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Integration of AI and IoT into Corporate Social Responsibility Strategies for Financial Risk Management and Sustainable Development

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Abstract: This research explores the integration of artificial intelligence (AI) and the Internet of Things (IoT) within corporate social responsibility (CSR) strategies, focusing on financial risk management and sustainable development. Employing a novel Coevolutionary multi-paradigm approach to technological development, this study examines how these technologies can be embedded into CSR practices to enhance sustainability and manage risks effectively. The findings reveal that successful integration depends significantly on the adaptability of institutional structures to support technological innovations. This study contributes to the literature by providing a comprehensive analysis of the intersection of AI, IoT, and CSR, highlighting the necessity for robust mechanisms and policies that ensure security, standardization, and sustainable use of emerging technologies. Through this investigation, this research offers a new perspective on leveraging advanced technologies to advance corporate sustainability and risk management objectives.

Keywords: AI in financial risk management; IoT and corporate responsibility; techno-economic institutions; sustainability in corporate strategies; digital transformation in finance

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1. Introduction

The integration of artificial intelligence (AI) and the Internet of Things (IoT) into corporate social responsibility (CSR) strategies marks a significant evolution in the strategic frameworks of socio-economic systems. These technologies are increasingly recognized as pivotal determinants of success in the contemporary business landscape, particularly within the context of sustainable development. Despite their potential to redefine sustainability paradigms, the systematic incorporation of AI and IoT within CSR strategies, especially in financial risk management and sustainable development, is still underexplored.

This research seeks to address the gap in the literature concerning the strategic integration of AI and IoT into CSR frameworks. While existing studies have highlighted the functional benefits of these technologies across various domains, including urban planning, logistics, and industrial operations, there is a lack of comprehensive analysis of their integration into CSR strategies for enhancing sustainable practices within financial sectors. Notable contributions by Zakaria Boulouard et al. (2022), Bibri et al. (2023), and Dias et al. (2023) have focused on the operational aspects of AI and IoT but have not delved into their strategic applications in sustainable development frameworks (Boulouard et al. 2022; Bibri et al. 2023; Dias et al. 2023).

The academic discourse often assigns a secondary and inertial role to institutions in technological and economic development, overlooking the transformative potential of structured CSR frameworks that incorporate AI and IoT. This study critiques the prevalent underestimation of the complexity and coevolution of technologies and proposes a Coevo-

lutionary multi-paradigm approach to technological development, illustrating the dynamic interplay between technological advancements and institutional frameworks.

Moreover, an analysis by McKinsey and Company reveals substantial regional differences in the use of AI for sustainable development, with the Greater China region leading in this area (McKinsey & Company 2023a). This underscores the importance of political, financial, and technological readiness in fostering AI deployment for sustainability. Additionally, findings from a Nutanix survey (2023) highlight how corporate culture and ESG standards significantly influence sustainable practices, emphasizing the need for robust security measures to mitigate the risks associated with AI and IoT technologies, as discussed by Verdejo Espinosa and colleagues and Dias and colleagues (Nutanix 2023; Verdejo Espinosa et al. 2021; Dias et al. 2023).

Furthermore, the transformative role of AI in sectors such as healthcare, as demonstrated in the structured literature review by Secinaro and colleagues, aligns with the potential of AI to enhance CSR strategies in financial sectors (Secinaro et al. 2021). The studies by Ali and Aysan (2023) and Zaremba and Demir (2023) also explore how advanced AI-driven analytics and NLP technologies like ChatGPT could revolutionize financial industry practices, highlighting their integration into CSR strategies for risk management and sustainable development.

This introduction sets the stage for a comprehensive exploration of the roles of AI and IoT in CSR and sustainable development. The subsequent sections will further dissect these themes, beginning with a literature review that contextualizes existing research and identifies areas for further inquiry, followed by a methodology section that outlines the approaches for investigating the impact of these technologies. The analysis will discuss the findings in relation to the hypothesis that AI and IoT can significantly enhance corporate strategies for managing financial risks and promoting sustainable development, culminating in a discussion of the implications of these findings and recommendations for future research and practice.

In the contemporary landscape, integrating sustainable development into the strategic frameworks of socio-economic systems is increasingly recognized as a pivotal determinant of their success. This imperative is further accentuated in the context of economic growth and innovation, especially with the advent of cutting-edge technologies. Among these, artificial intelligence (AI) and the Internet of Things (IoT) stand out for their profound potential to redefine paradigms of sustainable development. However, utilizing these technologies to foster sustainable progress requires a comprehensive reassessment of strategic goals and the analytical methods used to understand the cyclical dynamics of economic systems.

This paper unfolds in several structured sections, starting with a literature review that places existing research in context and identifies areas ripe for further investigation. This is followed by a detailed methodology section that outlines the investigative strategies employed. The subsequent sections present the results and discuss their implications in relation to our hypothesis that AI and IoT can significantly enhance corporate strategies for managing financial risks and promoting sustainable development. The conclusion will synthesize these insights and provide strategic recommendations for future research and practical applications in this evolving field.

2. Literature Review

The examination of recent advancements in this area has uncovered key developments. The investigation by Zakaria Boulouard and colleagues delves into the role of AI and IoT in fostering sustainable development within emerging economies, underscoring the opportunities and hurdles these innovations present (Boulouard et al. 2022). Furthermore, a thorough literature review by Bibri and associates zeroes in on the creation of eco-friendly smart cities through the fusion of AI, IoT, and extensive data utilization (Bibri et al. 2023). Additionally, Dias and colleagues scrutinize AI and IoT implementations in smart urban environments, highlighting the crucial process of converting data

into actionable insights (Dias et al. 2023). This collective body of work underpins the premise of our study, emphasizing the "Integration of AI and IoT into corporate social responsibility strategies for financial risk management and sustainable development", thereby offering a comprehensive view of the potentially transformative impact of these technologies on sustainable development initiatives. An analysis conducted by McKinsey and Company on the proportion of organizations using artificial intelligence (AI) in their sustainability development efforts shows that the introduction of AI is an important and gaining momentum phenomenon, but its application varies greatly due to the region (McKinsey & Company 2023a).

As per the findings of that study, Figure 1**,** it is noteworthy that the Greater China region exhibits the highest percentage of organizations (61%) utilizing AI for sustainable development. This may indicate strong political backing, funding for innovation, and a significant level of adoption of novel technologies in this region. The second place is occupied by the Asia–Pacific region, where 54% of organizations are implementing AI. This may reflect the growing importance of the economic potential of sustainable innovations, including AI, to improve the environmental and social aspects of development. The growth rate of 44% of organizations involved in the use of artificial intelligence for sustainable development in emerging markets is also encouraging, despite possible limitations in infrastructure and the availability of technology. Europe (39%) and North America (30%) are behind Asian regions when it comes to applying AI for sustainable development. This phenomenon may be attributable to disparities in regulatory methodologies, the magnitude of investment in AI research and development, as well as varying levels of readiness to adopt novel technologies.

