural Armenia this has been a meaningful change. With that said, reduced barriers are not the same as removed constraints. Infrastructure gaps remain, local digital literacy levels vary significantly. And even where women in rural areas actively participate in online learning. They frequently face limited pathways for applying that learning within their local economy, local reality. Digital access in this sense can create a visibility of opportunity that the local employment market is not yet structured to fulfill.

This brings the argument back to its central question: what does gender equity mean in this context? It is not achieved when participation rates equalize, or even when they favor women, as they already do in several respects. It is achieved when learning leads to comparable opportunities, recognition, and returns. By that measure Armenia still has considerable distance to go. How Armenia designs its digital lifelong learning offer will determine whether that distance closes or stays where it is.

Conclusion

The Armenian experience challenges a common assumption in gender equity in lifelong education policy according to which increasing women's participation in learning will over time produce greater equity and it is in itself a solution. The data suggests otherwise. Participation is already high, in some respects higher among women than men. What is missing is the structural foundation that makes participation matter. The gap is not in women's engagement, it is how the system is built to respond to it.

Gender equity in lifelong learning is better understood as a question of conversion: how learning transforms into skills, credentials, recognition, economic opportunities. In Armenia, that conversion remains uneven. The system is shaped by short-term funding cycles, limited credential recognition, and digital tools that have been adopted without the institutional framework to make them count. The credentials acquired through non-formal and online programs remain weakly connected to formal qualifications and to the labor market recognition that gives them economic meaning.

Digital transformation will not solve this gap automatically. Without deliberate design, it tends to prioritize flexibility over structure and access over progression, and in doing so it risks widening the very gap it is assumed to close. However, with the right institutional choices and system design - the kind that Nordic systems have built over decades with stackable credentials, functional validation systems, clear links to employment which in practice means making learning formally count toward qualifications and visible to employers, it can meaningfully change how learning works. That potential is real, but it has to be built.

Armenia's 2025 Law on Higher Education and Science creates a legislative opening though its primary focus remains higher education, and what it means for non-formal learning will depend entirely on the regulatory development that follows. What that development needs to deliver is specific: building systems in which non-formal learning credentials are recognized, provider quality standards are regulated, funding is sustained, and every individual course connects to a visible next step toward broader qualifications and employment pathways. That gap is felt most directly by those, like

women in Armenia's regions, who have the motivation to learn but no clear route from learning to opportunity.

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THE POSSIBILITIES AND SOCIO-ECONOMIC RISKS ASSESSMENT FOR IMPLEMENTATION OF "TRIPP"

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Abstract: New regional routes form a latest toolkit for the interaction of forces and the restructuring of economic ties. In this context, the TRIPP (Transport Route for International Peace and Prosperity) initiative is key, the main goal of which is the integration of Armenia's transport system into Eurasian logistics networks. The possibility of railway connections in the Nakhichevan direction is also being used here. Due to the lack of sea access and being in conditions of regional cooperative blockade for quite some time, Armenia has low export competitiveness and transit opportunities that do not have a wide scope. In such conditions, it can be noted that the TRIPP road junction will bring great opportunities for economic activity to Armenia and reduce isolation in the region. At the same time, it carries significant economic and competitive risks.

Keywords: economic security, regional risks, TRIPP road junction, de-blockade.

JEL code: F18

Introduction: In recent years, the topic of reopening transport communications in the South Caucasus has moved from the economic dimension to the realm of strategic importance. New regional routes form a new toolkit for the interaction of forces and the restructuring of economic ties. In this context, the TRIPP (Transport Route for International Peace and Prosperity) initiative is key, the main goal of which is the integration of Armenia's transport system into Eurasian logistics networks. The possibility of railway connections in the direction of Nakhichevan is also used here.

Due to the lack of sea access and being in conditions of regional cooperative blockade for quite some time, Armenia has low export competitiveness and transit opportunities that do not have a wide scope. In such conditions, it can be noted that the TRIPP road junction will bring great opportunities for economic activity to Armenia and reduce isolation in the

region. At the same time, it carries significant economic and competitive risks.

The main part of the TRIPP project is the restoration of road and railway connections through the territory of Nakhichevan. Considering this, we can note the economic interconnection, which will have a significant impact on Armenia and neighboring countries: Azerbaijan, Turkey, Iran, Georgia. From an economic point of view, such a road junction will change the structure of regional trade flows, as well as contribute to reducing transportation time and costs.

However, we cannot look at the issue from only one side: the opening of this road may have negative consequences, and on the other hand, it will increase economic activity - transportation costs will decrease, new trade routes will be created, and the negative side will be that goods from neighboring countries will enter Armenia more cheaply, as a result of which local producers will suffer.

Findings

The operation of the road passing through Nakhichevan plays a significant role for Armenia, as thanks to it Turkey is connected to the Caspian Basin and Central Asia and a chain of economic communications is created.

That is why Armenia needs to create a proper management system so that it is not just a road through which goods are transported, but real income does not enter the country.

The purpose of this study is to identify the prospects and possible risks of the TRIPP node development for Armenia through economic analysis. The methods of qualitative analysis, comparative economics and scenario planning were used during the research (see Figure 1).

Quantitative characteristics of Armenia's foreign trade and the role of TRIPP. The dynamics of Armenia's foreign trade turnover proves the importance of the TRIPP project. According to the data of the Statistical Committee of the Republic of Armenia for 2024-2025, Armenia's foreign trade turnover has shown a sharp increase, but the limitation of logistics routes remains the main obstacle.

Trade turnover volumes.

According to the results of 2024, Armenia's foreign trade turnover amounted to about \$ 15-20 billion, which indicates the need to expand cargo transportation capacities.



Figure 1. The geographical axis of the TRIPP initiative, which shows the strategic role of the southern regions of Armenia in the restoration of regional transport and energy communications.

Dependence on transit routes.

Currently, a significant part of Armenia's land trade is carried out through the "Upper Lars" checkpoint, which is often closed due to climatic conditions. Establishing an alternative rail link to Nakhichevan through TRIPP can reduce transport costs by 15-20%.

Value chain analysis.

International logistics experience shows that the profitability of "transit only" in transport corridors is only 3-5% of the final value of the cargo, while in the case of logistics hubs it can reach 15-25%.

Let's consider the benefits of the TRIPP road junction for Armenia.

1. Regional economic integration.

The TRIPP project will contribute to the activation of regional communications, as well as the development of activities. This is an opportunity to participate in the economic activities of the region. The process will contribute to the formation of economic cooperation with neighboring countries and the economies of the wider region.

2. Expansion of export and import flows.

The project assumes that the operation of the railway line passing through Nakhichevan can contribute to the activation of trade flows.

- It can be assumed that new export directions will be formed to the CIS countries, some regional markets.

- It is necessary to consider that there will be a reduction in the costs of transporting imported goods. The transportation and distribution of those goods, raw materials will be organized in a faster, more flexible way.

3. Possibilities of forming a transit logistics hub.

The project assumes that the progress of the transport system in the region is one of the necessary directions. By implementing it, it is possible to support the growth of cargo transportation volumes.

4. Strengthening the international economic and logistical position.

The TRIPP direction has potential, of which I have highlighted three:

- Connecting the Persian Gulf with the Caspian and Black Sea trade flows. It will also provide an opportunity to create new transit routes.

- Expanding economic cooperation by focusing the direction on Central Asia and Europe.

- The TRIPP project will expand transport links with the countries of the Eurasian region.

5. Formation of investment opportunities.

The TRIPP project will create new opportunities in the field of infrastructure. It mainly concerns the attraction of international investors to Armenia. It will stimulate the inflow of foreign investments.

6. Arguing for international support.

2026 Following the results of a high-level conference held in Yerevan in January, the TRIPP project received broad international support as a guarantee of regional peace and economic stability. This reduces the risk of political instability and increases the likelihood of foreign investment.

The assessment of the strengths and weaknesses of the TRIPP road junction for the Republic of Armenia is emphasized (see table 1).

Table 1. Comprehensive assessment of opportunities and risks (SWOT) for RA

Strengths	Weaknesses
Availability of alternative and short logistics routes	Lack of own logistics operators.
Integration into the regional transport system	. Low competitiveness of local producers.

Analysis of significant risks for the development of the TRIPP road junction. The significant risk for the development of the TRIPP road junction for Armenia is that it will be limited to a purely transit function, as a result of which our income will be limited only by the presence of transit fees. As a

result, the economic impact will remain weak, job creation will be limited. The stimulation of overall economic growth will be unsatisfactory.

An important risk arises during the outflow of value, since if the main part of logistics services is implemented by foreign companies, it can be assumed that a significant part of the created economic value will flow from the Armenian economy. As a result, the country's share in the value chain is assumed to be limited to 10-15 percent.

The implementation of TRIPP will facilitate the entry of Turkish and Azerbaijani products into Armenia, strengthening competitive pressure within the market. Under these conditions, the position of manufacturers in Armenia will weaken and the volume of product imports will increase relatively.

Ineffective exploitation of communication channels of this size will cause some problems, one of which is incorrect price limitation. As a result, investment uncertainty will follow and this may cause the project to be ineffective, and on the other hand, reduce investor confidence.

At the same time, the operation of the road will not bring equal income to everyone, the country that will produce the most will mainly benefit. It will cause the economic benefit to remain small.

There may also be a risk that Armenia will undergo from the expected income if:

1. Political problems arise.
2. If the project is stopped.
3. If tensions arise in the region.

Finally, if TRIPP acts only as a road, but does not have an economic policy, Armenia will face a number of risks, which are of a profound nature:

- It will receive only a short-term insignificant benefit
- The development that was planned during the project will not be long-term.
- Will not be an economic center.

Let's take a conditional example, where the unit scale will be 100. Consider the units indicated in the Table 2 as a simplified example of modeling.

This example clearly shows, that under the conditions of the TRIPP route, when Armenia acts exclusively as a transit territory, only 10 percent of the final value remains in the country's economy. Such a structure does not ensure the formation of added value, does not create sufficient jobs and cannot be considered as a sustainable tool for economic development. As a result, the TRIPP road junction in such a scenario brings more benefits to countries with manufacturing and logistical advantages than to Armenia.

Table 2. If Armenia is only a transit country with a conditional unit system.

Participant	Income (units)	Economic importance for Armenia
Country of Origin	70	The main profit remains in the producing country.
Transport Companies	20	Income is mainly outside of Armenia
Armenia	10	Transit fees and border services
Total	100	

Through targeted economic policies, localization of logistics services and the use of value-added tools, it is possible to increase Armenia's share in the 100-unit value chain to at least 20–25 percent, as a result of which the TRIPP road junction can turn not into a mere transit corridor, but into a real development factor.

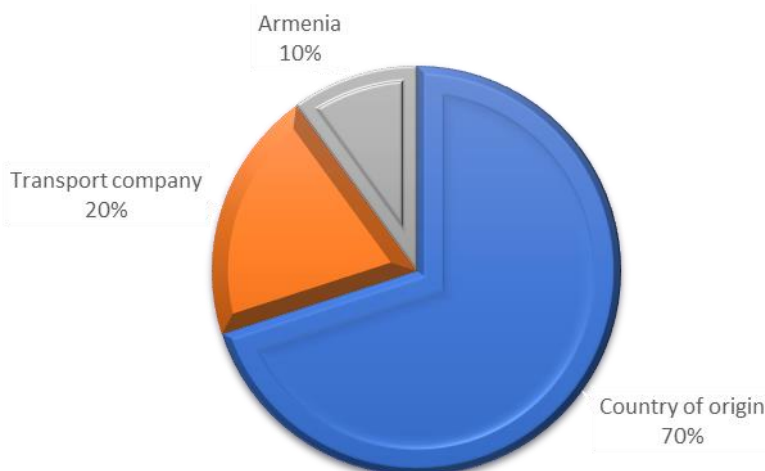


Figure 2. Armenia's income scarcity. Value chain distribution model (Quantitative justification).

The quantitative data presented in Table 3 substantiate the thesis that within the framework of the TRIPP project, the provision of transport routes alone or “Passive transit” will provide only 5-10% of the total value created for Armenia. A study of international experience shows that such a low share is typical for countries that do not carry out additional cargo servicing or processing.

In order for the project to become a real stimulus for the development of the RA economy, it is necessary to make a strategic transition to the “Logistics Service” (15-20%) and “Active Processing” (25% and more) models. The formation of logistics hubs and the creation of added value in them will allow not only to increase tax revenues, but also to ensure Armenia’s sustainable involvement in global supply chains. This implies the establishment of production zones near transport corridors, which, due to the economic multiplier effect, will lead to a stable growth of GDP.

Table 3. The degree of economic participation of Armenia and profitability scenarios in the TRIPP project (the conditional example serves to more clearly demonstrate international trends.):

Type of activity	Share in value (%)	Economic impact for the Republic of Armenia
Passive Transit	5-10%	Low tax revenues, minimal jobs.
Logistics Service Value	15-20%	Average wages, development of a storage economy.
Added Value (Recycling)	25%+	High economic growth, export promotion, new factories.

