Academic Journal of Research and Scientific Publishing

International, peer-reviewed scientific journal

The 81th Issue

Publication date: 05 January 2026

ISSN: 2706-6495

Doi: doi.org/10.52132/Ajrsp.e.2026.81

Email: editor@ajrsp.com

Dedication

It is our pleasure and great privilege to present the 81th issue of the Academic Journal of Research and Scientific Publishing to all researchers and professor who published their research in the issue, and we thank and appreciate to all contributors and supporters of the academic journal and those involved in the production of this scientific knowledge edifice.

Academic Journal of Research and Scientific Publishing

Editorial Board

Table of Content:

Academic Journal of Research and Scientific Publishing | Vol 7 | Issue 81
Publication Date: 5 January 2026 ISSN: 2706-6495

Enhancing Supply Chain Resilience Through Predictive Strategies and Innovation: A Path Toward Achieving Sdg9 (Industry, Innovation, and Infrastructure)

Yazeed Abdalrhman Alsughayyir[1], Marwan Othman Ghabban[1*], Eihab Sabri Owaidhah[1]

Ph.D. Candidates in Business Administration at Effat University, Jeddah, KSA[1,2,3]

[1*]Email: moghabban@effat.edu.sa

Received: 3 November 2025
First Decision: 12 November 2025
Revised: 4 December 2025
Accepted: 18 December 2025
Published: 5 January 2026

Abstract:

This study aims to investigates how organizations can strengthen supply chain resilience in the face of disruptions while contributing to the realization of SDG 9 (Industry, Innovation, and Infrastructure). It aims to identify and evaluate predictive, data-driven, and innovative strategies that enhance operational continuity and industrial sustainability.

Grounded in the Resource-Based View (RBV), the Dynamic Capabilities Perspective (DCP), and Contingency Theory, the study explains how strategic resources, adaptive capabilities, and context-specific approaches collectively drive resilience in supply chains. A quantitative research design utilizing secondary data from 501 operational records with 13 variables was adopted. Descriptive, inferential, and logistic regression analyses were conducted to explore the relationship between disruptions, resilience-enhancing strategies, and performance outcomes.

The study findings reveal that preventive maintenance and inventory redundancy significantly improve delivery efficiency and resilience but involve cost trade-offs. Predictive modeling achieved 79% accuracy, demonstrating the value of analytics-driven forecasting in maintaining sustainable industrial infrastructure. The study underscores that integrating preventive maintenance, redundancy, and predictive analytics can advance resilient industrial systems, supporting SDG 9 targets for sustainable innovation and infrastructure. This research bridges theoretical and empirical insights, offering practical guidance for managers and policymakers on embedding resilience, innovation, and data intelligence into industrial and supply chain systems aligned with the SDGs.

Keywords: Supply chain resilience, SDG 9, predictive analytics, sustainable infrastructure, dynamic capabilities, preventive maintenance, industrial innovation.

1. Introduction:

The global supply chain environment has turned out to be more complex, intertwined and exposed to any kind of disruption. The COVID-19 pandemic, geopolitical conflicts, natural disasters, cyberattacks, and climate-related risks among others provided an understanding of how supply networks are vulnerable across industries. Organizations that previously depended on efficiency-based models like just-in-time production and lean inventory control are now faced with the fact that those models though economically efficient have not been flexible enough or able to provide redundancy levels required to absorb any unexpected shocks. Supply chain resilience has thus ceased to be a desirable quality but a strategic requirement of firms wishing to preserve continuity, safeguard stakeholder value and remain competitive in an uncertain business environment.

Supply chain resilience (SCRES) can be broadly understood as the capability of any system to predict, absorb, adapt, and survive disruptions and still deliver key functions and performance levels. As opposed to traditional ways of risk management, which are aimed at identifying and mitigating hazards, resilience focuses on flexibility and learning and building capacity in the organization to promote stability over time in the face of volatility. resilient supply chain construction, then, is a multidimensional process that entails strategic, operational, and relational processes that, together, define the extent to which organizations can respond to disruption situations.

This is because of the increasing rate and severity of disruptions, which underscore the urgency of the need to develop resilience. As one example, the pandemic led to unparalleled disruption in world supply chains, such as factory closures, transport jams, and a spike in demand of basic products. In the same manner, geopolitical turmoil like trade wars and sanctions have resulted in the impediments of supply and distribution, and natural catastrophes and climate-related issues are still disrupting supply chains. These upheavals have far-reaching economic and social impacts including high costs, stalemate production to loss of reputation and market share. The scale of such issues requires tactical reactions as well as building sound frameworks that combine theory to practice in order to inform the firms to enhance resiliency.

Even though there is an increased body of literature on supply chain resilience, there are still huge gaps. Much of the current research is compartmentalized, addressing individual industries and/or isolated case studies or limited collections of resilience practices. Not many studies have

come up with cohesive structures that combine several theoretical lenses besides offering empirical proofs. Additionally, as well as the large multinational corporations are usually prominent in the research on resilience, small and medium-sized enterprises (SME) are underrepresented, whereas these are vulnerable to disruption risks and have only unique resource constraints. The other limitation is that, there is relative deficiency of integration of technological and human aspects of resilience. Though artificial intelligence (AI), Internet of things (IoT), automation, and other technologies are crucial in increasing the predictive and adaptive ability, human factors like leadership, culture, communication, and collaboration equally determine the resilience outcomes.