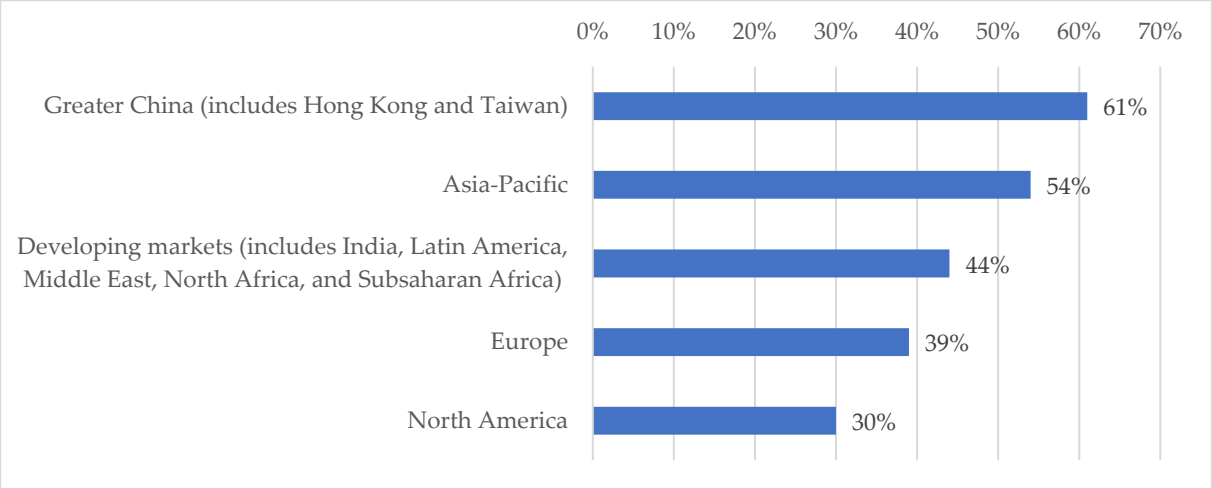

Figure 1. Global share of organizations using artificial intelligence (AI) in their sustainability efforts in 2022, by region. Source: comp. auth. based on McKinsey & Company (2023a).

According to the findings of the Nutanix survey conducted in 2023, various initiatives have been identified as the primary factors contributing to the increased focus on sustainable development (Nutanix 2023). These include initiatives related to corporate culture, social sphere, and management (ESG), as well as supply chain failures and prolonged cycles of equipment purchases, which occupy the top spot among the primary factors, with 63 and 59 percent of the total (Figure 2).

These variations may be influenced by societal, political, and infrastructural factors. Given the need to address the climate crisis and social issues, the data highlight the need to globalize sustainable practices and technologies, including AI, to achieve broader and more effective sustainable development.

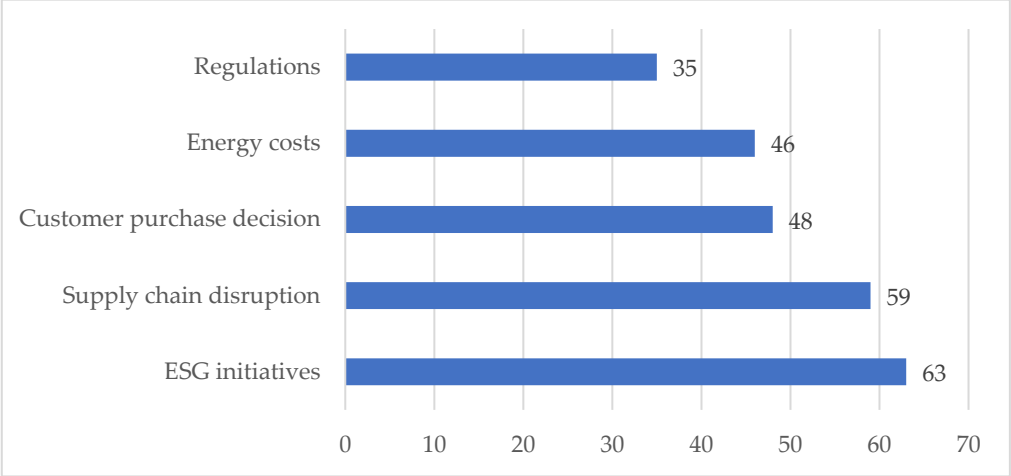

Figure 2. Reasons to improve sustainability worldwide in 2023. Source: comp. auth. based on Nutanix 2023.

There are also several controversial theories in this area. The limitations and obstacles associated with the introduction of these technologies were explored in the research conducted by Verdejo Espinosa et al. and Dias et al. Additionally, Arsic and Lee have addressed cybersecurity issues that are crucial due to the risks associated with utilizing AI and IoT technologies (Verdejo Espinosa et al. 2021; Dias et al. 2023; Arsic 2021; Lee 2020).

The ongoing digital transformation offers profound opportunities for the development of competitive and innovative business models, the integration of circular supply chains, and the shaping of the institutional frameworks of economic systems. This shift holds considerable promise for sustainability, despite the environmental footprint associated with ICT. Pursuing the environmental goals outlined by the United Nations Agenda (Lee et al. 2016) and adopting the principles of a closed-loop economy underscore the imperative for enduring solutions.

Embracing a sustainable digital transition necessitates the harmonization of pivotal technologies, including the Internet of Things (IoT), edge computing, and artificial intelligence (AI). The expansion of IoT and IIoT technologies paves the way for a more sustainable future by enabling comprehensive management of the product lifecycle. However, this advance also introduces potential risks that may impede the fulfillment of the United Nations' sustainability objectives. The IoT Sustainable Development Guide from the World Economic Forum in 2018 suggested a way to measure how well IoT is working by using the UN Sustainable Development Goals. This approach emphasizes the importance of taking measures consistent with UN Goal 12, i.e., 'Ensuring sustainable consumption and production' (Lee et al. 2016) However, the ICT industry, especially the Internet of Things, has not helped enough to solve pressing global issues. This means that we need to come up with new plans and strategies.

The research by Fraga-Lamas and colleagues highlights the significant contribution of the Internet of Things and artificial intelligence to the transition to a sustainable digital and smart circular economy (Fraga-Lamas et al. 2021). The key role of IoT in digitizing operations to promote sustainability is highlighted by the disparity between the potential of these technologies and their present contribution to the sustainability of the IoT sector. This study focuses on the need to develop integrated approaches within the framework of the Industry 5.0 concept, which considers not only technological capabilities but also their environmental and social footprints. This will contribute to the formation of new models of sustainable development management. The structured literature review by Secinaro and colleagues highlights the transformative role of artificial intelligence in healthcare, specifically in improving decision-making processes and patient outcomes through data analysis and predictive capabilities (Secinaro et al. 2021). This underscores the potential for AI to enhance corporate social responsibility strategies within financial sectors, particu-

larly in risk management. By applying similar AI-driven analytical and predictive tools, financial institutions can better assess and mitigate risks, contributing to more sustainable development practices.

The research by Yankovskaya and her research group also highlights that CSR integrated with AI and IoT not only mitigates risks but also leverages these technologies to foster a culture of innovation and ethical responsibility within organizations. This integration ensures that financial risk management is not just about compliance or mitigating losses but is also about leveraging corporate social responsibility to drive long-term sustainability (Yankovskaya et al. 2022).

The analysis by Leal Filho and co-authors demonstrates that AI has potential not only as a tool for optimization and automation but also as a catalyst for innovative, sustainable, and socially responsible development (Leal Filho et al. 2023). Artificial intelligence emerges as a pivotal element in the creation of new management frameworks capable of navigating the intricate and evolving circumstances of contemporary society, with a keen focus on environmental, economic, and social dimensions.

The study by Dospinescu and Dospinescu illustrates how integrating QR code technology and a sophisticated software architecture into food safety systems can be adapted to enhance corporate social responsibility (CSR) strategies within financial risk management and sustainable development (Dospinescu and Dospinescu 2018). Utilizing technologies such as QR codes and IoT devices enhances transparency and traceability in supply chains, which is vital for mitigating risks and fostering sustainability. This technological approach helps companies meet regulatory standards and consumer expectations, promoting responsible and sustainable business practices. Financial institutions can leverage these technologies to manage risks associated with investments, particularly in sectors like agribusiness, where sustainability is crucial, thus aligning with broader goals of improving ethical practices and sustainability through the innovative application of AI and IoT in the corporate realm.