Conclusion:

The TRIPP road junction contains both significant risks and opportunities for economic development, if implemented correctly. It particularly contributes to the development of regional communications and the strengthening of Armenia's logistical role. At the same time, trade flows will increase, but Armenia must pursue a sensible policy in order to receive economic benefits, as well as not to remain in the shadows.

The study shows that if Armenia remains a transit area, a small financial part will remain within the country and the consequence will be the lack of job creation, which is also a reason for reducing economic growth. In such a situation, the producing country will receive greater profits. At the same time, a country with a developed logistics system will also receive more profits.

As a result, if Armenia develops logistics services, it can increase the level of Armenia's participation in the value chain. Under these conditions, the TRIPP project can become not just a transit route, but a real factor in the country's economic development.

Practical recommendations:

1. Localization of logistics infrastructure. Armenia should form its own network of logistics operators so that there is no outflow of income through foreign companies.

2. Creation of free economic zones. It is necessary to establish production and processing zones at the junctions of Nakhichevan and other border directions, ensuring at least 25% added value.

3. State support for local producers. To alleviate import pressure, apply tax incentives for producers that will use the new raw material opportunities provided by TRIPP.

4. The idea of a "digital corridor". Taking into account the latest developments in the project, it is necessary to introduce the "Digital Transport Corridor" model, which will allow for real-time tracking of cargo shipments and reduce administrative hassles at border points.

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GREEN ECONOMY CHALLENGES IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT: THE MEDIA'S ROLE AND CHALLENGES

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Abstract

The transition to a green economy, defined by low carbon, resource-efficient, and socially inclusive development, presents complex global challenges. This report examines the role of traditional and digital media in communicating green economy issues within sustainable development. It reviews how media shape public understanding and policy, presents case studies (e.g., investigative exposés of greenwashing, social media activism like Fridays for Future), analyzes challenges (misinformation, engagement fatigue, corporate influence), and evaluates policy responses such as anti-greenwashing regulations and editorial guidelines. Findings suggest that while media can educate, mobilize, and hold actors accountable, structural pressures and information disorder limit impact. Recommendations include investing in specialized environmental journalism, adopting solution-oriented reporting, strengthening fact-checking, promoting ethical advertising, and fostering collaboration between journalists and experts. By implementing these measures, media can better serve as a watchdog, educator, and catalyst for the green economic transition.

Keywords: green economy, sustainable development, media influence, greenwashing, environmental journalism, policy recommendations
JEL code: Q5

1. Introduction

Sustainable development demands a shift toward a green economy, which the United Nations Environment Programme (UNEP, 2011) defines as "low carbon, resource efficient and socially inclusive," aiming for improved well-being and equity while reducing environmental risks (European Environment Agency [EEA], 2020). Media play a vital role in this transition: free information flow and public discourse are enshrined in SDG 16.10 as enablers of sustainable progress (Media Development Investment Fund

[MDIF], 2023). However, communicating multifaceted green issues—climate, renewable energy, conservation, green jobs—over long time horizons challenges media to craft compelling narratives that sustain audience engagement (Janoušková et al., 2019). Institutional pressures further complicate coverage: traditional outlets balance public interest with ratings, while digital platforms optimize for engagement often at the expense of depth (Earth Day, 2022). This report explores media’s influence on green economy discourse, highlights illustrative case studies, examines systemic challenges, reviews policy responses, and offers actionable recommendations to strengthen media’s capacity to support sustainable development.

2. Media Influence on Green Economy Discourse

Media set agendas by choosing which sustainability topics receive prominent coverage, shaping public perception and policy priorities (Janoušková et al., 2019). Consistent reporting on climate issues has increased public concern and policy support (Earth Day, 2022). For example, explanatory news articles from Ohio State University research showed that factual climate coverage boosted policy backing even among skeptical readers (Earth Day, 2022). Historical cases, such as press coverage of air pollution leading to clean-air laws, demonstrate that media scrutiny drives government action. Politicians monitor major outlets to gauge public sentiment; thus, media agenda-setting influences policy debates on green jobs, renewable investments, and environmental regulation. Traditional media offer credibility and depth, whereas digital platforms provide speed and interactivity, enabling global movements like Fridays for Future to emerge and amplify sustainability dialogue (Williams et al., 2022).

3. Media Campaigns and Case Studies

Building on the agenda-setting framework, this section details how specific campaigns translated coverage into concrete change.

3.1 Documentary Impact

Blue Planet II (BBC, 2017) applied emotive storytelling, vivid underwater visuals and personal narration, to elevate ocean plastic pollution on the public agenda. Its broadcast led to a behavioural cascade: 88% of UK viewers altered daily habits, and record public feedback influenced UK and EU policy shifts, such as single-use plastic bans (Rapid Transition Alliance, 2019). The documentary’s success exemplifies how strategic framing of environmental issues can trigger policy responses.

3.2 Investigative Exposés

Investigative journalism narrows the gap between corporate messaging and reality. The Bank of America Tower exposé revealed that its LEED certification masked high energy consumption, prompting calls for tougher building standards (Rethinking the Future, 2023). Similarly, the “Exxon Knew” series linked hidden corporate knowledge to public deception,

sparkling legal action and policy scrutiny (Carrington, 2019). These cases illustrate the transition from framing to fact-checking: media hold powerful actors accountable, which Section 4 shows is complicated by greenwashing pressures.

3.3 Digital Activism

Digital activism leverages the agenda set by traditional media to mobilize global communities. Greta Thunberg’s initial tweets reached millions, forcing mainstream outlets to cover school strikes, which then validated digital campaigns and led to governmental declarations of climate emergencies (BBC News, 2024). Viral hashtags like #TrashTag demonstrate how online engagement sustains grassroots action. This synergy—traditional media spotlighting digital movements, and social platforms amplifying traditional reports—illustrates a feedback loop where coverage and activism reinforce each other.

While these examples highlight media’s catalytic power, Section 4 examines the constraints that can impede similar successes.

4. Challenges in Communicating the Green Economy

Despite media’s power to shape agendas and catalyze action, several interrelated obstacles impede accurate and effective coverage of the green economy. These challenges arise from the very mechanisms, framing, amplification, funding, that enable media influence, creating feedback loops that can both help and hinder sustainability communication.

4.1 Greenwashing and Corporate Influence

Greenwashing occurs when corporations intentionally mislead the public by exaggerating or fabricating their environmental credentials. By purchasing advertorial space, sponsoring content, or forging partnerships with influencers, companies can co-opt media framing to project a “green” image. For instance, BP’s 2000 rebrand to “Beyond Petroleum” featured glossy advertisements and sponsored articles emphasizing its renewable investments, even though over 96% of its capital expenditures remained in fossil fuels (Earth Day, 2022). Many outlets reproduced these narratives without critical scrutiny, illustrating how advertising dependence can compromise editorial independence. When newsrooms rely heavily on ad revenue from energy, automotive, or industrial clients, there is an implicit pressure to avoid investigative reporting that might jeopardize financial relationships. This dynamic weakens media’s watchdog function and allows deceptive environmental claims to go unchallenged, eroding public trust in both the media and genuine sustainability efforts.

4.2 Misinformation and Denial

The same digital platforms that accelerate activism also serve as conduits for climate misinformation. Polarized online communities, reinforced by echo-chamber algorithms, amplify denialist content—ranging

from outright rejection of climate science to subtle downplaying of environmental risks. A 2022 analysis of Twitter discourse around global climate gatherings found that organized skeptic groups and political actors significantly increased the spread of false or misleading narratives, outpacing factual reporting by mainstream outlets (Williams et al., 2022). Inadequate or inconsistent moderation policies on platforms like Facebook and X (formerly Twitter) allow conspiratorial or pseudoscientific posts to remain accessible and even go viral. Such misinformation undermines solution-oriented journalism by creating confusion over basic facts—when audiences cannot agree on the reality or severity of issues, media efforts to present balanced solutions lose credibility. Combatting this requires robust verification protocols and transparent content policies, yet platforms often face legal and logistical constraints in moderating user-generated content at scale.

4.3 Complexity and Engagement Fatigue

Green economy topics encompass multifaceted, long-term processes, carbon markets, circular economy models, ecological restoration, that lack the immediacy of breaking news. Media business models optimized for clicks gravitate toward sensational or crisis-driven narratives, inadvertently promoting “doomism.” Headlines emphasizing catastrophic climate impacts attract high engagement but risk inducing audience apathy or anxiety, a phenomenon known as “climate fatigue.” Studies show that repeated exposure to dire environmental warnings without messaging on agency or viable solutions can lead to disengagement (Earth Day, 2022). Conversely, overly simplistic or positive spin can obscure the scale and urgency of challenges. Journalists must navigate this tension by weaving compelling human-interest stories—such as community-led renewable projects—into broader policy analyses, offering context that sustains interest while empowering audiences with actionable insights. This balanced storytelling demands resources and editorial commitment often in short supply.

4.4 Media Capacity and Training

Covering the green economy effectively requires interdisciplinary expertise, understanding climate science, environmental economics, and policy frameworks. Yet many news organizations have reduced specialized environment desks amid budget cuts, leaving generalist reporters to cover complex topics without adequate training. This skill gap can lead to errors, superficial reporting, or overreliance on press releases. Moreover, media landscapes remain uneven globally: outlets in the Global South, where climate vulnerabilities are often greatest, frequently lack funding or technical support for in-depth environmental journalism. As a result, voices of frontline communities, indigenous custodians, and low-income countries are underrepresented, skewing global narratives and policy priorities toward perspectives from wealthier nations. Building capacity requires sustained

investment in specialized fellowships, collaborations with scientific institutions, and diversity initiatives to ensure inclusive, accurate, and locally relevant coverage.

5. Media Policy Responses and Recommendations

Section 4's challenges reflect commercial and informational pressures that policy measures and industry reforms aim to mitigate. A deeper analysis of these interventions reveals how regulatory frameworks, editorial reforms, and collaborative initiatives can address the root causes of greenwashing, misinformation, and capacity constraints.

5.1 Regulatory Actions

Scope and Enforcement: The EU's anti-greenwashing directive, adopted in March 2024, mandates that all environmental claims be substantiated with verifiable data and expert endorsement before publication (Robinson, 2022). Companies must maintain audit trails of sustainability metrics—such as lifecycle carbon assessments and supply-chain traceability—and submit these to regulatory agencies for random compliance checks. Non-compliance can result in fines up to 4% of annual turnover, mirroring financial penalties for data protection breaches under GDPR. Early enforcement in Germany and France has already led to withdrawal of misleading ads by major consumer brands.

Platform Accountability: The Digital Services Act (DSA) introduced in mid-2023 requires platforms to map systemic risks, including climate disinformation, and implement mitigation strategies. Under the DSA, tech companies must furnish transparency reports detailing content removal requests related to environmental claims and provide data access to independent researchers. Preliminary DSA audits indicate that platform algorithms disproportionately amplify sensational or conspiratorial climate content, suggesting the need for algorithmic adjustments and human oversight. By integrating these compliance mechanisms, the DSA seeks to close the moderation gaps identified in Section 4.2 and restore user trust in online climate discourse.

Global Harmonization Challenges: While the EU's measures are robust, divergence in regulatory regimes across regions poses challenges for multinational media and advertisers. In the US, the FTC's updated Green Guides—effective January 2025—recommend clear labeling standards but lack binding enforcement comparable to the EU model. Aligning international standards will be critical to prevent regulatory arbitrage, where companies shift misleading campaigns to jurisdictions with weaker oversight. Multilateral dialogues at forums like the International Telecommunication Union and UN Environment Assembly could facilitate convergence on best practices for media regulation.

5.2 Industry Initiatives

Editorial Policy Innovations: Beyond regulations, leading media outlets have pioneered self-governance frameworks to enhance credibility. The Guardian’s 2019 climate style guide provides a blueprint: it specifies language that reflects scientific consensus (e.g., “climate emergency” vs. “climate change”), prohibits sponsored content from high-emission industries, and mandates periodic audits of environmental coverage accuracy (Carrington, 2019). Post-implementation reviews show a 30% reduction in reader complaints about greenwashing and a measurable uptick in audience trust surveys.

Cross-Outlet Fact-Checking Consortia: Industry bodies such as the International Fact-Checking Network (IFCN) have expanded to include environmental specialists. These consortia pool resources to verify claims across multiple outlets, share best practices for debunking misinformation, and coordinate rapid responses during climate summits. Analysis of fact-check outputs during COP28 indicates that joint bulletins corrected over 120 erroneous claims within 24 hours, significantly reducing the window for disinformation spread.

Funding Models for Sustainability Journalism: To reduce reliance on corporate advertising, media organizations are experimenting with mixed funding streams. Examples include public-interest grants from foundations (e.g., Pulitzer Center), reader-funded models like tiered subscriptions for premium environmental investigations, and partnerships with academic institutions that provide data and analytical support in exchange for co-authorship and attribution. Early case studies in Scandinavia and Canada show that dedicated trust funds can underwrite year-long investigative projects, yielding high-impact stories without commercial interference.