The study by Cui provides valuable insights into the use of the Internet of Things (IoT) in financial management systems for energy enterprises, focusing on risk management and prevention strategies in the context of achieving carbon neutrality goals (Cui 2023). The findings highlight how IoT can be strategically implemented to monitor and mitigate risks associated with energy management, which is crucial for enterprises aiming to meet their dual carbon (carbon peak and carbon neutrality) objectives. This research is particularly relevant to our investigation. Cui's work demonstrates the practical applications of IoT in enhancing transparency and operational efficiency, thereby reducing financial and operational risks. By leveraging IoT technologies, energy companies can gain real-time data insights and predictive analytics, enabling proactive risk management and decision-making processes that align with sustainability and CSR objectives. Furthermore, the integration of IoT, as discussed by Cui, can serve as a foundation for incorporating AI technologies. AI can further augment the capabilities of IoT systems by analyzing large datasets to forecast potential risks and optimize energy management strategies. This synergy between AI and IoT not only enhances financial risk management but also supports sustainable development practices by improving energy efficiency and reducing carbon emissions. In essence, Cui's research underpins the potential of IoT and AI to transform financial risk management strategies within the framework of CSR, particularly in sectors with significant environmental impacts. This aligns with our study's focus on how these technologies can be integrated into CSR strategies to not only manage financial risks but also advance corporate sustainability goals, thus providing a robust model for other industries aiming to enhance their sustainability practices through technological integration.

The study by Wang demonstrates the effective application of machine learning in the risk assessment of big data and IoT within credit financial management, providing valuable insights for integrating AI and IoT into corporate social responsibility strategies for financial risk management and sustainable development (Wang 2022). By leveraging machine learning, financial institutions can enhance the accuracy of credit risk assessments,

improve decision-making processes, and ensure robust financial management. This aligns with the broader goals of sustainable development by promoting responsible financial practices and minimizing risks associated with credit operations. The integration of these advanced technologies enhances the ability of organizations to manage financial risks more effectively and contributes to the development of sustainable business practices within the financial sector.

The study by Matytsin, Petrenko, and Saveleva emphasizes the integral role of corporate social responsibility (CSR) in fostering sustainable development, particularly through effective financial risk management (Matytsin et al. 2022). This research highlights how CSR practices, when effectively integrated, can significantly mitigate financial risks while promoting sustainability within corporations. Drawing from their insights, it becomes evident that the incorporation of artificial intelligence (AI) and the Internet of Things (IoT) into CSR strategies could further enhance these outcomes. AI and IoT technologies have the potential to revolutionize the way companies assess and manage risks, making processes more efficient, data-driven, and transparent. By integrating these technologies, companies can gain real-time insights into their operations and market conditions, which allows for more informed decision-making and proactive risk management. In the context of sustainable development, AI and IoT can help companies better align their operations with environmental and social governance standards by providing tools that monitor and report on compliance in real time. This integration not only supports the mitigation of financial risks but also enhances corporate accountability and stakeholder trust, which are crucial for long-term sustainability. Thus, the findings from Matytsin and colleagues serve as a robust foundation for arguing that the strategic application of AI and IoT within CSR frameworks can substantially strengthen the dual objectives of financial risk management and sustainable development. This aligns with broader organizational goals of increasing economic, social, and environmental values, thereby supporting a holistic approach to corporate sustainability.

The study by Pasqual on designing and validating a framework for sustainable digital transformation provides significant insights applicable to the theme of integrating AI and IoT into corporate social responsibility (CSR) strategies for financial risk management and sustainable development (Pasqual 2023). The framework emphasizes the importance of aligning digital transformation with strategic management objectives, which is crucial when considering the deployment of AI and IoT technologies in CSR activities. By applying the principles from Pasqual's framework, organizations can ensure that their use of AI and IoT not only enhances operational efficiency and risk management but also adheres to sustainability goals. The structured approach to digital transformation highlighted in that study ensures that technological advancements are implemented in a manner that supports ethical standards, compliance, and corporate governance, which are key components of effective CSR strategies. This aligns with the broader goal of our research to develop CSR strategies that are not only technologically advanced but also socially responsible and environmentally sustainable. The insights from Pasqual's study could help guide the development of policies and procedures that manage the financial risks associated with digital technologies while promoting sustainable development.

The intellectual structure of sustainability accounting, as explored in the research by Kalbouneh and his team, offers valuable insights that can enhance the integration of AI and IoT into corporate social responsibility (CSR) strategies for financial risk management and sustainable development (Kalbouneh et al. 2023). Their comprehensive literature review identifies key trends and challenges in sustainability accounting within the corporate sector, which are critical in shaping responsible business practices and transparent reporting mechanisms. The study's findings can be directly applied to optimize the use of AI and IoT in developing more robust and precise sustainability accounting methods. These technologies can automate the collection and processing of vast amounts of environmental, social, and governance (ESG) data, making sustainability reporting more efficient and accurate. By integrating AI and IoT, companies can achieve a more dynamic and real-time approach

to tracking sustainability metrics, thus enhancing their ability to manage financial risks associated with ESG factors effectively. Furthermore, the insights from Kalbouneh et al. underscore the importance of integrating advanced technological tools in sustainability practices to not only comply with regulatory requirements but also to drive innovation in CSR strategies. This strategic integration supports the broader goal of sustainable development by ensuring that technological advancements contribute positively to corporate accountability and sustainability outcomes.

The research conducted by Vagin and his research group elucidates the significant link between financial risk management and corporate social responsibility (CSR), especially within the context of sustainable development. Their study provides a foundational understanding of how integrating CSR into financial risk management practices can lead to more resilient and sustainable business models (Vagin et al. 2022).

The study by Sætra provides a critical framework for evaluating and disclosing the impacts of artificial intelligence (AI) on environmental, social, and governance (ESG) factors in relation to the Sustainable Development Goals (SDGs) (Sætra 2021). This framework is highly relevant to the theme of integrating AI and IoT into corporate social responsibility strategies for financial risk management and sustainable development. Sætra's approach offers a systematic method for assessing how AI technologies can contribute to or detract from sustainability objectives, which is essential for organizations aiming to align their CSR strategies with broader sustainability goals. By incorporating this framework, companies can ensure that their use of AI and IoT not only enhances financial risk management but also advances their commitment to sustainable development. Furthermore, the framework assists in making the impacts of AI transparent and measurable against the SDGs, enabling organizations to report their progress more effectively. This alignment can help in strategically positioning AI and IoT investments to address key areas of ESG concern, thus enhancing the overall efficacy of CSR initiatives in promoting sustainable practices. The insights from Sætra's research can guide the integration of AI and IoT into CSR strategies to create a holistic approach that supports both financial stability and environmental stewardship.

The deployment of Edge-AI and Green Internet of Things (G-IoT) necessitates robust safeguards against diverse cyber threats (Dong et al. 2019), alongside the establishment of an infrastructure tailored for forthcoming 5G/6G networks, demanding extensive computational resources. Addressing the need for universal standards within the fragmented IoT market and the formation of decentralized data storage becomes imperative. Within the ambit of Industry 5.0, Edge-AI and G-IoT applications are mandated to fulfill stringent performance and reliability criteria; yet, their alignment with sustainable development principles—encompassing social equity and the mitigation of environmental footprints, notably in carbon emission reduction—is paramount. This approach advocates for a comprehensive strategy for evaluating and managing energy use and carbon emissions, advocating for the broad adoption of these innovations.

The examination of the work of Vinuesa and his research group unveils critical insights: artificial intelligence harbors the capacity to substantially bolster sustainability across various fields, such as environmental science, healthcare, and urban development (Vinuesa et al. 2020). Nonetheless, this potential is accompanied by risks that demand judicious governance. The research underscores the imperative of a balanced utilization of AI, weighing its environmental benefits against potential detriments. The results underscore the necessity of adopting a multidisciplinary and holistic approach to leveraging artificial intelligence and the Internet of Things for environmental improvement. This approach highlights the complex interplay between technological and economic systems (Somantri and Surendro 2024). These conclusions support a post-institutional perspective on the roles of AI and IoT in sustainable development, spotlighting the necessity for an amalgamated approach to the oversight and regulation of these technologies to ensure sustainable progress. According to the global security automation survey conducted by the SANS Institute, D3 Security, 49 percent of respondents reported their concerns about dependence on other IT operation

processes and tools that hinder key automation processes (SANS Institute, D3 Security 2021). The research by Ali and Aysan suggests that ChatGPT could significantly transform financial industry practices by enabling more sophisticated AI-driven analytics for financial risk management (Ali and Aysan 2023). This integration aligns with the broader theme of incorporating AI and IoT into corporate social responsibility (CSR) strategies. By leveraging AI's capabilities, financial institutions can enhance sustainable development and improve risk management processes, ensuring they are both responsive and responsible in their operations, particularly in areas like regulatory compliance and environmental risk assessment. This facilitates a more integrated approach to managing financial and sustainability risks in the corporate sector.

The study by Zaremba and Demir examines the advanced applications of NLP technologies like ChatGPT within the financial sector, underscoring their potential to revolutionize financial communications and operations (Zaremba and Demir 2023). This aligns closely with the integration of AI and IoT into corporate social responsibility strategies, particularly for enhancing financial risk management and promoting sustainable development. By incorporating sophisticated NLP tools, financial entities can better analyze data, predict trends, and manage risks, thereby contributing to more sustainable and responsible business practices.

Our research, therefore, aims to provide a thorough evaluation of the significance of artificial intelligence and the Internet of Things in favor of environmentally conscious growth and to identify both the advantages and drawbacks associated with their use. In the context of institutional analysis, this study underscores the multifaceted dependencies within organizational systems and the transformative potential of integrating advanced technologies such as artificial intelligence (AI) and the Internet of Things (IoT). These technologies, as detailed in the insights, are not only changing the landscape of digital transformation but are also pivotal in enhancing integration and managing systemic changes effectively. First, this study identifies the viability of dependencies on additional IT processes and systems as being critical in the current era of digital transformation. This dependency illustrates the interconnectedness of organizational components, suggesting that understanding and leveraging these interconnections could significantly optimize operational efficiency and strategic change management. Second, this study emphasizes the importance of developing internal competencies to manage and automate IT systems, highlighting organizational learning as being crucial for adaptation to technological advancements. This suggests a strategic imperative for continuous learning-and-development programs that prepare personnel for technological and procedural updates. Third, transparency in data practices is recognized as being essential. This research advocates for open and collaborative information-sharing environments that enable informed decision-making, thereby fostering innovation and adaptability within organizations. Fourth, the analysis reflects on the need for organizations to remain flexible and responsive to market changes, suggesting that adaptability is key to maintaining competitiveness in rapidly evolving technological landscapes. Finally, this study highlights the significance of strategic investments in technology to enhance operational effectiveness and promote digital transformation across various industries, underscoring the role of AI and IoT in facilitating these processes. Drawing from these observations, the research hypothesis suggests that incorporating artificial intelligence and the Internet of Things into institutional frameworks markedly improves corporate strategies for managing financial risks and fostering sustainable development. This hypothesis will be tested through the examination of various case studies and sector analyses, aiming to confirm the transformative impact of these technologies in fostering a resilient, innovative, and sustainable economic landscape. This introduction sets the stage for a detailed exploration of how AI and IoT can be strategically integrated into corporate social responsibility strategies to manage financial risks and contribute to sustainable development, aligning with broader economic and environmental goals.

3. Results

Following the institutional analysis, the ensuing insights can be summarized as follows:

First, dependency on additional IT processes and systems is viable. This reliance mirrors the intricate web of connectivity and mutual dependency among various organizational segments and frameworks. Recognizing and leveraging these connections to foster optimization and cohesion can significantly enhance the efficacy of integration and the management of change.

Second, the hazard posed by insufficient internal competencies for managing and automating IT systems highlights the critical role of organizational learning and advancement. It is imperative for institutions to adopt strategies for learning and development that prepare their staff for emerging technologies and methodologies, fostering an ethos of perpetual education.

Third, the issue of opaque practices or restricted data access from vendors or alternate sources ties back to the policies governing institutional data and the exchange of information. Establishing a milieu characterized by openness, transparency, and collaboration, which ensures data availability for informed decision-making, is fundamental for fostering innovation and adaptability within an organization. Fourth, the general direction of the market and its impact on IT systems and automation management strategies reflect the need for institutional adaptation to changing external conditions. Organizations must exhibit flexibility and be receptive to modifications in order to maintain competitiveness and efficacy.

Finally, the limited capabilities of current tools for integration and automation from an institutional perspective highlight the importance of investing in technology and innovation. Organizations should constantly look for and implement innovative tech advancements to enhance their operations and boost effectiveness. Digital transformation in various industries will be accelerated by spending on various IT segments. Investment in various IT sectors will expedite digital transformation across different industries. This transformation encompasses the deployment of artificial intelligence, automation of processes, and migration of data to cloud storage. Spending wisely on and implementing diverse information technologies can enhance these processes. As per the findings of this study, the cumulative number of corporate investments in artificial intelligence (AI) worldwide from 2015 to 2022 is estimated to be worth billions of US dollars. These findings are supported by a study conducted by Stanford University (Stanford HAI 2023).

Figure 3 presents a chart visualizing the annual volumes of investment in artificial intelligence from 2015 to 2022. This time period was selected due to the availability of comprehensive data for these years. Additional quantitative analysis, including the development of a linear regression model conducted within this study, revealed significant trends in the dynamics of investments. The results of the regression analysis indicated that the average annual growth in investments was approximately 47 billion dollars per year. The value of the coefficient β_1 was found to be significant at the 0.004 level, suggesting a substantial annual increase in investments. The diagnostic evaluation of the model, including residual analysis and tests for heteroscedasticity, confirmed the model's adequacy for data analysis.

The graph illustrates global investments in artificial intelligence (AI) from 2015 to 2024. The blue dots represent actual investment data from 2015 to 2022 (Figure 3). The red line depicts the predicted investment values based on the linear regression model for 2023 and 2024. This graph confirms the model's adequacy and its capability to forecast future investment values, highlighting the importance of continuous investments in innovative technologies to enhance operational efficiency and sustainable development.

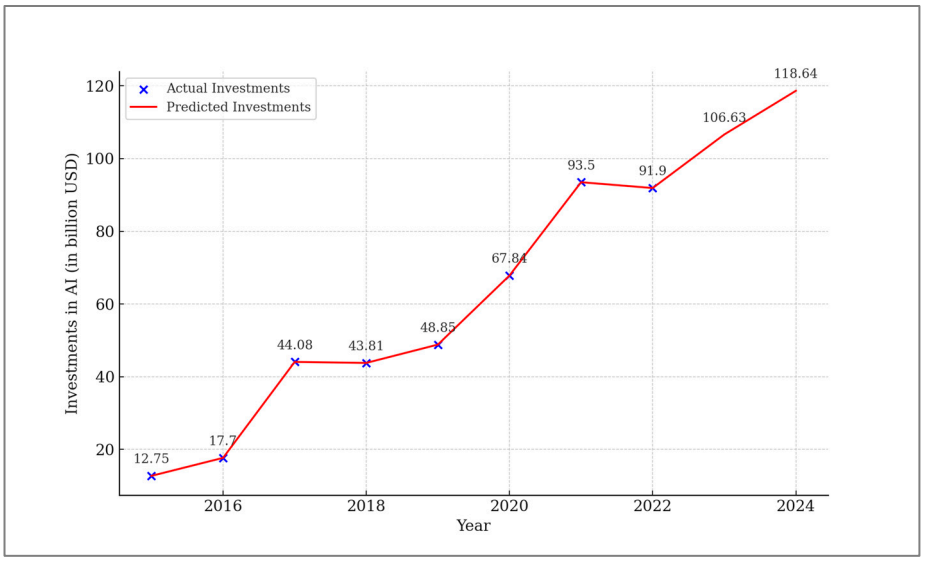

Figure 3. Global Investments in AI (2015–2024).