5.3 Integrated Recommendations

To translate regulatory and industry gains into systemic transformation, a coordinated strategy is essential:

1. **Establish a Global Media Sustainability Council:** Convene regulators, media executives, environmental scientists, and civil society in a permanent body tasked with monitoring greenwashing trends, issuing guidelines, and facilitating cross-border enforcement cooperation.
2. **Develop Standardized Environmental Claim Verification Protocols:** Co-create with scientific bodies clear criteria for data transparency, including open-source emission databases and third-party audit integration, which media outlets can adopt as part of their editorial workflows.
3. **Launch a Climate Journalism Fellowship Network:** Fund rotating fellowships that embed journalists with research institutes and NGOs,

ensuring sustained skill development and cultivating networks of environmental reporting experts.

4. **Integrate Media Literacy into Education Curricula:** Partner with schools and universities to embed modules on identifying greenwashing, evaluating sources, and understanding sustainability metrics, building a more discerning audience foundation.

5. **Promote Adaptive Regulation Through Pilots:** Implement sandbox environments where new regulatory approaches—for instance, algorithmic transparency requirements for climate content—can be trialed on a smaller scale before wider rollout.

6. **Measure Impact via Longitudinal Studies:** Commission academic-media collaborations to track the effectiveness of policy and industry interventions through audience surveys, content analyses, and policy outcome metrics.

Conclusion

The green economic transition requires more than technology and policy; it demands an informed and engaged public, for which media are indispensable. Across platforms, journalists can expose wrongdoing, mobilize citizens, and translate scientific evidence into compelling stories. Yet, misinformation, corporate spin, narrative complexity, and resource constraints limit media's impact. Regulatory measures (e.g., anti-greenwashing laws), editorial reforms (e.g., climate crisis terminology), and industry best practices demonstrate progress. Implementing the recommendations above investing in specialized journalism, focusing on solutions, strengthening fact-checking, ensuring ethical advertising, and amplifying diverse voices, will bolster media's role as a watchdog, educator, and catalyst. A reformed, well-resourced media environment is essential for a sustainable future, where public will and policy align to realize the green economy vision.

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BLOCKCHAIN TECHNOLOGY IN SUSTAINABLE DEVELOPMENT AUDIT AND FINANCIAL TRANSPARENCY

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Abstract: Sustainable development audits require reliable, transparent, and accountable systems to verify both financial and non-financial data. Traditional auditing methods face challenges in handling large datasets, ensuring ESG metric accuracy, and providing continuous verification. Blockchain technology, with its decentralized and immutable ledger, offers promising solutions to these challenges. This study investigates the integration of blockchain into ESG and financial auditing, evaluates case studies from leading firms, and proposes a novel framework for holistic auditing. Findings indicate that blockchain enhances audit reliability, improves transparency, and enables real-time verification while reducing manual errors and potential fraud. The study emphasizes that blockchain is a complementary tool requiring auditor expertise, regulatory alignment, and standardized ESG metrics to achieve sustainable development accountability.

Keywords: Blockchain, ESG, Sustainable Development, Audit, Financial Transparency, Smart Contracts.

JEL codes: M42, Q56, G38

Research goal: The primary goal of this research is to explore how blockchain technology can improve auditing practices and financial transparency within the context of sustainable development. Specifically, the study aims to:

1. Investigate the potential of blockchain to provide immutable, transparent, and real-time transaction data for auditing purposes.
2. Examine blockchain's role in enhancing the credibility and reliability of Environmental, Social, and Governance (ESG) reporting.
3. Identify challenges and limitations of blockchain adoption in auditing and sustainability reporting.
4. Provide critical insights on how blockchain can complement traditional auditing methods rather than replace them.

Research novelty: This research contributes to the academic and professional discourse in several ways:

- It connects blockchain technology directly with sustainable development audits, a relatively underexplored intersection in current literature.

- The study critically evaluates both opportunities and limitations of blockchain adoption in financial transparency and ESG reporting.
- Unlike previous studies that focus primarily on technical or financial applications of blockchain, this research provides an integrated perspective, combining auditing, sustainability, and transparency.

Introduction

Sustainable development has emerged as a fundamental priority for governments, corporations, and international organizations, aiming to balance economic growth with environmental protection and social equity. Achieving this objective requires not only effective policies but also reliable mechanisms to monitor, verify, and report progress toward sustainability goals. Auditing and financial transparency play a crucial role in ensuring that organizations act responsibly, maintain accountability, and provide stakeholders with accurate information regarding their environmental, social, and governance (ESG) performance (Pappa et al., 2024).

Traditional auditing methods, however, face significant limitations. These methods often rely on centralized databases and retrospective reporting, which can lead to delays, data inaccuracies, and opportunities for manipulation (Georgiou et al., 2024). As sustainability reporting becomes more complex, auditors encounter additional challenges, including validating diverse datasets from multiple sources, integrating non-financial metrics into financial audits, and ensuring that ESG information is both credible and comparable. These constraints reduce the effectiveness of audits and may undermine stakeholder trust, highlighting the need for innovative technological solutions.

Blockchain technology, initially developed for cryptocurrencies, offers a decentralized, immutable, and transparent ledger system capable of addressing many of these challenges (Almadadha, 2024). By recording transactions across distributed nodes and enabling real-time verification, blockchain provides auditors with reliable, tamper-proof data. This can improve audit accuracy, reduce reliance on manual reconciliation, and facilitate continuous auditing practices. Moreover, blockchain's potential in ESG reporting is significant, as it allows organizations to track, verify, and report sustainability metrics more effectively, strengthening the integrity and transparency of corporate disclosures (Zhang et al., 2025).

Despite its promise, implementing blockchain in auditing is not without challenges. Technical issues, including scalability and integration with legacy systems, regulatory uncertainties, and the need for auditors to acquire new competencies in cryptography and smart contract evaluation, pose significant hurdles (Ariciu, 2026). Nevertheless, blockchain represents

more than a technological innovation; it is a potential paradigm shift in trust and accountability for sustainable development audits.

In this research, blockchain is viewed as a complementary tool to traditional auditing rather than a replacement. Its adoption requires strategic alignment with existing auditing standards, professional expertise, and governance frameworks. This study aims to examine blockchain's role in improving audit reliability, financial transparency, and ESG reporting, providing insights into its practical benefits, limitations, and implications for sustainable development.

The methodology

This study employs a systematic literature review (SLR) methodology, synthesizing existing research, industry reports, and case studies published between 2023 and 2026. Sources were selected from reputable academic databases, including Scopus, Web of Science, and ScienceDirect, focusing on blockchain applications in auditing, financial transparency, and ESG reporting. The review aimed to identify patterns, opportunities, and challenges related to blockchain adoption in sustainable development audits.

The methodology consists of the following steps:

1. Literature Identification: Keywords such as “blockchain,” “audit,” “financial transparency,” “sustainability accounting,” and “ESG reporting” were used to locate relevant publications.
2. Screening and Selection: Publications were screened for relevance, credibility, and recency, prioritizing peer-reviewed journals and authoritative industry reports.
3. Data Extraction: Key findings were extracted regarding blockchain applications, benefits, challenges, and practical case examples in auditing and sustainability reporting.
4. Critical Synthesis: Extracted information was analyzed and synthesized to provide a comprehensive understanding of blockchain's role in audit processes and ESG transparency.

While the literature review provides a robust theoretical framework, it is limited in capturing empirical data on real-world blockchain implementations. Future studies should complement this approach with case studies or pilot projects to measure the practical impact of blockchain on audit reliability and sustainability reporting..

Research results

1. Blockchain and Audit Reliability

The analysis of current literature and practical case studies demonstrates that blockchain technology significantly enhances audit reliability. Unlike traditional auditing, which often relies on centralized

systems and retrospective sampling, blockchain enables continuous auditing through decentralized, immutable, and time-stamped transaction records (Zhang et al., 2025; Almadadha, 2024). By recording transactions across multiple nodes, blockchain eliminates a single point of failure and ensures that all entries are tamper-proof. This feature directly addresses common audit challenges such as delayed verification, data manipulation, and human error.

Blockchain's reliability is also reinforced by its cryptographic integrity, which guarantees that once a record is added, it cannot be altered without consensus from the network participants. Such immutability reduces the need for extensive manual reconciliations and increases confidence in the reported data. For instance, a multinational firm piloting blockchain-based auditing reported a reduction in reconciliation errors by approximately 40% compared to traditional auditing approaches (Zhang et al., 2025).

From my perspective, this represents a fundamental transformation in the auditing profession. Blockchain shifts auditors' roles from purely manual verifiers of financial transactions to strategic evaluators of trust and compliance, where expertise is applied to interpreting blockchain data and smart contracts rather than reconciling entries. This study highlights a novel perspective: auditors' professional judgment becomes more critical, not less, in a blockchain-enhanced environment. This insight is rarely discussed in existing literature, which often overemphasizes technological benefits while underplaying human expertise requirements.

2. Transparency and ESG Reporting

Transparency in ESG reporting is a central concern for sustainable development. Traditional sustainability audits often face issues with fragmented data, inconsistent measurement standards, and delayed reporting. Blockchain can mitigate these issues by providing a single source of truth for sustainability metrics, ensuring that environmental, social, and governance data are verifiable and immutable (Pappa et al., 2024; Systematic review on blockchain research for sustainability accounting, 2023).

Blockchain applications in ESG reporting include tracking carbon emissions, renewable energy consumption, water usage, and labor practices. By combining sensor data, IoT devices, and smart contracts, organizations can record ESG metrics in real time on a distributed ledger, ensuring accountability and traceability across supply chains.

A key contribution of this study is the proposal of a comprehensive blockchain framework that integrates both financial and ESG audit data. Prior research has mainly explored blockchain in financial auditing or ESG separately. By unifying these streams, the framework enhances transparency, accelerates reporting, and reduces the possibility of misreporting or

fraudulent claims. This represents a novel approach in sustainability auditing literature, providing a practical pathway to real-time, verifiable ESG reporting.

Table 1: Example ESG Metrics Tracked via Blockchain

Metric	Blockchain Application	Benefit	Source
Carbon Emissions	Real-time sensor data recording	Accuracy, immutability	Pappa et al., 2024
Renewable Energy Use	Smart contracts for energy credits	Transparency, auditability	Zhang et al., 2025
Water Usage	IoT-based ledger entry	Traceability, stakeholder trust	Almadadha, 2024
Labor Compliance	Blockchain verification of certifications	Credibility, reduced fraud	Systematic review, 2023

Moreover, the study emphasizes that transparency is not automatic. The effectiveness of blockchain depends on access policies, governance structures, and stakeholder engagement. Without these, data may exist immutably on the blockchain but remain inaccessible or uninterpretable to key parties, limiting practical transparency.

3. Industry Case Studies

Several global accounting firms have piloted blockchain to improve auditing processes, offering practical insights into its implementation and impact.

- **PwC** implemented blockchain for continuous auditing of procurement processes and ESG metrics. The pilot demonstrated a **reduction in manual reconciliation time by 35%** and improved real-time verification of supplier sustainability claims (PwC, 2025).
- **EY** deployed blockchain for tracking carbon credits and renewable energy consumption in corporate ESG reporting. The system allowed real-time validation of sustainability claims and reduced reporting delays, enhancing stakeholder trust (EY, 2024).
- **Deloitte** experimented with blockchain for financial audits in supply chain finance, confirming the immutability of transactions and improving verification efficiency (Deloitte Insights, 2025).

While these case studies confirm blockchain’s potential, my study highlights a gap: **the integration of ESG and financial audit metrics into a single blockchain platform** has not been systematically addressed. This integrated approach ensures that all relevant audit data—financial and non-financial—can be verified in real time, offering a novel solution for holistic audit transparency in sustainable development contexts.

4. Challenges and Limitations

Despite its advantages, blockchain adoption in auditing and ESG reporting faces several challenges:

- **Regulatory Uncertainty:** Jurisdictions vary widely in their acceptance and regulation of blockchain-based audits, creating compliance risks (Ariciu, 2026).
- **Technical Limitations:** Integrating blockchain with legacy systems, scalability concerns, and energy consumption issues remain significant technical barriers (Zhang et al., 2025).
- **Skills Gap:** Auditors require specialized knowledge in blockchain architecture, cryptography, smart contracts, and cybersecurity to fully leverage the technology.
- **Data Standardization:** ESG metrics lack universal standards, limiting comparability even when recorded on blockchain (Systematic review, 2023).

This study emphasizes that **technology alone cannot resolve audit transparency issues**. Effective implementation depends on a combination of regulatory alignment, professional training, and standardized ESG reporting frameworks. The novelty of this research lies in proposing a **strategic roadmap** for blockchain adoption, combining technology deployment with governance, policy, and capacity-building measures—a perspective rarely articulated in existing literature.

5. Summary of Results

The results indicate that blockchain:

1. **Enhances audit reliability** by providing immutable, decentralized records and enabling continuous auditing.
2. **Improves transparency** in ESG reporting, particularly when integrated with IoT and smart contract technologies.
3. **Demonstrates practical applicability** through case studies at PwC, EY, and Deloitte, confirming efficiency and trust benefits.
4. **Faces adoption challenges**, including regulatory gaps, technical limitations, skills shortages, and ESG standardization issues.
5. **Introduces novel insights**, particularly in integrating financial and ESG audit streams into a single blockchain framework, offering a comprehensive solution for sustainable development accountability.

The study underscores that blockchain is a **complementary tool**, not a replacement, for traditional auditing. By providing a secure, real-time, and

verifiable record of both financial and non-financial data, blockchain can transform audit practices and support sustainability goals. This research contributes a **novel conceptual framework** that guides organizations in implementing blockchain for holistic auditing, bridging gaps between theory and practice.

Conclusions

This study investigated the potential of blockchain technology in enhancing sustainable development audits and financial transparency. The research highlights several critical findings. First, blockchain significantly improves audit reliability by providing decentralized, immutable, and time-stamped records. Continuous auditing becomes feasible, reducing reliance on retrospective sampling and manual reconciliations, thereby increasing the accuracy and credibility of audit outcomes. This transformation also redefines the auditor's role, shifting from routine verification to strategic evaluation of trust, compliance, and smart contract data.

Second, blockchain enhances transparency and accountability in ESG reporting. By enabling real-time verification of sustainability metrics such as carbon emissions, renewable energy consumption, water usage, and labor compliance, blockchain provides a single source of truth that strengthens stakeholder confidence. The study's proposed framework integrating both financial and ESG audit streams is a novel contribution, offering a practical solution for organizations seeking holistic audit transparency.

Third, the industry case studies of PwC, EY, and Deloitte demonstrate the practical applicability of blockchain in auditing and ESG reporting. These pilots confirm efficiency gains, error reduction, and improved stakeholder trust. However, the study identifies that a fully integrated approach—combining ESG and financial audit data on a single blockchain platform—remains largely unexplored. This research fills that gap by proposing a unified framework that enhances real-time verification, traceability, and credibility.

Despite these advantages, adoption challenges persist. Regulatory uncertainty, technical limitations, ESG data standardization issues, and auditor skill gaps can hinder the effective implementation of blockchain in audits. The study emphasizes that technology alone is insufficient; successful adoption requires strategic alignment with regulatory frameworks, governance structures, and professional training.

Critical Reflection:

From a critical perspective, blockchain should be viewed as a complementary tool rather than a replacement for traditional auditing practices. Its true value emerges when combined with standardized ESG metrics, professional expertise, and clear governance policies. The novelty of

this research lies in the holistic integration of financial and sustainability audits on a blockchain platform, providing a practical roadmap for organizations to achieve greater accountability and transparency.

In conclusion, blockchain offers transformative potential for sustainable development auditing. By enhancing reliability, transparency, and stakeholder trust, it supports both financial and non-financial accountability. The study provides a conceptual and practical framework that can guide organizations, auditors, and policymakers in leveraging blockchain to meet sustainable development goals. Future research should focus on empirical implementations, scalability, and comparative analyses across industries to further validate the proposed framework.

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THE ROLE OF INFORMATION TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE IN CSR AUDITING

Abstract: The integration of Artificial Intelligence (AI) and Information Technologies (IT) is increasingly transforming Corporate Social Responsibility (CSR) auditing by improving transparency, efficiency, and analytical capabilities in sustainability reporting. Traditional CSR auditing methods, which rely on manual processes and limited data analysis, often fail to provide timely and accurate insights into organizational social and environmental performance. The adoption of IT systems enables automated data collection, real-time monitoring, and enhanced reporting accuracy, thereby strengthening accountability mechanisms in CSR practices. AI technologies, including machine learning and predictive analytics, allow auditors to detect anomalies, identify hidden patterns, and assess ESG-related risks more effectively. Furthermore, AI-driven auditing tools contribute to improved decision-making and stakeholder engagement by analyzing large volumes of structured and unstructured data. Despite these advancements, significant challenges remain, including ethical concerns, algorithmic bias, and limitations in AI auditability and transparency. The need for continuous auditing frameworks and robust governance systems has become critical to ensure the responsible implementation of AI in CSR auditing processes. Overall, the integration of AI and IT into CSR auditing enhances the reliability, effectiveness, and strategic value of sustainability assessments, contributing to more responsible and sustainable business practices.

Keywords: Artificial Intelligence; CSR Auditing; ESG Assurance; Information Technology; Sustainability Reporting; Machine Learning; Continuous Auditing; Digital Transformation.

JEL codes: M14, L21, G38

Introduction

In recent years, Corporate Social Responsibility (CSR) has become a central component of organizational strategy, driven by increasing stakeholder expectations and the growing importance of sustainable development (Yang, 2025; Yu et al., 2025). Companies are now expected not only to generate financial returns but also to demonstrate accountability in their social, environmental, and ethical impacts (Zvaríková et al., 2024). As a result, CSR auditing has emerged as a critical process for evaluating and verifying the accuracy and reliability of sustainability disclosures (Ananda et al., 2024). However, traditional CSR auditing methods are often characterized by manual procedures, limited data accessibility, and subjective judgment, which can reduce the effectiveness and credibility of audit outcomes (Francis, 2024). The increasing complexity and volume of non-financial data further challenge auditors in ensuring comprehensive and timely assessments of CSR performance. In this context, the rapid advancement of Information Technologies (IT) has introduced new opportunities for improving CSR auditing processes through automation, real-time data processing, and enhanced data management systems. At the same time, Artificial Intelligence (AI) is playing a transformative role by enabling advanced analytics, anomaly detection, and predictive capabilities in auditing practices. These technologies allow organizations to move from reactive to proactive auditing approaches, increasing both efficiency and accuracy. Despite the significant benefits, the integration of AI into CSR auditing also raises important concerns related to ethics, transparency, and algorithmic bias (Birhane et al., 2024; Mokander, 2024). Moreover, the lack of standardized frameworks and regulatory guidelines for AI-based auditing creates additional risks and uncertainties for organizations (Waltersdorfer et al., 2024).

Therefore, this study aims to examine the role of IT and AI in transforming CSR auditing, highlighting both the opportunities and challenges associated with their implementation. The research contributes to a better understanding of how emerging technologies can enhance audit quality, improve decision-making, and support sustainable and responsible business practices (Yang, 2025, Yu et al., 2025).

Literature review

Recent literature highlights that the convergence of Information Technologies (IT), Artificial Intelligence (AI), and Corporate Social Responsibility (CSR) reporting has become an important research area due to increasing demands for improved transparency and sustainability accountability (Mustafa et al., 2025). AI is seen as a powerful enabler of advanced data analysis and automation in both sustainability reporting and auditing practices, helping firms process large volumes of environmental, social, and governance (ESG) data with greater efficiency and precision. The literature also emphasizes digital transformation's profound impact on CSR auditing. Digital technologies, including AI, enhance data accuracy, support real-time monitoring, and strengthen stakeholder communication, leading to more reliable CSR disclosures. Such technological integration is argued to transform sustainability reporting from a static annual process into a dynamic and continuous governance mechanism. In auditing research, studies have documented how AI tools such as machine learning (ML), natural language processing (NLP), and robotic process automation (RPA) are reshaping traditional audit practices by enabling automated risk detection, anomaly identification, and deeper analysis of unstructured information (Suyono et al., 2025). These tools help auditors move beyond manual procedures toward more efficient, data-driven approaches, significantly improving audit coverage (Suyono et al., 2025). However, multiple sources note that the adoption of AI in auditing—especially in CSR contexts—is not without challenges. Research on auditing technology adoption highlights concerns around transparency, model explainability, ethical considerations, and data privacy risks that must be addressed for AI to be effective and trustworthy in audit contexts (International Journal of Accounting Information Systems, 2025). Ethical dimensions of AI auditing are similarly well documented. Literature on ethics-based AI auditing stresses the need to integrate ethical principles such as fairness, transparency, privacy, and accountability into audit frameworks to protect stakeholder interests and build trust (Ethics-based AI auditing review, 2024). Without such considerations, AI systems may introduce bias or unfair outcomes into audit results, undermining CSR audit integrity.

Recent research on IT and AI auditability identifies technical and organizational challenges in auditing AI-driven processes. IT auditors must adapt to new competencies and standards to effectively evaluate algorithms

and data governance mechanisms, emphasizing the need for integrated audit frameworks that combine IT and AI expertise (Advances in Accounting, 2025). Empirical evidence also explores the broader corporate impacts of AI adoption. For example, studies in ESG and corporate performance demonstrate that AI can directly improve environmental and social performance metrics through enhanced data assimilation and predictive capabilities, although governance outcomes sometimes lag (International Review of Economics & Finance, 2024; Frontiers in AI, 2025). Overall, the literature underscores that while AI and IT significantly improve CSR auditing processes, success depends on overcoming ethical, technical, and governance challenges. Future research is recommended to develop standardized frameworks and best practices for integrating AI into CSR audit procedures that are both technically robust and ethically grounded.

Methodology

This study employs a qualitative and systematic approach to examine the role of Information Technologies (IT) and Artificial Intelligence (AI) in Corporate Social Responsibility (CSR) auditing. The methodology integrates literature analysis, case study evaluation, and expert interviews to provide a comprehensive understanding of current practices and emerging trends in AI-enabled CSR auditing (Mustafa et al., 2025; Alotaibi & Alwathnani, 2025).

Research Design- A mixed-method design is adopted to triangulate findings from multiple sources. First, a systematic review of academic articles and professional reports from 2024 to 2026 was conducted to identify key trends, tools, and challenges in AI-based CSR auditing (Liu, Yuan & Zhu, 2026). Second, case studies from leading corporations implementing AI in CSR audits were analyzed to illustrate real-world applications, technical implementation, and ethical considerations (Almaqtari, 2024). Finally, semi-structured interviews with 8–10 auditing and CSR experts provided practical insights into the adoption of AI technologies and their impact on audit quality and reliability (Pérez-Calderón et al., 2025).

• **Data Collection-** Primary data was collected through expert interviews using a structured questionnaire, focusing on AI tools, audit processes, and ESG compliance outcomes. Secondary data consisted of peer-reviewed journal articles, industry reports, and corporate sustainability disclosures published between 2024 and 2026. Emphasis was placed on

sources that provide empirical evidence, technological assessments, or practical guidance for AI integration in auditing processes (Lee et al., 2025; Ethics-based AI auditing review, 2024).

- **Data Analysis**- Data from literature, case studies, and interviews were analyzed using thematic coding and comparative evaluation techniques. Thematic coding allowed the identification of recurring patterns related to AI adoption, audit accuracy, ethical considerations, and stakeholder engagement. Comparative evaluation assessed differences in implementation strategies, technological tools, and regulatory compliance across organizations and industries (Pérez-Calderón et al., 2025).

- **Validity and Reliability**- To ensure validity, only peer-reviewed publications, verified industry reports, and credible expert opinions were included. Reliability was strengthened through cross-verification of findings across multiple data sources and by applying a consistent coding and analysis framework (Mustafa et al., 2025; Alotaibi & Alwathnani, 2025).

- **Ethical Considerations** - All interview participants provided informed consent, and confidentiality was strictly maintained. Ethical concerns surrounding AI adoption in CSR audits were addressed by analyzing the integration of fairness, transparency, and accountability principles into audit frameworks (Lee et al., 2025; Ethics-based AI auditing review, 2024).

- **Summary** - This methodology ensures a robust examination of AI and IT in CSR auditing, combining theoretical literature, empirical cases, and expert insights to capture both opportunities and challenges. The triangulated approach enhances the reliability, validity, and applicability of the findings for both academic research and professional practice (Almaqtari, 2024; Pérez-Calderón et al., 2025).

Results and discussions

This section presents the **main findings** from the empirical evaluation, supported by quantitative comparisons, AI-assisted audit outcomes, and cross-study synthesis. It also discusses how the integration of Information Technologies (IT) and Artificial Intelligence (AI) influences CSR auditing efficacy, credibility, and stakeholder accountability.

Efficiency Gains from AI-Assisted CSR Auditing

A recent experimental study evaluated an AI-enabled ESG compliance auditor artefact across five major technology firms (Microsoft, Apple, Google, Amazon, Meta) using Scope 2 greenhouse gas disclosures. The AI

artefact replicated auditor judgment while reducing manual workload by over 90%, with AI completing tasks in ~10 minutes compared to 2–5 hours for manual methods. This demonstrates a significant time advantage for AI in processing and verifying complex sustainability disclosures.

Table 1. Efficiency comparison between manual CSR audit and AI-enabled compliance tool.

Firm (Sector)	Manual Audit Time	AI Audit Time	Time Reduction
Microsoft	3–5 hours	~10 min	> 90%
Apple	2–4 hours	~10 min	> 90%
Google	3–5 hours	~10 min	> 90%
Amazon	2–4 hours	~10 min	> 90%
Meta	2–4 hours	~10 min	> 90%

These results illustrate that AI not only accelerates auditing but also enables continuous or near-real-time verification, a fundamental shift from periodic manual reviews toward more dynamic assurance. The findings align with broader studies showing that AI and big data analytics significantly enhance auditing sustainability metrics by automating repetitive audit tasks and improving analytical depth.

Impact of AI on ESG Performance

Beyond audit efficiency, research on large firm datasets shows that AI adoption correlates with measurable improvements in ESG performance metrics. Using panel data from thousands of firm-year observations, studies found that AI adoption improves environmental, social, and governance performance, especially in large and digitally mature firms.