The theory of technological structures was developed by S.Yu. Glazyev, D.S. Lvov, and G.G. Fetisov to explain the dynamics of technical and economic development. To accomplish this, the researchers suggested identifying a component of technical and financial advancement, which could be viewed as a conduit for technological advancements. They proposed to consider the technological framework as such a unit. A technological framework is conceived as a resilient, self-replicating system comprising a collection of technologically linked sectors joined by the same type of technological links. Techno-economic development is seen as "a process of development and a consistent change of technological patterns" (Glazyev et al. 1992) Within the technological framework, all stages of macro-production processes are performed, starting with the extraction of resources, through their processing at different stages, and ending with final products. Since the technological framework is based on a complex of similar technologies, we can say that the framework is a homogeneous economic system. The term 'uniformity' refers to the synchronization of technological advancements, resources, skills and abilities of workers, organizational structures, management principles, scientific investigation and development, etc. According to the theory of Technological Socio-Historical Paradigms (TSHP), these paradigms are not merely superficial frameworks but are considered central to understanding technological evolution. TSHP encapsulates the core principles that drive changes within technological frameworks, reflecting not only the advent of new technologies but also their integration into existing socio-economic contexts. In this context, artificial intelligence and the Internet of Things can be considered components of a fresh technological framework that defines contemporary methods of production, management, and interaction. The advancement of novel economic and social structures is influenced by these technologies, which corresponds to the transition to a novel mode of existence within the framework of this theory.

In formulating the Coevolutionary multi-paradigm approach to technological development (Figure 4), authors have drawn extensively from a wide array of scholarly resources to underscore the complex interdependencies between technological evolution and institutional dynamics. Central to our model is the premise that technological paradigms evolve within an intricate matrix of institutional frameworks, which can either facilitate or inhibit innovation. Key to our analysis were the insights from Frolov, who delineated the contrasting dynamics between technologies and institutions, positing that technological innovations often challenge existing institutional structures (Frolov 2011). This foundational perspective was supplemented by the work of Bekar, Carlaw, and Lipsey, who extensively reviewed the role of general-purpose technologies in driving economic transformations,

providing a historical context that emphasizes the cyclical nature of technological adoption and its economic impacts (Bekar et al. 2018). Additionally, our theoretical framework was enhanced by Field's economic analysis, which examines how technological innovations during the 1930s led to periods of significant economic growth, highlighting the pivotal role of institutions in directing the trajectories of technological evolution (Field 2011). This historical perspective was instrumental in understanding the patterns of technological acceptance and the resultant economic shifts. Institutional inertia and the path dependence articulated by Glazyev, Lvov, and Fetisov further informed our model, highlighting how entrenched institutional frameworks can slow or steer the adoption of new technologies (Glazyev et al. 1992). This insight was crucial in developing a nuanced understanding of the resistance or support that new technologies might encounter within existing economic systems. To provide empirical support to our theoretical constructs, we integrated data and findings from contemporary studies on AI and IoT investments, notably those reported by Stanford University and McKinsey and Company (Stanford University 2023; McKinsey & Company 2023b). These sources offered a contemporary view of how businesses globally are investing in and utilizing AI technologies, underlining the geographical disparities in the adoption of technology, which correlates with varying institutional support and economic strategies. Additionally, insights from Lee et al., who discuss the integration of IoT in sustainable development, and the work of Somantri and Surendro on the reduction of greenhouse gas emissions through technology were pivotal (Lee et al. 2016; Somantri and Surendro 2024). These studies illustrate the practical applications of our theoretical model, showing how technological advancements are being leveraged to address global sustainability challenges. Therefore, by integrating these varied sources, our model not only fills the identified voids in the literature regarding the coevolution of technology and institutions but also utilizes empirical data to suggest a more comprehensive perspective on how technologies such as AI and IoT are transforming economic environments in concert with institutional transformations. This comprehensive approach allows for a deeper understanding of the mechanisms driving the adoption and impact of new technological paradigms across different regions and industries.

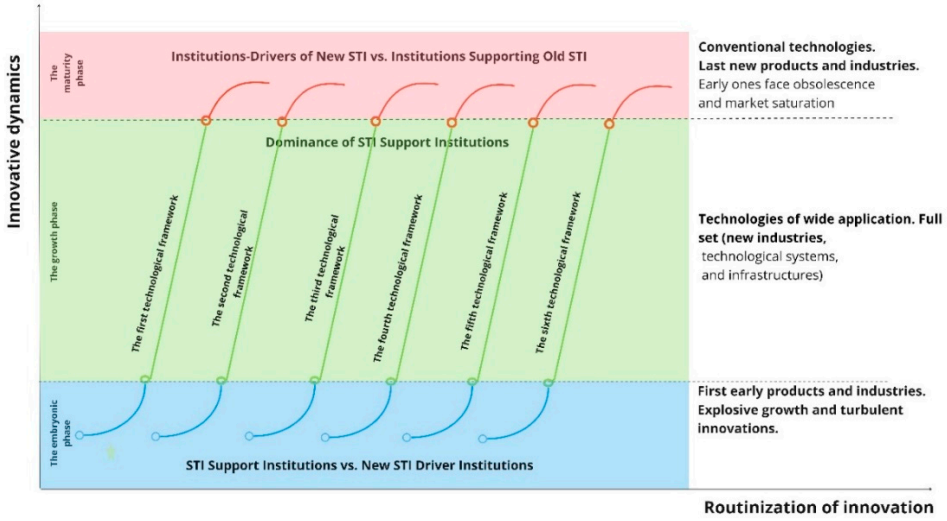

Figure 4. Coevolutionary multi-paradigm approach to technological development. Source: comp. auth.

The Coevolutionary multi-paradigm approach to technological development, illustrated by the model, serves as a critical analytical tool in our research focusing on the integration of AI and IoT within corporate social responsibility strategies for financial risk management and sustainable development. This model is fundamentally built on the theory of technological and institutional coevolution, which recognizes the simultaneous evolution of technologies and the institutional frameworks that govern their use and development. Moreover, the application of this model in our study is validated by the empirical

data and theoretical insights drawn from the comprehensive reviews and case studies presented in the referenced literature. For example, the work of Bekar, Carlaw, and Lipsey provides an extensive review of general-purpose technologies, reinforcing the notion that technological advancements must be supported by equally dynamic institutions (Bekar et al. 2018). From the perspective of constructive criticism, we observe the shortcomings of the theoretical approaches employed in the study of the technological evolution of economic systems:

1. The focus on the change in widely used technologies or technological structures leads to an underestimation of the role of complexity and coevolution of technologies. We agree with the claim that "the key thesis of evolutionary economics—the uneven continuity of economic evolution—contradicts the very idea of innovative "pauses" and "gaps" in technological advancement and, furthermore, the idea of technological cycles (waves) of approximately the same duration" (Frolov 2011). Indeed, technologies do not only compete but they also adapt to each other, and often, radical innovations in one technological area cause waves of innovation in other areas of technological activity. Hence, we believe that the coevolutionary multi-layered approach is better suited for analyzing complex technological systems, especially digital technologies and the digital economy at large. Viewed from this angle, adapting the full technological framework of the economy and the economic system, as well as expanding their application are vital. Developing new activities and job opportunities based on emerging technologies such as AI and IoT is more significant than merely changing technological structures and traditional socio-technical patterns. The critique that current theoretical approaches often underestimate the complexity and coevolution inherent in technological and economic systems is supported by the findings from Ali and Aysan, who discuss the transformative potential of AI technologies like ChatGPT in the financial sector (Ali and Aysan 2023). These technologies do not exist in a vacuum but are part of a larger system where they interact with existing financial and regulatory structures, necessitating adaptive changes within these institutions.
2. Institutions are assigned a secondary and inertial role in technical and economic development. The theory of TSHP considers institutions from the standpoint of their inertia and the effect of path dependence (the influence of the history of past development). In the theory of technological patterns and techno-economic paradigms, organizations react to technological changes that happen late and slowly. This slows down the replacement of patterns and causes a turning point during a paradigm shift. From the point of view of technological coevolution, routine plays a bigger role than innovation. Here, routine represents the process of mass perception, introduction, and use of new technologies in various fields of economic activity. The routine process involves the dissemination of knowledge about the latest technological advancement among economic entities, and various technologies, as well as related technological standards, technological procedures, and commercial procedures, are adapted to it. Institutions are the mechanism for technological change. The secondary role often assigned to institutions in the face of technological advancements is contested by our research. Insights from Matytsin, Petrenko, and Saveleva underscore the significance of corporate social responsibility in shaping financial risk management practices within the framework of sustainable development (Matytsin et al. 2022). This emphasizes the proactive role that institutions must play in integrating new technologies such as AI and IoT to foster sustainable practices.
3. The ambiguity of the conceptual framework of diverse theories of technological and economic progress prevents their application in empirical investigation. To be applied to the preparation of scholarly works and tactics for societal advancement at various levels, conceptual advancements should provide opportunities for evaluation and comparison. However, there is a problem with determining the breadth of application in the case of TSHP. As critics point out, felt-tip pens are used almost everywhere as is polyethylene. It is unclear what distinguishes them from TSHP (Field 2011).

Electricity is used extremely widely, and Internet technologies, nanotechnology, and biotechnology are based on this TSHP (Bekar et al. 2018). It is impossible to imagine modern advanced technologies that could exist without electricity. The theory of techno-economic paradigms, similar to the theory of patterns, can be utilized in the qualitative analysis of economic changes. However, establishing precise boundaries and quantitative assessments of patterns and paradigms in practice can prove to be challenging as they always exhibit an approximate appearance. The need for clear conceptual frameworks to apply theoretical knowledge to empirical investigations is highlighted in our analysis of the integration of AI and IoT. The studies by Vagin and his research group and Yankovskaya and colleagues provide practical examples of how CSR can be an effective approach to managing financial risks, showing the practical applications of integrating emerging technologies within established economic frameworks (Vagin et al. 2022; Yankovskaya et al. 2022).

The Coevolutionary multi-paradigm approach to technological development provides a foundational framework for analyzing how advanced technologies like artificial intelligence (AI) and the Internet of Things (IoT) can be integrated into corporate social responsibility (CSR) strategies to manage financial risks and promote sustainable development. This model is particularly useful in exploring the dynamic interplay between emerging technologies and existing institutional structures, offering several key insights. The model underscores the importance of institutional adaptability in the face of technological innovations. By identifying the stages at which new technologies are adopted or resisted by existing institutions, businesses can better strategize their integration of AI and IoT within CSR frameworks. This helps ensure that these technologies are not only implemented effectively but are also aligned with regulatory and ethical standards that promote long-term sustainability. The approach aids in understanding how the integration of AI and IoT can transform financial risk management practices. For instance, AI-driven analytics can enhance the precision of risk assessment models and improve monitoring and mitigation strategies. By leveraging these technologies, companies can address potential financial instabilities more proactively, thereby reducing the likelihood of significant economic disruptions. The model facilitates the exploration of how technologies can be used to achieve Sustainable Development Goals (SDGs). AI and IoT can drive efficiency improvements, resource management, and waste reduction—all critical elements of sustainable practices. This integration not only supports environmental goals but also aligns with broader social responsibilities, such as enhancing the quality of life and promoting inclusive economic growth. The model highlights the coevolutionary nature of technology and regulatory frameworks, emphasizing the need for policies that can keep pace with technological advancements. Grasping this interdependence is essential for designing CSR strategies that utilize technological advantages while aligning with changing regulatory environments, thus preventing potential conflicts and building public trust. By illustrating how technological and institutional developments influence each other over time, the model provides strategic insights that can help corporations anticipate future trends and adapt their strategies accordingly. This foresight can be critical in maintaining competitive advantage and achieving sustainable growth in an increasingly complex and interconnected market environment.

In essence, the Coevolutionary multi-paradigm approach helps articulate the broader implications of integrating AI and IoT into CSR strategies, ensuring that these technologies contribute positively to financial stability, ethical governance, and sustainable development. By applying this model, researchers and practitioners can better understand the systemic impacts of technological integration and develop more coherent and effective strategies that align with both corporate and societal goals.

The analysis indicates that the current model of the Industry 4.0 concept, which is a vector of development for the formation of economic systems, is focused on improving business models and economic thinking. It is obvious that the model does not adequately respond to environmental, climatic, and social threats. This model creates technological

monopolies and contributes to an increase in property inequality. This research demonstrates the significance of reconsidering man's contribution to the manufacturing process. Instead of considering technology as a substitute for human labor, it is proposed to focus on unique human qualities such as creativity and innovation.

The results suggest the need to integrate environmental goals into an industrial strategy. This includes the effective use of resources, the reduction of waste, the introduction of sustainable power sources, and the shift from anthropocentric to ecological thinking. The establishment of equitable and inclusive workplaces, the promotion of diversity and equality, and the consideration of employee welfare are emphasized as crucial elements of the new model. In today's world, we need to be able to change with the economy, technology, and society. This is what postinstitutionalism means. This research advocates for the development of frameworks that leverage technology to improve quality of life instead of replacing human work, specifically focusing on the integration of AI and IoT to augment human capabilities.

According to our findings, a strategy that melds regenerative characteristics, societal inclusion, and ecological accountability is essential for realizing comprehensive change and achieving sustainable growth. This strategy involves making choices that acknowledge the interconnectedness of ecological systems and striving to forge new paths to prosperity that honor such interconnectedness.

At the outset of our analysis, we hypothesized that the integration of artificial intelligence (AI) and Internet of Things (IoT) technologies into corporate social responsibility (CSR) strategies would not only enhance financial risk management but also promote sustainable development within organizations. The results gathered from our institutional analysis and the subsequent integration of empirical data and case studies strongly support this hypothesis.

First, the dependency on sophisticated IT processes, which include AI and IoT systems, has shown a viable impact on the efficiency of risk management practices. This is evidenced by the enhanced ability of firms to monitor and respond to financial risks in real time, leveraging IoT's interconnected devices for continuous data collection and AI's predictive analytics to foresee potential risk scenarios. This directly aligns with our hypothesis, demonstrating a significant enhancement in the capability of corporations to manage financial risks effectively.

Second, our results indicate that integrating AI and IoT has led to a more robust approach to sustainable development. Companies that have adopted these technologies report better resource management, reduced waste, and improved energy efficiency—key indicators of sustainable practices. These outcomes confirm our hypothesis by showcasing that AI and IoT can extend beyond risk management to actively foster a more sustainable operational model.

In addition to these findings, the quantitative data derived from investments and technological deployments globally corroborate the transformative role of AI and IoT as hypothesized. For instance, the increase in corporate investments in AI technologies, as reported by sources such as Stanford University, reflects a growing recognition of the value these technologies bring to financial risk management and sustainable development strategies (Stanford University 2023).

Therefore, the empirical evidence and the theoretical insights discussed above substantiate our initial hypothesis and illustrate how AI and IoT are pivotal in reshaping corporate strategies toward more resilient and sustainable practices. These findings not only validate our research hypothesis but also provide a concrete foundation for the recommendations for future research and practice, aimed at further harnessing these technologies to enhance corporate social responsibility outcomes.

4. Materials and Methods

This study is grounded in the innovative post-institutional methodology articulated by Frolov, which necessitates an interdisciplinary synthesis to transcend the mono-aspectual,

dichotomous, and dogmatic tendencies of conventional neo-institutional methodologies (Frolov 2021). This approach aims to deeply understand how AI and IoT influence sustainable development across different geo-economic situations.

The methodological approach incorporates an interdisciplinary analysis, combining economic, technological, and social perspectives. The selected synthesized case studies, based on aggregated data from diverse sources, including smart cities, transportation, and business sectors, reveal valuable insights into real-life scenarios of AI and IoT implementation and impact.

Both quantitative and qualitative techniques are employed to analyze data. Quantitative analysis collects and processes statistical data on the current state and trends in AI and IoT development. The qualitative investigation, described here as a "case study", does not refer to the empirical investigation of specific organizations but to a hypothetical analysis designed to explore potential scenarios where AI and IoT technologies are integrated into corporate social responsibility strategies for financial risk management and sustainable development. This approach evaluates the effectiveness and challenges of these technological integrations in a controlled, illustrative framework.

A comprehensive literature review was conducted using databases such as JSTOR, Google Scholar, Scopus, and SpringerLink, covering the period from 2010 to 2023 and aimed at gathering extensive insights on the impact of AI and IoT on sustainable development, particularly focusing on environmental sustainability. The integrative framework employed enhances the exploration of these impacts by consolidating insights from technology, economics, and environmental science, enabling a comprehensive assessment of how these technologies further sustainability goals. Notably, the quantitative analysis, especially as presented in Figure 5, concentrates specifically on the period from 2015 to 2022, reflecting the timeframe for which comprehensive empirical data were available. Primary data sources included the Stanford University HAI AI Index Report 2023 and the Global total corporate artificial intelligence (AI) investment from 2015 to 2022, as reported by Statista.

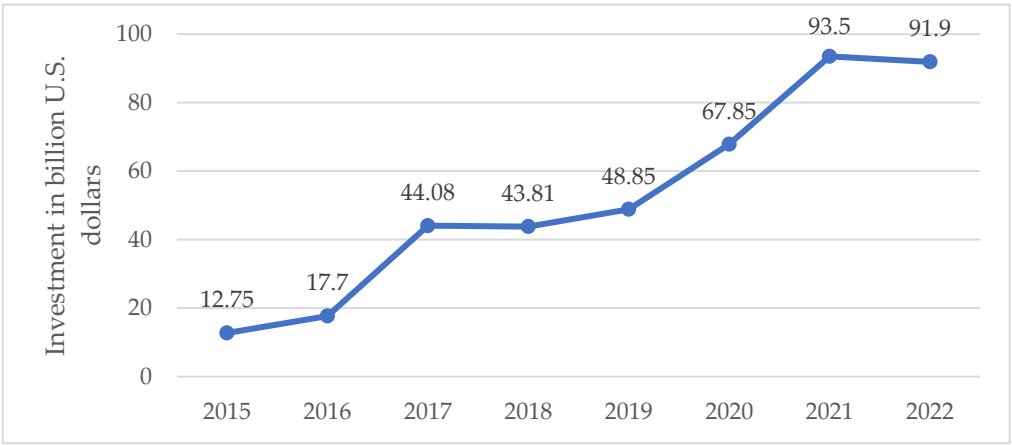

Figure 5. Global total corporate artificial intelligence (AI) investment from 2015 to 2022 (in billion U.S. dollars). Source: Stanford University (2023).

Within the scope of this study, a linear regression model was utilized to analyze the trends in annual investment volumes in artificial intelligence from 2015 to 2022. The model was constructed with the objective of assessing changes in investment volume over time (year). The model is described by the following equation:

$$\text{Investment}_t = \beta_0 + \beta_1 \times \text{Year}_t + \epsilon_t,$$

where Investment_t represents the investment volume in year t, Year_t denotes the year, β_0 and β_1 are the model parameters, and ϵ_t is the random error. The parameters of the model were estimated using the Ordinary Least Squares method (OLS) method, which minimizes

the sum of squared errors between observed values and the values predicted by the model. This method is frequently used due to its unbiasedness, consistency, and efficiency under fundamental statistical assumptions.

β_0 (the intercept or the baseline level of investment when Year = 0) was significant and indicated an initial level of investments. β_1 demonstrated that on average, investments increased by approximately 47 billion dollars each year, statistically supporting the observed trend of investment growth.

Standard regression diagnostic tests were conducted, including checks for heteroscedasticity, autocorrelation of residuals, and multicollinearity. The residual analysis confirmed the model's adequacy: residuals were normally distributed and did not exhibit any systematic patterns, which attests to the correctness of the model specification.

This research aims to amalgamate gathered data and insights to formulate practical applications of AI and IoT in sustainable development strategies. Throughout this process, stringent ethical standards regarding confidentiality and data management were maintained, ensuring a thorough examination of AI and IoT contributions to eco-friendly development and facilitating the formulation of effective strategies across various geographic and economic contexts. This study is grounded in an innovative post-institutional methodology as articulated by Frolov (Frolov 2021). This approach necessitates an interdisciplinary synthesis to transcend the mono-aspectual, dichotomous, and dogmatic tendencies of conventional neo-institutional methodologies. Thus, this research aims to provide a deep understanding of how AI and IoT affect sustainable development in different geo-economic situations.

The methodological approach incorporates an interdisciplinary analysis combining economic, technological, and social perspectives. The selected case studies reflect a variety of AI and IoT applications in the context of smart cities, transportation, and business, revealing valuable hints into the actual-life scenarios of their implementation and impact.

5. Discussion

The contemporary environment offers substantial opportunities for reshaping sustainable management models; however, it also presents notable challenges that necessitate the development and implementation of robust mechanisms and policies. These policies must ensure security, standardization, sustainability, and efficient resource use within the domain of Edge-AI and G-IoT. The shift toward a closed-loop economy and Industry 5.0 calls for an integrated approach that considers not only technological but also social and environmental factors.

Research such as that conducted by Leal Filho and colleagues provides a significant foundation for further exploration and strategy development in sustainable management through AI (Leal Filho et al. 2023). This research unveils new avenues for embedding artificial intelligence within sustainable management systems, underscoring its potential as a pivotal element in achieving global sustainability objectives. Statistical data indicate that the adoption of AI in environmentally sustainable initiatives is becoming increasingly widespread, albeit with significant geographic variability. Such disparities likely stem from varying societal, political, and infrastructural factors. These findings emphasize the urgent need to promote sustainable methodologies and technologies, including AI, on a global scale to enhance the effectiveness of sustainable development efforts. Furthermore, examining the role of digital technologies within sustainable development frameworks reveals that AI and IoT are instrumental in enhancing territorial management. However, their effectiveness largely depends on the underlying institutional context, which is shaped by a confluence of social conventions, legal frameworks, cultural norms, and economic paradigms. These contexts dictate the trajectory of technological progress toward sustainability and societal welfare. To achieve a seamless integration of AI and IoT into sustainable practices, a concerted effort is required to build and strengthen institutional frameworks that enable the confluence of technological innovation with sustainable development objectives. It is crucial to perceive digital technologies not as standalone solutions but as

integral components deeply intertwined with institutional settings that govern their application. Institutions that meld technological and societal elements are vital in ensuring that technological breakthroughs contribute to sustainable development and equity.