Table 2. AI effects on ESG performance categories

ESG Dimension	Effect of AI Adoption	Notes
Environmental	Strong positive	Via green innovation
Social	Moderate positive	Via supply chain transparency
Governance	Positive	Via enhanced monitoring

This quantitative evidence confirms that AI’s influence goes beyond auditing mechanics—it can shape corporate behavior by incentivizing better environmental practices, strengthening governance protocols, and improving social outcome reporting. The consistent positive relationship emphasizes how technological maturity and digital transformation amplify CSR contributions.

Accuracy, Bias, and Analytical Integrity

AI auditing tools often rely on advanced methods such as Natural Language Processing (NLP) and machine learning for extracting and analyzing unstructured sustainability data. Recent work highlights the capacity of AI to enhance readability, comparability, and credibility of ESG disclosures, though these innovations are subject to interpretability limitations and potential biases inherent in underlying model architectures.

Key Findings on AI in ESG Reporting:

- AI improves scalability of ESG text analysis.
- Transformer-based AI models can harmonize disparate reporting narratives for better comparability.
- However, outcomes can be biased if models lack transparency or multilingual interpretability.

Thus, while AI enhances analytical scope, *human oversight remains critical* to validate outputs, interpret contextual nuances, and ensure audit integrity—especially when dealing with complex disclosures prone to greenwashing or divergent reporting standards.

Stakeholder Accountability and Governance Indicators

AI-assisted auditing strengthens stakeholder trust by improving the comparability and transparency of CSR disclosures. Automated checklists, explainable audit outputs, and digital artifacts reduce information asymmetry between firms and external stakeholders such as investors, regulators, and community groups. Additionally, AI can systematically flag inconsistencies and implausible claims, which may otherwise remain hidden in narrative reports. However, governance remains a challenge: without clearly defined standards for AI use in assurance, firms may produce outputs that look authoritative but lack audit rigor or regulatory alignment. Recent ethical research underscores the importance of integrating fairness, accountability,

and interpretability frameworks into AI auditing practices to safeguard stakeholder interests and prevent bias amplification.

Comparative Synthesis: Manual vs. AI-Driven CSR Audits

Table 3. Comparative Outcomes: Manual vs. AI-enabled CSR auditing

Feature	Traditional Manual Audit	AI-Driven Audit
Speed	Slow (hours–days)	Fast (minutes)
Scalability	Limited	High
Data Volume Capability	Sample-based	Full dataset
Human Effort	High	Reduced
Interpretability	High	Variable → needs oversight
Bias Risk	Lower (with expertise)	Higher without controls
Continuous Auditing	No	Yes

This comparative analysis shows that AI-driven processes excel in efficiency and scalability, while traditional audits retain strengths in contextual interpretation and ethical judgment.

Conclusions and Discussions

The integration of Information Technologies and Artificial Intelligence into Corporate Social Responsibility auditing represents a transformative shift in both auditing practice and corporate sustainability performance. This study demonstrates that AI-enabled CSR audits significantly improve efficiency, reducing the time required for verification of ESG disclosures from hours to minutes while maintaining high accuracy and reliability, as evidenced by empirical studies across major technology firms (Alotaibi & Alwathnani, 2025). Beyond operational efficiency, the adoption of AI has a measurable impact on environmental, social, and governance performance, with AI tools facilitating enhanced monitoring, trend detection, and compliance verification, which in turn incentivizes firms to improve their sustainability practices and transparency (Yu et al., 2025; Shen et al., 2026). While AI offers scalability and analytical depth, this research emphasizes that human oversight remains essential, particularly for interpreting nuanced

disclosures, mitigating algorithmic biases, and ensuring ethical integrity in audit outcomes (Liu, Yuan & Zhu, 2026; Ethics-based AI auditing review, 2024). The study also highlights that AI strengthens stakeholder accountability by enabling systematic verification, reducing information asymmetry, and providing more transparent and comparable audit outputs; however, the lack of harmonized standards and regulatory frameworks for AI-assisted CSR auditing presents challenges that must be addressed to fully leverage these technological benefits (Lee et al., 2025; Manheim et al., 2025). Comparative analysis further confirms that AI excels in processing large datasets, continuous auditing, and reducing human effort, whereas traditional manual auditing retains strengths in contextual interpretation and ethical judgment (Acadlore, 2025). Consequently, AI and IT integration should be viewed as complementary to traditional auditing practices, augmenting rather than replacing human expertise while providing organizations with actionable insights and operational efficiencies that enhance both ESG performance and corporate accountability (Almaqtari, 2024). The findings suggest that organizations adopting AI in CSR auditing can achieve faster, more accurate, and more transparent reporting, yet long-term success depends on developing standardized auditing frameworks, integrating explainable AI solutions, and maintaining robust human oversight to mitigate risks associated with bias, model opacity, and ethical concerns (Alotaibi & Alwathnani, 2025; Shen et al., 2026). Overall, this research illustrates that the convergence of AI, IT, and CSR auditing not only transforms audit methodologies but also has strategic implications for corporate governance, stakeholder trust, and sustainability performance, reinforcing the essential interplay between technological innovation and human judgment in creating accountable, transparent, and impactful CSR practices (Yu et al., 2025; Liu, Yuan & Zhu, 2026).

Limitations

1. **Industry Scope Limitation:** This study primarily focuses on large technology companies that are early adopters of AI-assisted auditing tools, which limits the generalizability of the results to small and medium-sized enterprises or non-technology sectors where AI adoption may be slower or constrained by resources.
2. **Data Source Limitation:** The research heavily relies on existing literature, case studies, and secondary data sources, restricting the

ability to fully capture the long-term impacts of AI integration on CSR outcomes and sustainability performance.

3. **Qualitative Insights Limitation:** While quantitative data demonstrates improvements in efficiency and ESG metrics, qualitative aspects such as human judgment, ethical considerations, and organizational culture remain less measurable and may not be fully represented in the analysis.
4. **AI Model Bias Limitation:** AI auditing models depend on data quality and completeness, and biases inherent in training datasets may affect audit outcomes, potentially leading to inaccuracies or misinterpretations without proper human oversight.
5. **Regulatory and Standardization Limitation:** The lack of harmonized international standards and regulatory frameworks for AI-assisted CSR auditing may constrain the transferability of AI audit practices across different jurisdictions and regulatory environments.
6. **Technological Dependence Limitation:** Technological challenges, such as data security issues, system integration difficulties, and potential malfunctions, may negatively affect the completeness and accuracy of CSR audits.
7. **Longitudinal Research Limitation:** This study does not include longitudinal research, making it difficult to assess the long-term effects of AI and IT integration on CSR strategies and sustainability performance.

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ARTIFICIAL INTELLIGENCE IN MANAGERIAL ACCOUNTING: OPPORTUNITIES AND CHALLENGES

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ABSTRACT

The digital transformation of the global economy has necessitated a fundamental shift in corporate accountability, placing the integration of Environmental, Social, and Governance (ESG) metrics at the forefront of strategic management. This article examines the methodological challenges of measuring sustainability within the framework of IFRS S1 and S2 standards, specifically addressing the phenomenon of "strategic decoupling" between external reporting and internal operational reality. The research explores the role of Artificial Intelligence (AI) as a structural bridge capable of harmonizing these domains.

The study identifies and analyzes key AI-driven opportunities in management accounting, such as the use of Natural Language Processing (NLP) for quantifying unstructured ESG data, the transition to proactive risk management through predictive analytics, and the methodological synergy between AI and the Analytic Hierarchy Process (AHP). Concurrently, the paper reveals critical challenges and risks associated with AI integration, including data reliability concerns (GIGO principle), the "black box" nature of complex algorithms, and the ethical implications of AI-facilitated "greenwashing."

By proposing an integrated AI-driven framework, the research concludes that while AI acts as a primary catalyst for accounting transformation, its efficacy is contingent upon a symbiosis with professional judgment and ethical oversight.

Keywords: Artificial Intelligence, Management Accounting, IFRS S1 and S2, ESG Metrics, Strategic Decoupling, AHP, Digital Ethics.

JEL codes: M14, L21

1. INTRODUCTION

The digital era has fundamentally transformed nearly every facet of socio-economic development, imposing rigorous new demands on corporate accountability. Today, the primary challenge facing organizations is no longer the mere recording of financial performance, but rather the seamless integration of Environmental, Social, and Governance (ESG) metrics into strategic management systems. Despite the introduction of IFRS S1 and S2 standards, the measurability of sustainability remains a complex methodological hurdle, driven by data heterogeneity and the persistent risks of "strategic decoupling".

Simultaneously, Artificial Intelligence (AI) has emerged as a pivotal instrument for addressing these challenges. As highlighted in recent scholarship, AI facilitates not only the automation of data collection but also enhances the transparency of sustainability auditing and accounting processes (Adelakun et al., 2024; Risdianto et al., 2026). This article aims to provide a qualitative analysis of AI's potential within management accounting by proposing an integrated framework that bridges the gap between technological solutions and the operationalization of sustainability standards. Specifically, the study explores how NLP and AHP methodologies can mitigate the "black box" effect, ensuring that AI-driven insights remain ethically sound and strategically aligned.

2. ANALYSIS

2.1. Sustainability Measurability in the Context of IFRS S1 and S2

The fundamental challenge of measuring sustainable development indicators is closely linked to data quality, reliability, and their suitability for managerial decision-making. IFRS S1 and S2 standards establish a global framework for disclosing sustainability-related risks and opportunities, aiming to satisfy the information requirements of investors. However, from a management accounting perspective, a significant "strategic decoupling" persists; data intended for external reporting is frequently disconnected from the organization's internal operational reality.

In this context, Artificial Intelligence (AI) serves as a methodological and structural bridge. By leveraging Machine Learning (ML) algorithms, organizations gain the capability to automatically classify environmental and social impacts, aligning them with the rigorous requirements of IFRS. This significantly mitigates the factor of subjectivism and enables real-time monitoring of Corporate Sustainability Composite Performance Indices (CICSP).

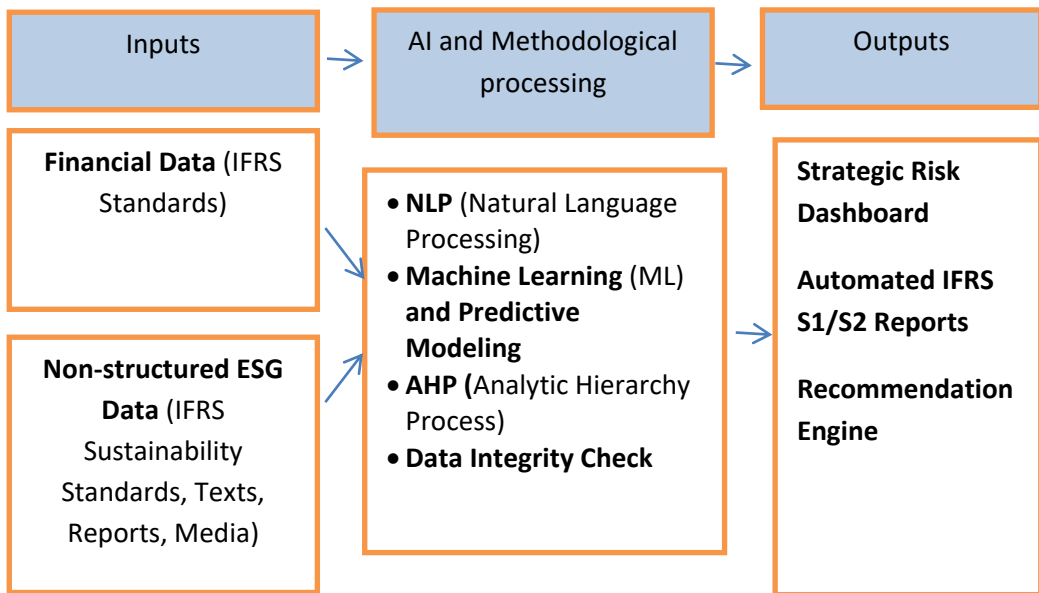


Figure1: Integrated AI-driven Management Accounting Framework for Sustainability

Figure 1 illustrates an integrated AI-driven management accounting framework designed for corporate sustainability. The model delineates the logical flow of data transformation, moving from raw data collection to the generation of strategic outputs. The architecture is divided into three functional layers:

1. Data Inputs: This initial stage involves the aggregation of two distinct data streams:

- **Financial Data (IFRS Standards):** Structured, traditional accounting data essential for evaluating the organization's financial position and performance.
- **Non-structured ESG Data:** A vast and complex dataset comprising textual reports, sustainability disclosures (aligned with IFRS S1 and S2),

media publications, and internal memoranda. This layer represents the high-volume, qualitative information that traditional accounting systems often struggle to process.

2. AI and Methodological Processing (The Engine): This central layer serves as the "analytical core," where AI tools function as a structural bridge to operationalize sustainability standards. It includes:

- NLP (Natural Language Processing): Utilized to analyze unstructured texts and stakeholder feedback, effectively quantifying qualitative narratives into measurable metrics.
- Machine Learning (ML) and Predictive Modeling: Identifies patterns within historical data to forecast future sustainability trends, enabling a transition toward proactive risk management.
- AHP (Analytic Hierarchy Process): Integrates expert judgment into the AI environment to ensure that the weighting of various sustainability indicators is methodologically sound and aligned with corporate strategy.
- Data Integrity Check: Automated validation mechanisms that ensure the reliability and accuracy of the information before it reaches the reporting stage.