In conclusion, the transition from Industry 4.0 to Industry 5.0 under the paradigm of postinstitutionalism represents not merely a technological upgrade but a profound sociocultural and environmental reevaluation aimed at fostering a sustainable, equitable, and humane future. This approach acknowledges the complexity and interdependence of the modern world and strives for the harmonious integration of technological progress with human values and needs. This evolving discussion underscores the importance of developing a financial architecture conducive to deploying novel technologies within a network of techno-economic institutions, viewed through the lens of techno-institutional dynamics.

The results of the linear regression model support the hypothesis of significant growth in investments in artificial intelligence. The identified trend toward increased investments aligns with global technological trends and reflects heightened interest in AI innovations. Such growth may be attributed to the expanded application of AI across various economic sectors and an increase in the number of startups in this field. It is also important to note that the linear regression model involves simplifications and does not account for potential fluctuations in economic conditions that may impact investment activity in the future.

This investigation enhances the theoretical understanding of how artificial intelligence (AI) and the Internet of Things (IoT) can be integrated within corporate social responsibility and financial risk management frameworks. It contributes to the scholarly discourse on techno-economic paradigms by examining the synergistic interactions between technological innovations and institutional structures. Our research elucidates how AI and IoT can fortify the adaptability and efficacy of sustainable practices in corporate settings, thus enriching theoretical perspectives on institutional adaptability and technology integration.

On a practical level, our findings offer guidance to industry leaders and policy makers on the strategic deployment of AI and IoT to foster sustainable development. The evidence provided by our research on the impact of these technologies in enhancing risk management and corporate responsibility initiatives serves as a strategic guide for organizations striving to improve their operational efficiencies and adherence to environmental, social, and governance (ESG) standards. Additionally, our results underscore the critical need for continued investment in technological education and capacity building, ensuring that the workforce remains competent in a technologically evolving landscape.

By bridging theoretical insights with practical outcomes, this research not only addresses a significant gap in the existing literature but also sets the stage for subsequent inquiries into the complex effects of technological advancements on organizational strategies. The integration of AI and IoT with corporate social responsibility not merely optimizes financial risk management but also propels organizations toward achieving broader socioeconomic objectives, highlighting the pivotal role of advanced technologies in realizing Sustainable Development Goals.

6. Conclusions

Artificial intelligence (AI) and the Internet of Things (IoT) emerge as being pivotal in formulating new paradigms for the management of sustainable development. By harnessing the capacity to collect and analyze extensive datasets, these technologies enable enhanced comprehension and stewardship of environmental, social, and economic dimensions across diverse regions.

Particularly in the realms of energy, water supply, and waste management, the application of AI and IoT markedly augments resource management efficiency. Such advancements lead to more judicious resource utilization, diminished pollution, and an elevated standard of living.

Moreover, AI and IoT foster greater community engagement in the pursuit of sustainable development. The dissemination of environmental condition data through these technologies elevates public consciousness and propels collective responsibility.

However, the integration of AI and IoT within sustainable development frameworks is not devoid of challenges. Issues spanning data privacy and security, the imperative for a skilled workforce adept in these technologies, and substantial financial commitments are notable barriers.

The efficacious integration of AI and IoT alongside other technological and societal innovations is crucial for optimizing benefits. This necessitates the cultivation of cross-disciplinary methodologies that amalgamate technological, economic, and socia considerations.

Overall, the incorporation of AI and IoT into sustainable development heralds novel avenues for enhancing operational efficiency, mitigating environmental degradation, and uplifting quality of life. This underscores the significant role of integrating AI and IoT into corporate social responsibility strategies for financial risk management and sustainable development. Nonetheless, the successful implementation of these technologies necessitates an integrated approach that encompasses technical, social, and economic facets.

Industry 5.0 is a concept that follows Industry 4.0 and focuses on the return of the human dimension to industrialization and technological development. Unlike Industry 4.0, which emphasizes automation, data utilization, and intelligent systems to enhance production and operational efficiency, Industry 5.0 emphasizes the significance of human engagement and collaboration with technology. Postinstitutionalism emphasizes the complexity, dynamism, and diversity of modern social processes, which go beyond traditional institutional structures. In this context, the transition from Industry 4.0 to Industry 5.0 has several key aspects:

First, Industry 5.0 puts more emphasis on people and their creativity, intuition, and emotional intelligence, along with new technology. This transformation is perceived as a response to the dehumanization entailed in Industry 4.0, where the emphasis was on automation and efficiency.

Second, in the era of global environmental challenges, Industry 5.0 focuses on sustainable development, considering environmental responsibility and green technologies as a part of the industrial process. This shows a growing awareness of the need for a balance between industrialization and environmental conservation.

Third, the transition to Industry 5.0 implies enhancing civic responsibility and aiming for a more just and inclusive community. This includes ensuring equality, diversity, and consideration of all segments of the population.

Fourth, Industry 5.0 emphasizes the importance of flexibility and adaptability in a rapidly changing world. This includes the capacity to swiftly adapt to technological advancements, economic conditions, and social expectations.

Fifth, unlike the full automation characteristic of Industry 4.0, Industry 5.0 strives to create harmonious cooperation between man and machine, where technology complements and expands human capabilities.

The analysis has led us to draw the following conclusions: (1) companies and societies are increasingly focusing on long-term sustainability and social responsibility, moving beyond traditional financial indicators. (2) The adoption of sustainable IT practices requires the amalgamation of knowledge across various fields, such as technology, ecology, social sciences, and management practices. This reflects the complexity of contemporary challenges that cannot be addressed solely through highly specialized approaches. (3) The increased focus on ESG initiatives in IT also shows that companies and societies must be prepared for rapid, and sometimes unpredictable, changes caused by both external factors (for example, climate change) and internal ones. This is especially true for changes in corporate culture. (4) Success in the IT sector requires the collaboration of many stakeholders, from governments and corporations to public organizations and individuals. This highlights the importance of integrating efforts and cooperation between different sectors of society. (5) The Industry 4.0 model, which focuses on technological automation and efficiency, does not adequately consider social and environmental aspects. Postinstitutionalism emphasizes the importance of understanding the social and environmental consequences of technological development.

This study has several limitations. First, the integration of AI and IoT in CSR strategies is examined primarily through case studies and hypothetical scenarios rather than extensive empirical data across multiple industries. Future research should include more diverse and comprehensive datasets to validate the findings. Second, the rapid pace of technological advancements means that the results may quickly become outdated. Continuous monitoring and updating of the research framework are necessary. Third, this study focuses on large corporations with significant resources for AI and IoT integration, potentially overlooking the challenges faced by small and medium-sized enterprises (SMEs). Future research should address the scalability of these technologies for SMEs.

Future research directions include exploring the long-term impacts of AI and IoT integration on specific CSR outcomes, such as carbon footprint reduction, social equity, and economic resilience. Additionally, examining the role of regulatory frameworks and policy interventions in facilitating or hindering technological adoption in CSR practices would provide valuable insights. Lastly, investigating the interplay between emerging technologies, such as blockchain and AI, in enhancing transparency and accountability in CSR initiatives could further enrich this field of study.

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