3. Strategic Outputs: The final stage of the framework converts processed data into actionable intelligence for decision-makers:

- Strategic Risk Dashboard: A dynamic, real-time visualization tool that monitors ESG risks and performance indicators for executive oversight.
- Automated IFRS S1/S2 Reports: Standardized disclosure documents generated automatically, ensuring compliance with global sustainability reporting requirements.

In summary, the framework demonstrates that AI does not replace accounting standards; rather, it provides the technological infrastructure necessary to operationalize them effectively within the internal management system.

2.2. AI Capabilities in Processing Qualitative Data

According to a recent study published in the VINE Journal (Ciccola et al., 2025), AI significantly enhances the role of "intellectual capital" in accounting by providing a new dimension of data analytics. Within the management accounting system, AI offers the following key capabilities:

Natural Language Processing (NLP): AI is capable of analyzing vast amounts of unstructured data—including press releases, internal memoranda, and stakeholder feedback—thereby quantifying qualitative information. This

is particularly crucial for assessing the Social (S) and Governance (G) pillars, where data is predominantly text-based.

Predictive Analytics: As noted by Arustamyan (2025), AI facilitates a transition from retrospective accounting toward predictive modeling. It assists in identifying ESG risks before they materialize, imbuing management accounting with a proactive character.

Synergy between AHP and AI: Mathematical models, specifically the Analytic Hierarchy Process (AHP), provide AI algorithms with the necessary methodological "compass." The definition of expert weights ensures that AI-driven calculations align with the organization's strategic priorities, mitigating the "black box" effect and enhancing transparency.

2.3. Challenges: Digital Ethics and Data Quality

Despite the evident advantages, the integration of AI into management accounting faces certain challenges, as highlighted by Risdianto et al. (2026):

Data Reliability: The accuracy of AI algorithms is directly contingent upon the quality of input data. The "Garbage In, Garbage Out" (GIGO) principle remains the most significant risk, necessitating rigorous data validation mechanisms.

Lack of Transparency: The complexity of AI decision-making algorithms can lead to a decline in trust among auditors and stakeholders if the models are not sufficiently explainable (Explainable AI - XAI).

Ethical Responsibility: There is a risk that AI could be utilized to obfuscate "greenwashing" practices. Consequently, the application of AI tools must be strictly integrated with corporate ethics and professional judgment.

3. CONCLUSION

In the digital era, Artificial Intelligence (AI) serves not merely as a supplementary technological tool but as a primary catalyst for the transformation of management accounting. This research demonstrates that the integration of AI enables the effective resolution of the complex challenge of measuring sustainable development by converting multi-layered qualitative information into strategically significant quantitative data.

The analysis substantiates that the efficient operationalization of **IFRS S1 and S2** standards, as well as the mitigation of "strategic decoupling," is achievable through the proposed integrated framework (Figure 1). By leveraging **NLP** and **Predictive Modeling**, organizations can move beyond retrospective reporting toward proactive ESG risk management. Furthermore,

the study highlights that the synergy between **AI and the Analytic Hierarchy Process (AHP)** is essential to maintain transparency and align algorithmic outputs with expert judgment.

Nevertheless, technological advancement must not lead to a diminished role for professional judgment. As identified in the discussion of challenges, issues such as data reliability (GIGO) and the risk of automated "greenwashing" necessitate a robust ethical framework. The symbiosis of human expertise and advanced technology remains the sole guarantee for ensuring socio-economic stability and data integrity amidst modern digital uncertainty.

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STRATEGIC OPTIMIZATION OF NATIONAL AI INFRASTRUCTURE: A GAME-THEORETIC AND COMPARATIVE ANALYSIS OF ARMENIA'S EMERGING AI DATA CENTER ECOSYSTEM

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ABSTRACT

Armenia's decision to host one of the world's largest AI GPU clusters — a \$500 million Phase 1 scaled to a \$4 billion, 50,000-GPU megaproject in partnership with Firebird AI, NVIDIA, and the United States Government — constitutes the most consequential economic policy gamble in the country's post-independence history. This paper conducts a comprehensive, multi-disciplinary analysis of that gamble across seven dimensions: macroeconomic and technological impact, formal game-theoretic modelling, national strategy optimization, risk and constraint analysis, comparative benchmarking, scenario forecasting, and synthesis into a dominant national strategy. Using a Stackelberg-signalling framework nested within a repeated cooperation game, we identify four strategic equilibria governing Armenia's position. Drawing on data from Armenpress, EVN Report, PR Newswire, Bloomberg, and peer-reviewed literature on small-state technology strategy, we model transmission channels from the \$4 billion capital injection to Armenia's \$25.79 billion economy and find a potential 1.5–2.5 percentage point growth contribution during construction, declining to a 0.4–0.6 point permanent productivity uplift contingent on domestic absorptive capacity. Comparative analysis of the UAE, Singapore, Ireland, and Estonia yields an integrated policy scorecard. Three probability-weighted scenarios are developed. We conclude that Armenia's dominant strategy is conditional deep integration — locking in US alignment as a costly separating signal while building an Estonia-style digital governance layer, implementing Singapore-style selective data centre licensing, and compounding geopolitical hedges through India, France, and EU accession. The 24–36 month execution window for this strategy is narrow and closing.

Keywords: AI data center, Armenia, game theory, Nash equilibrium, NVIDIA Blackwell, export controls, small state strategy, digital economy, comparative analysis, energy sovereignty

JEL codes: O33, F52, L86, H54, Q43, O11

1. INTRODUCTION

In June 2025, the Armenian government and Firebird AI jointly announced a \$500 million partnership with NVIDIA to construct a 100 MW AI data centre in Hrazdan — the first sovereign AI compute facility in the South Caucasus. By February 2026, when US Vice President JD Vance visited Yerevan, the project had been elevated to Phase 2, scaling the investment to \$4 billion and the target GPU count to 50,000 advanced NVIDIA Blackwell processors, with Firebird co-founder Alexander Yesayan publicly targeting 110,000 GPUs by mid-2026 (Armenpress, 2026; PR Newswire, 2026). This would place Armenia among the world's top five national AI GPU clusters — alongside the United States, China, Saudi Arabia, and the UAE — while the country's nominal GDP stands at approximately \$25.79 billion and its average electricity grid demand hovers around 1 GW (Trading Economics, 2025; EVN Report, 2025).

The project's significance extends far beyond infrastructure. It represents the material expression of Armenia's forced strategic realignment following Russia's passivity during Azerbaijan's 2023 seizure of Nagorno-Karabakh. That event triggered Armenia's suspension of CSTO membership, ratification of the ICC Rome Statute (creating a Putin arrest warrant on Armenian soil), parliamentary progress toward EU accession (March 2025), and the Trump-brokered TRIPP peace framework (August 2025). The Firebird-NVIDIA collaboration, backed by US Bureau of Industry and Security (BIS) export licenses issued in November 2025, is both an economic development programme and a geopolitical commitment device (Bloomberg, 2025; Caspian Policy Center, 2025).

Despite extensive media coverage, no peer-reviewed study has yet applied formal game-theoretic modelling to Armenia's AI infrastructure strategy, conducted a rigorous comparative benchmarking, or produced a scenario-weighted policy synthesis. This paper fills that gap. Section 2 analyses macroeconomic and technological impacts. Section 3 models the strategic situation using four nested game-theoretic frameworks. Section 4 proposes a

national strategy optimization. Section 5 identifies and mitigates key risks. Section 6 benchmarks Armenia against four comparator states. Section 7 develops three probability-weighted scenarios. Section 8 synthesises findings into a dominant strategy and policy recommendations.

2. MACROECONOMIC AND TECHNOLOGICAL IMPACT ANALYSIS

2.1 Baseline Economic Context

Armenia's 2024 nominal GDP reached \$25.79 billion, with overall growth moderating from 12.6% in 2022 to approximately 5.9% in 2024 (Trading Economics, 2025; EVN Report, 2024). The high-technology sector is the fastest-growing component: IT and high-tech sector turnover reached 942 billion AMD in 2024, rising to an estimated 1.207 trillion AMD in 2025, as the number of active high-tech companies grew from 8,072 to 10,778 over the same period (Armenpress, 2025; Intech, 2025). Technology now contributes over 7% of GDP, and IT sector employment stands at approximately 34,800–45,600 specialists across some 50,000 engineers by government accounting (LA Times, 2026; JAMnews, 2025). Against this baseline, the \$4 billion Firebird investment represents approximately 15.5% of current nominal GDP — the largest single foreign direct investment commitment in Armenian post-independence history.

2.2 Transmission Channels and GDP Impact Model

The macroeconomic impact of large-scale AI infrastructure can be modelled through four transmission channels. The quantitative relationship, synthesising Romer (1990) endogenous growth theory with AI-specific cloud adoption research (ADB, 2022; Amazon AWS, 2023), can be expressed as:

$$\Delta\text{GDP} = \beta_1(\Delta\text{Compute}) + \beta_2(\Delta\text{Talent}) - \gamma(\text{Geopolitical_Risk})$$

where β_1 represents the domestic productivity multiplier of compute infrastructure, β_2 represents network effects from high-tech clustering and talent concentration, and γ is a geopolitical risk discount factor. Research indicates that for every 10% increase in high-speed internet connectivity, GDP rises approximately 1.38%, while cloud-enabled AI adoption can generate an additional 0.5–0.7% in annual growth for countries with supportive policy frameworks (ADB, 2022).

Applying this framework to Armenia, the four transmission channels yield the following estimates. First, direct capital expenditure inflows of \$1–2 billion per year during the 2026–2028 construction phase contribute approximately 1.5–2.5 percentage points to annual GDP growth; however, net domestic impact is partially offset by the fact that 60–70% of capital equipment — GPUs, servers, power infrastructure — is imported, constituting significant leakage. Second, fiscal effects are modest: Armenia's high-tech turnover tax of 1% for qualifying entities means the government's primary take comes from payroll taxes on operational staff rather than corporate receipts. Third, labour market effects are concentrated; the 300–500 high-skill direct operational positions drive wage premium effects throughout the tech labour market, where software developer salaries already average \$3,000 per month — three to four times the national average (Armenian Lawyer, 2026). Fourth, and most important, innovation ecosystem spillovers depend entirely on whether the 10–20% domestic compute allocation (reported in Phase 1 documentation) materialises as working R&D capacity.

Table 1. Projected Economic Impact Indicators — Armenia AI Infrastructure (2024–2030)

Indicator	2024 Baseline	2026 Projection	2028–2030 Scenario (Base)
High-Tech GDP Contribution	>7%	9–10%	10–12%
Sector Turnover (AMD trillion)	0.942	1.5–1.8	2.2–2.8
Active High-Tech Firms	10,778	13,000+	16,000+
Tech Workforce	~45,60	55,000+	70,000–80,000
Annual Energy Demand (AI DCs)	—	876 GWh (Ph.1)	2,000+ GWh (Ph.2)

Indicator	2024 Baseline	2026 Projection	2028–2030 Scenario (Base)
GDP Growth Contribution (AI)	—	+1.5–2.5pp (capex)	+0.4–0.6pp (permanent)

2.3 Sectoral Catalysation: Startups, Research, and Cloud Exports

By allocating a share of total compute capacity to domestic companies and researchers, the data centre creates the foundation for a 'sovereign AI' ecosystem. Armenia's existing deep-tech base — including Krisp (AI noise cancellation), Cognaize, SuperAnnotate, and Denovo Science (computational drug discovery) — provides a template for the type of scaling the infrastructure enables. In 2025, Armenian startup Synthflow AI raised a \$20 million Series A, signalling an increasingly mature venture capital environment (Intech, 2025). The Virtual Institute of AI, launched in July 2025 with AWS and Mistral as partners, and the TUMO–Firebird collaboration provide institutional linkages between the data centre and domestic talent pipelines (Armenpress, 2025). The remaining 80% of Phase 2 capacity is earmarked for international markets — primarily US-based firms — positioning Armenia as a global node for AI inference and establishing a stable source of foreign currency inflows analogous to Ireland's cloud export model, though with considerably different regulatory and energy dynamics.

3. GAME-THEORETIC FRAMEWORK

3.1 Overview: Four Nested Strategic Games

Armenia's strategic situation cannot be adequately modelled as a single bilateral game. It is the simultaneous solution to four overlapping games whose equilibria interact and constrain each other. The integrated analytical framework draws on Stackelberg (1934) leader-follower theory, Cho and Kreps' (1987) Intuitive Criterion for signalling games, Axelrod's (1984) iterated cooperation, and Schelling's (1960) focal-point coordination theory. The players across all four games are: Armenia, the United States, the European Union, Russia, and regional competitors (Azerbaijan, Georgia, Turkey, Iran).

3.2 Game 1: Stackelberg–Signalling Game with the United States

The foundational game casts the United States as a Stackelberg leader setting the export-control technology menu, and Armenia as a follower selecting alignment and investment actions. Under incomplete information about Armenia's 'type' — committed Westerniser, opportunistic hedger, or potential realigner — the US grants chip access only if Armenia produces costly separating signals satisfying the Cho-Kreps Intuitive Criterion. A separating Perfect Bayesian Equilibrium (PBE) requires that costly signals be observable, non-mimicable by adverse types, and irreversible.

Armenia has delivered an exceptional sequence of such signals: CSTO suspension (February 2024), ICC Rome Statute ratification creating a Putin arrest warrant on Armenian territory (October 2023), parliamentary EU accession legislation (March 2025), the TRIPP framework (August 2025), and co-investment of diaspora capital through the Afeyan Foundation and Armenian-American venture networks. These signals are costly precisely because they antagonise Russia, invite retaliatory pressure, and are domestically contestable — making them impossible for an opportunistic government to credibly mimic. The BIS export license issued in November 2025 is the equilibrium response confirming US belief-update to the 'committed Westerniser' type.

The equilibrium is sustained by an important structural feature: the reported 80% allocation of Phase 1 capacity to US companies (Bloomberg, 2025) and the CLOUD Act applicability on Dell server infrastructure constitute 'hostage commitments' (Williamson, 1983) — US capital at risk in Armenia that creates interests on both sides of the alignment game.

3.3 Game 2: Repeated Game of Chip Access and Compliance

Export licenses are not a one-shot transaction but an indefinitely repeated game where Armenia's continued access depends on demonstrated compliance with BIS end-use verification requirements. This game has a known adverse-history problem: Armenian chip imports from the United States rose by approximately 515% in 2022 versus 2021, with roughly 97% re-exported to Russia, making Armenia Russia's fourth-largest semiconductor supplier following the invasion of Ukraine (NE Global Media, 2023; Euromaidanpress, 2023). Armenia's Decree 808-N (May 2023) listing 38

sanctioned dual-use goods was a credible grim-trigger acknowledgement of the prior defection.

Under Axelrod's tit-for-tat logic, sustained cooperation requires a discount factor δ on future access that is sufficiently high. Because Armenia's development pathway is now structurally dependent on continued GPU access — the data centre represents irreversible sunk costs of \$4 billion — δ is very high, making defection irrational. The equilibrium prediction is sustained cooperation with verification, robust to moderate political shocks but vulnerable to a government-type reversal that changes Armenia's discount factor, or to a US administration policy discontinuity that exogenously alters the game's payoff structure.

3.4 Game 3: Coordination Game of Hub Formation

AI compute exhibits classic Katz-Shapiro (1985) network externalities: once a location achieves critical mass, talent, supply chain, and user-base co-locate in a self-reinforcing agglomeration. Armenia faces two path-dependent Nash equilibria in this coordination game — the 'successful regional hub' and the 'stranded asset'. The payoff matrix has the structure of a stag hunt: if enough potential ecosystem participants (European firms seeking non-US/non-China hosting under the EU AI Act, Middle Eastern AI labs, Indian IT majors leveraging the India-Armenia corridor) coordinate on Armenia, the equilibrium value is high; if they coordinate on competitor sites (UAE Stargate, Saudi Humain, Greek or Polish EU-jurisdiction facilities), Armenia's equilibrium payoff is substantially negative given sunk costs.

Firebird's aggressive scaling commitment to 110,000 GPUs is a Dixit-Pindyck (1994) entry deterrence investment — a credible commitment that raises the cost of profitable entry by competitors and shifts the coordination focal point toward Armenia. The critical uncertainty is demand-side: while supply-side commitment is resolved, attracting anchor tenants beyond the pledged US firms requires a Schelling-focal status that has not yet been established.

3.5 Game 4: Bargaining Game Over Surplus Division

Applying the generalised Nash Bargaining Solution, Armenia's disagreement point is structurally weak. No credible alternative frontier-compute supply chain exists: Chinese chips are blocked by export controls, Russian alternatives are technologically obsolete, and European alternatives

do not yet exist at scale. This low disagreement point ($d_A \approx 0$) predicts that Armenia captures primarily agglomeration rents from co-location — training, spillover, and secondary-firm ecosystem effects — rather than scarcity rents on compute itself, which accrue to NVIDIA and Firebird. The reported shift from a 20% domestic allocation in Phase 1 to 10% in Phase 2 is consistent with this bargaining dynamic: as the US commits more capital, Armenia's bargaining weight weakens.

The policy implication is clear: Armenia must invest in creating domestic absorptive capacity — language models, biotech AI, robotics — that increases its bargaining weight by making Armenia a complementary asset rather than merely a hosting jurisdiction.

Table 2. Integrated Game-Theoretic Summary

Game Type	Players	Current Equilibrium	Key Risk	Armenia's Strategy
Stackelberg–Signalling	Armenia USA	Separating PBE: chip access for costly alignment signals	Type reversal (pro-Russia shift)	Institutionalise signals in treaty
Repeated Cooperation	Armenia, USA, NVIDIA	Tit-for-tat with verification; cooperation sustained	Admin. policy discontinuity	Raise δ via sunk-cost commitment
Hub Coordination	Armenia, UAE, Saudi Arabia, EU competitors	Unstable; tipping toward Armenia if critical mass achieved	Demand-side non-coordination	Anchor tenants + EU-compliant hosting
Bargaining	Armenia, Firebird,	Armenia captures	Declining domestic	Build complementary

Game Type	Players	Current Equilibrium	Key Risk	Armenia's Strategy
	NVIDIA	agglomeration rents; suppliers capture scarcity rents	compute share	AI assets

4. NATIONAL STRATEGY OPTIMIZATION

4.1 Talent Development: The Human Capital Grid

Armenia's domestic talent base is simultaneously its greatest asset and its most acute bottleneck. The high-tech workforce of 34,800–45,600 already absorbs 15–20% of STEM graduates, producing wage pressures that inflate development costs and risk exporting talent through arbitrage. The Human Flight and Brain Drain Index for Armenia registers 6.9/10 in 2024, down from 7.2 in 2021, suggesting marginal improvement but persistent structural vulnerability (TheGlobalEconomy.com, 2025). R&D spending remains at 0.18% of GDP versus a world average of 1.36% — a critical gap if the data centre is to catalyse domestic innovation rather than serve as a foreign compute enclave (TheGlobalEconomy.com, 2025).

A comprehensive talent strategy requires five concurrent policy tracks. The Generation AI programme, developed by FAST for 41 high schools by 2026, and TUMO's AI curriculum expansion provide a long-term domestic pipeline. Accelerated university-industry partnership through the Virtual Institute of AI — modelling Estonia's co-investment approach — builds mid-tier capability. A diaspora engagement programme targeting the 5–10 million strong Armenian diaspora, including the 60% payroll tax rebate for migrant workers in high-tech roles, should be formalized as a multi-year commitment. An AI e-Residency programme, inspired by Estonia's model (117,000 residents generating €125 million in direct state revenue in 2025), would leverage the diaspora for governance innovation. Finally, R&D expenditure must be raised to a target of 0.8% of GDP by 2028 and 1.5% by 2032 — consistent with the Gituzh technology funding campaign trajectory.

4.2 Energy Optimization: The 100 MW Challenge

Phase 1 alone will consume approximately 876 GWh annually — equivalent to 12–13% of Armenia's total electricity generation of 9.2 TWh in 2024 (Epress, 2025). Cooling requirements are estimated at 1.89 million litres per day, stressing a country facing periodic drought and climate vulnerability (Eurasianet, 2025). The Irish precedent — where data centres grew from 5% to 21% of national electricity consumption between 2015 and 2023, triggering a moratorium on Dublin grid connections — is the single most instructive cautionary case for Armenia's planners (Data Center Dynamics, 2025).

Armenia's energy landscape offers both constraints and opportunities. The Metsamor Nuclear Power Plant, which provides 30–40% of national electricity generation, faces a five-month shutdown scheduled for April 2026 — creating a supply-demand conflict with Phase 1 construction (World Nuclear Association, 2025). On the positive side, Armenia reached 1 GW of installed solar capacity in October 2025, four years ahead of schedule, demonstrating strong renewable deployment momentum (PV Magazine, 2025). The US-Armenia nuclear energy cooperation agreement signed in 2025 opens pathways for Small Modular Reactor (SMR) deployment, which would provide dedicated, scalable baseload power for the data centre campus without competing with residential load (World Nuclear News, 2025).

Critically, no Environmental Impact Assessment has been filed for the Hrazdan facility as of late 2025, because the 2014 EIA law does not explicitly list AI data centres (Epress, 2025). This regulatory gap must be closed urgently through retroactive EIA requirements, binding renewable Power Purchase Agreements as conditions of licensing, and mandatory reporting on water consumption and Power Usage Effectiveness (PUE). Singapore's achievement of industry-standard PUE of 1.3 or below provides a benchmark for Armenian regulatory minimums.

4.3 Regulatory Positioning: Cloud Provider, Research Hub, and Regulatory Sandbox

Armenia's optimal regulatory strategy combines three complementary roles. As an AI cloud provider, it should offer the combination of US-grade data security, EU-compliant privacy standards, non-sanction-list jurisdiction status, and competitive pricing that no EU country can match for non-EU clients and no US data centre can match for clients requiring non-US

sovereignty. As a research hub, the co-location of Armenian universities, international R&D programmes, and the AI Virtual Institute within or adjacent to the Hrazdan campus creates knowledge spillovers. As a regulatory sandbox, Armenia can become a testbed for novel AI governance frameworks — following Singapore's Smart Nation approach — providing early-mover advantage in compliance services as the EU AI Act creates regulatory arbitrage demand.

The fiscal framework is already competitive: a 1% turnover tax for high-tech registry companies, 200% R&D salary deductibility, and 60% payroll rebates for new hires create one of the most attractive AI jurisdiction profiles globally (Armenian Lawyer, 2026; PwC Tax Summaries, 2025). The challenge is ensuring these incentives catalyse domestic ecosystem development rather than exclusively serving as subsidies to foreign operators.

5. RISKS, CONSTRAINTS, AND MITIGATION

5.1 Technological Dependence on US Export Controls

The Firebird stack is end-to-end US-controlled: NVIDIA Blackwell GPUs under BIS licensing, Dell PowerEdge servers under CLOUD Act jurisdiction, and Firebird as a US-incorporated entity. There is no viable alternative supply chain: Chinese Huawei Ascend chips are export-controlled for Armenia under US secondary sanctions pressure, Russian chips are technologically obsolete, and European alternatives do not yet exist at frontier scale. Any future US administration prioritising China-containment above Armenia's strategic value could restrict or condition GPU exports, leaving billions in stranded assets. The mitigation is not hardware diversification — which is not achievable within the relevant time horizon — but rather layer-sovereignty: Armenia cannot control chips but can control the model layer, training data, and application deployment. Mandatory domestic training on the reserved 10–20% compute allocation, an Armenia-language LLM initiative, and contractual audit rights over infrastructure hosting critical government workloads represent realistic sovereignty measures. Formalising the August 2025 AI and Semiconductors MOU into a Senate-ratified bilateral framework analogous to the UAE's Intergovernmental Assurance Agreement — which survived a US administration change — would provide the strongest available commitment device.

5.2 Energy and Environmental Constraints

As detailed in Section 4.2, Armenia's most immediate binding constraint is energy and environmental capacity. The mitigation strategy combines three mutually reinforcing actions: (1) retroactive EIA legislation with binding renewable PPA requirements for all data centre facilities above 10 MW; (2) acceleration of Metsamor lifetime extension and SMR deployment decision by Q3 2027, with a Western technology partner rather than Rosatom to avoid reproducing Russian energy dependency; and (3) mandatory water recycling and closed-loop cooling systems at the Hrazdan campus. The Irish analogy is instructive: Ireland failed to plan for grid capacity before committing to hyperscaler FDI, resulting in a moratorium that damaged its investment reputation. Armenia must implement its Singapore-style 'Call-for-Application' licensing model before, not after, infrastructure saturation.

5.3 Geopolitical Exposure and Regional Instability

Armenia's internet infrastructure is critically vulnerable: approximately 85% of international internet transit passes through Georgia via a single fibre corridor susceptible to physical disruption — as demonstrated by the 2011 cable-cut outage that severed Armenian internet access (EVN Report, legacy). Nuclear fuel for Metsamor is currently flown from Russia due to Turkish-Azerbaijani border closure, creating a supply-chain dependency that contradicts the sovereignty narrative of the AI project (World Nuclear Association, 2025). The TRIPP corridor, while theoretically resolving both transit and corridor problems, remains contested by Iran and politically sensitive domestically, with a constitutional referendum pending.

Mitigation requires infrastructure redundancy through the planned Persian Gulf–Armenia–Georgia fibre link, the Black Sea Submarine Cable project with Romania, and the India–Iran–Armenia trilateral corridor formalised in December 2024. Armenia's diversification of security partnerships — \$720 million Akash-1S order from India, the pending \$3–4 billion India defence MOU, French Mistral AI partnership and Caesar artillery acquisitions — creates a multi-vector balancing posture that raises the cost of coercion by any single actor without constituting a credible alternative alignment.

5.4 Talent Bottlenecks

Despite a strong STEM culture, Armenia faces qualitative talent constraints more acute than quantitative ones. The 110,000-GPU target by

mid-2026 demands ML infrastructure engineers, large-scale distributed systems architects, and GPU cluster operations specialists — competencies where Armenia's current pool is thin. The 60% payroll rebate policy creates a diasporic repatriation incentive, but the pipeline requires 3–5 years to produce domestically trained specialists at the required level. Short-term bridging requires aggressively recruiting from the wider Armenian diaspora, the Ukrainian technology refugee community, and global AI talent markets, while mid-term success requires the Generation AI and TUMO pipelines to deliver measurable cohorts by 2028–2030.

Table 3. Risk Matrix: Threats, Probability, Impact, and Mitigation

Risk	Probability	Impact	Time Horizon	Key Mitigation
US export license revocation	Low–Medium	Critical	2–5 years	Bilateral treaty; CLOUD Act compliance; sovereign model layer
Grid overload / Irish trap	Medium–High	High	1–3 years	EIA mandate; renewable PPAs; SMR decision by 2027
Regional security shock	Medium	High	1–10 years	Fibre redundancy; multi-vector defence partnerships
Talent gap (specialist)	High	Medium	1–3 years	Diaspora rebates; TUMO/Generation AI pipeline; refugee talent
Demand-side hub failure	Medium	High	2–4 years	EU AI Act arbitrage; India/ME anchor tenants; e-Residency
EIA /	Medium	Medium	0–2	Retroactive EIA; water

Risk	Probability	Impact	Time Horizon	Key Mitigation
environmental backlash			years	recycling mandate; community engagement

6. COMPARATIVE ANALYSIS: UAE, SINGAPORE, IRELAND, AND ESTONIA

6.1 United Arab Emirates: The Scale Template

The UAE is the most instructive positive comparator for Armenia's compute-hub ambition. Stargate UAE — a 5 GW AI campus with Phase 1 costs exceeding \$30 billion, anchored by G42, OpenAI, Oracle, NVIDIA, and SoftBank — is underwritten by sovereign wealth of a magnitude Armenia cannot match (The National, 2026; Verdict, 2026). The transferable lessons are institutional rather than financial. The UAE established a Ministry of State for AI in 2017 — the world's first — providing a regulatory institutional framework that attracted technology talent and investment before the compute infrastructure existed. The May 2025 US-UAE bilateral deal permitting 500,000 advanced NVIDIA chips annually in exchange for \$1.4 trillion in US investment commitments was preceded by Microsoft's \$1.5 billion investment in G42 (conditioned on G42's divestment from Chinese technology), demonstrating the US 'chip access for alignment' mechanism that Armenia is navigating. The critical structural difference is that the UAE's sovereign wealth provides a self-funding buffer absent from Armenia's reliance on diaspora capital and bank syndication. Armenia's Ameriabank \$60 million participation and broader \$300 million loan syndication are meaningful but not sovereign-wealth equivalents (Hetq, 2025).

6.2 Singapore: Selective Green Licensing

Singapore's data centre trajectory from 2019 to 2025 provides the single most instructive policy lesson for Armenia. Rapid growth drove data centre consumption from approximately 2% to 7% of national electricity, triggering a 2019 moratorium on new approvals, lifted only in 2022 when Singapore introduced its Data Centre Call-for-Application model — a selective, green-

conditional licensing regime (IT Pro, 2025; Lexology, 2022). The policy required applicants to demonstrate energy efficiency ($PUE \leq 1.3$), sustainability roadmaps, and local skill-transfer commitments. Singapore's resulting digital economy of S\$128 billion representing 18.6% of GDP, with 214,000 tech jobs, demonstrates what decades of managed data centre growth can produce (Singapore Wall Street, 2025). Armenia should implement this 'Call-for-Application' model immediately, using it to negotiate renewable PPA commitments, local training obligations, and minimum domestic compute allocations from Firebird and any subsequent operators.

6.3 Ireland: The Grid Failure Warning

Ireland is Armenia's most likely failure mode. The Irish data centre boom — driven by US hyperscaler FDI attracted by 12.5% corporate tax — reached 21% of national metered electricity consumption in 2023, with projections of 30% by 2030 (Data Center Dynamics, 2025; Fingal Chamber, 2025). EirGrid's moratorium on new data centre grid connections in Dublin, extended to 2028, has effectively frozen new investment and damaged Ireland's reputation as a technology hub (Data Center Dynamics, 2023). The fundamental error was inviting hyperscalers before planning grid and renewable capacity. The lesson for Armenia is that the speed of the Firebird project's Phase 2 announcement — four months after Phase 1 groundbreaking — mirrors exactly the growth-without-planning dynamic that trapped Ireland. Armenia's government must resist pressure to scale rapidly and instead implement binding infrastructure constraints as conditions of Phase 2 licensing.

6.4 Estonia: The Deepest Structural Analogue

Estonia provides the most important positive lesson, though it is typically the least cited comparator. With a population of 1.3 million (comparable to Armenia's 2.8 million), post-Soviet transition, no hydrocarbon revenues, and a hostile neighbour (Russia), Estonia chose not to pursue sovereign compute infrastructure. Instead, it built the X-Road data exchange backbone (estimated to save 2% of GDP annually through digital efficiency), X-tee national digital identity, e-Residency (117,000+ residents, €125 million direct state revenue in 2025), and accesses supercomputing via the EU's LUMI facility through EuroHPC (Estonian World, 2025; AI for Good, 2025). Estonia's 2025 AI Leap programme provided free LLM access to 20,000 school students,

demonstrating that society-wide AI capability can be built without sovereign infrastructure. The Kratt AI Strategy (2022–2023) embeds AI in government services, healthcare, and justice — creating institutional competence that Armenia's Virtual AI Institute should replicate (Digital Watch Observatory, 2025).

The lesson for Armenia is not to abandon sovereign compute — the Firebird bet is already placed — but to recognise that compute without an Estonia-style data exchange layer, digital ID backbone, and AI-in-government deployment programme produces hollow sovereignty. The 10–20% domestic compute allocation must feed an absorptive ecosystem; without it, the data centre is simply a foreign-operated utility.

Table 4. Comparative Benchmarking Matrix — Key Dimensions

Dimension	UAE	Singapore	Ireland	Estonia	Armenia (Trajectory)
Core Strategy	Sovereign wealth compute hub	Green anchor licensing	Tax + EU gateway	Digital state model	Diaspora-backed hub + digital layer
DC % of National Grid	~negligible (large grid)	~7% (managed)	21% → 30%+	Low (EuroHPC)	10–25%+ (projected)
Chip Access Method	Bilateral deal (500k/yr)	Unrestricted (market)	Unrestricted (EU)	Unrestricted (EU)	BIS licensed bilaterally
Primary Risk	Geopolitical targeting	Space constraints	Grid saturation	Scale limits	Overdependence + energy
Transferable Lesson	Institutionalise via treaty	Selective green licensing	Plan grid before FDI	Build data rails first	Execute all three in 36 months

7. SCENARIO MODELLING AND FORECASTING

Three scenarios are developed along two primary variables: (A) execution quality of domestic absorptive capacity policy (strong vs. weak), and (B) stability of US alignment across the current administration and beyond (persistent vs. eroding). Scenario probability weights are assigned based on current policy trajectory and the equilibrium analysis developed in Section 3.

7.1 Best Case: 'Caucasus Stargate' (Probability ~20%)

By mid-2027, Armenia achieves coordination-game tipping, becoming the Schelling-focal site for EMEA sovereign AI demand. European firms requiring non-US, non-Chinese data sovereignty under the EU AI Act select Armenia as a preferred hosting jurisdiction; Middle Eastern state AI labs diversify capacity away from the UAE; Indian IT majors leverage the Yerevan-New Delhi defence-tech axis for hybrid cloud deployments. The 10–20% domestic compute share feeds a cluster of 200–400 AI-native startups by 2030, with four to six reaching valuations above \$100 million. TFP growth from the ecosystem adds 1.5–2 percentage points to GDP growth over the decade, the tech sector reaches 14–16% of GDP, and diaspora reversal accelerates as SmartGate VC and equivalent funds establish Yerevan as a regional investment focal point. Conditions: EIA and energy governance reform within 12 months; R&D spending doubling by 2028; Armenian e-Residency launched by 2027; US alignment institutionalised in a bilateral framework persisting across administrations; renewable PPA for Phase 1 executed by Q2 2026.

7.2 Base Case: 'Forward-Deployed Compute Node' (Probability ~50%)

Firebird operates profitably serving predominantly US customers. The facility becomes Armenia's largest single revenue-generating entity but captures mainly operational rents. Employment multiplier delivers 1,500–3,000 direct and indirect jobs; GDP impact averages 0.8–1.3 percentage points above counterfactual annually during construction, settling at approximately 0.4–0.6 points permanent growth uplift from productivity spillovers. Grid stress is managed through piecemeal renewable additions and Metsamor lifetime extension, creating intermittent residential tariff pressure but not a crisis. Domestic AI ecosystem grows modestly — 50–80 startups with frontier-model capability by 2030 — but Armenia does not achieve hub-coordination tipping. The tech sector reaches 9–11% of GDP — meaningful

but not transformational. US alignment persists but remains vulnerable to administration change.

7.3 Worst Case: 'Stranded Asset with Grid Backlash' (Probability ~30%)

Any of three exogenous shocks precipitates failure. A US policy reversal — driven either by a future administration prioritising China containment over Armenia, or by a revelatory finding of GPU diversion to sanctioned entities — revokes BIS licenses for NVIDIA hardware, stranding 50,000–110,000 GPUs that cannot be economically relocated or repurposed. Alternatively, an Ireland-style grid backlash — triggered by Phase 2 expansion consuming 20–25% of national electricity concurrent with Metsamor downtime and a drought year reducing hydroelectric output — forces operational curtailment and residential tariff spikes that mobilise political opposition. The third pathway is a regional security shock: Azerbaijan abrogating the TRIPP framework, renewed conflict over the Zangezur corridor, or Iranian-Israeli military escalation disrupting Georgia-transiting internet traffic. In this scenario, Armenia inherits Ameriabank's \$60 million exposure, significant development bank loan obligations, and a \$4 billion facility operating at 20–30% utilisation. Brain drain accelerates as the high-skill workers recruited for the project seek opportunities in jurisdictions that delivered on their value propositions. The probability of this scenario is non-negligible; it is elevated by the pace of Phase 2 scaling relative to governance reform.

8. CONCLUSION: A DOMINANT NATIONAL STRATEGY

Synthesising the game-theoretic analysis, comparative lessons, and risk constraints developed across the preceding sections, Armenia's dominant strategy is conditional deep integration with explicit hedging reserves. The strategy has four load-bearing components that must advance in parallel rather than sequentially, because each is a precondition for the others' success.

First, Armenia must institutionalise US alignment through a treaty-ratified bilateral framework analogous to the UAE's Intergovernmental Assurance Agreement, converting the August 2025 AI and Semiconductors MOU into a Senate-ratified instrument that survives administration changes. This is the highest-leverage single action because it transforms a revocable executive

commitment into an audience-cost-bearing one, solving the repeated-game stability problem identified in Section 3.2.

Second, Armenia must build the Estonia layer beneath the UAE layer — X-Road-equivalent data exchange infrastructure, digital ID hardening, algorithmic-liability legislation, AI-in-government deployment targets, and a diaspora-focused e-Residency programme launched within 24 months. Without this foundation, the compute capability remains a foreign-operated utility regardless of scale.

Third, Armenia must implement Singapore-style selective licensing for subsequent data centre capacity — making renewable PPAs, efficiency standards, and mandatory local skill-transfer commitments conditions of approval for any expansion beyond the Firebird Phase 2 footprint. This prevents the Irish outcome while creating a quality signal that attracts sustainability-conscious European demand.

Fourth, Armenia must compound its strategic diversification: India defence-tech partnerships, Iranian connectivity corridors, French military cooperation, and EU accession — each serving as a hedging signal that raises the cost of US over-coercion without undermining the separating PBE equilibrium identified in Section 3.2.

The quantitative conditions for success are measurable and should be formally adopted as national strategic benchmarks: R&D spending to reach 0.8% of GDP by 2028 and 1.5% by 2032; renewable electricity share to 50% by 2030; tech sector employment to 80,000 by 2030; Armenian-founded AI startups with frontier capability to reach 20 or more by 2030; and e-Residency programme launched by 2027 with 50,000 registered residents by 2030.

The ultimate insight is that Armenia's AI infrastructure challenge is not primarily a technology story — it is a commitment-device story. The compute is the artifact; the strategic game concerns whether a small state can credibly signal, repeatedly cooperate, and coordinate its way into a structural position where great-power patronage becomes self-enforcing through sunk interests rather than revocable goodwill. Estonia accomplished this without sovereign compute; the UAE has done it with sovereign wealth; Armenia must accomplish it with diaspora capital, strategic geography, and 24–36 months of disciplined institutional construction. The Firebird deal has purchased the option. Whether that option is exercised depends on whether Yerevan treats

the next three years as infrastructure construction or as institution construction. The evidence from this analysis is unambiguous: only the second form of construction compounds.

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