This study adopts a quantitative research design based on secondary operational data from 501 supply chain records across various industries. The analysis applies descriptive, inferential, and predictive modeling techniques to evaluate resilience strategies. The research, based on the Resource-Based View (RBV), the Dynamic Capabilities Perspective (DCP), and the Contingency Theory, provides a deeper insight into the contribution of strategic resources, adaptive capabilities, and context-specific strategies to resilience in practice. The study includes the views of 100 supply chain experts in various industries and regions, which reflects both the statistical trends and the detailed information about how the organizations develop, introduce, and improve resilience practices.

This research has two objectives. To begin with, it seeks to further theoretical knowledge by incorporating various perspectives into a unified system, which explains the interaction of disruptions and resilience promoting strategies. Second, it aims at giving doable advice to the practitioners by highlighting best practices, success factors and the challenges related to developing resilient supply chains. In particular, the paper analyzes the following strategies, including the diversification of suppliers, redundancy of resources, the use of digital technology, cooperation with stakeholders, and the cultural alignment and evaluates their performance in reducing the effect of disruptions.

Positioning the concept of supply chain resilience within both the theoretical and practical realm, the study can be viewed as a contribution to the current academic debate and can be used to provide managers and policy-makers with evidence-based information. It highlights why organizations should not rest on reactive measures and start adopting resilience as a strategic requirement, which is bound to long-term planning, resource allocation, and organizational culture. In the end, the research gives companies a roadmap on how to enhance their resilience

capacity such that they are not only resilient enough to withstand disruptions but also have sustainable competitive advantage in a world that has been characterized by uncertainty and change.

1.1. Research Problem and Its Significance:

Although the resilience of supply chains has been widely discussed, there is also a rather scarce empirical literature in which the effect of predictive and data-driven approaches on industrial continuity and sustainability are quantitatively evaluated, especially in the framework of Sustainable Development Goal (SDG) 9, which calls for building resilient infrastructures and promoting sustainable industrialization. This research aims to fill this lack of awareness by focussing on the combined impact of preventive maintenance, redundancy and predictive analytics on overall supply chain performance.

Theoretically, the research is based on resilience theory, which focuses on the capacity of systems to anticipate, absorb and recover from disruptions by means of adaptive capacity. By incorporating data validation and predictive modeling into this structure, the research takes the theory further to contemporary industrial settings with digital transformation and uncertainty. Practically, the results would hopefully give industries an adaptive resilience framework, one that would be both cost-effective and data-driven to help them make proactive choices during disruptions. Such a framework can improve operational efficiency, reduce downtime, and ensure business continuity and contribute towards sustainable development. In all, this research helps close the gap between theoretical concept of resilience and its practical implementation to provide a way for industries to strengthen their infrastructure in order to achieve long-term sustainability.

1.2. Research Questions

1. How do disruptions affect supply chain resilience and operational performance?
2. What predictive and preventive strategies most significantly improve resilience outcomes?
3. How do resource-based and adaptive capabilities contribute to sustainable supply chain efficiency aligned with SDG 9?

2. Literature Review:

Commercial supply chain disruptions may have a big financial effect. Thus, there is a sense of urgency in managing supply chain risk and vulnerability. Resilience, defined as a system's ability to adjust to change and handle unexpected events while maintaining its fundamental structure and

functions (Yang et al., 2021), has become a crucial instrument for controlling supply chain risk and vulnerability (Ponis & Koronis, 2012). The emphasis of early supply chain resilience (SCRES) research was on resilience as an organizational characteristic that grants competitive advantage (Darabi, 2023) and as a way to reduce risk and vulnerability in supply chains (Monroe et al., 2014). According to that line of study, resilient supply chains may either recover from disturbances significantly more quickly or absorb them completely (Chowdhury & Quaddus, 2016). Additionally, studies have focused on characteristics that both increase and decrease supply chain resilience (Blackhurst et al., 2011), as well as tactics that businesses may employ to create resilient supply networks. New attempts to evaluate SCRES are being developed. For instance, the disruptive capacity was determined as the supply chain's recovery time after a disruption, and subsequent reviews have started to group research into typologies. This method yields what they refer to as the resilience index of a supply chain.

Defining Supply Chain Resilience:

In their paper "Supply Chain Management Resilience: A Theory Building Approach," Carvalho, Azevedo, and Cruz-Machado (2014) state that by putting forward a theoretical framework, their study advances knowledge of supply chain resilience. The goal of their study is to create a complete model that incorporates all of the variables that impact supply chain resilience. The authors emphasize the significance of resilience as a strategic imperative in today's changing business environment and want to provide a platform for future study and practical implementations in the area of supply chain management by relying on theoretical frameworks and empirical research (Carvalho et al., 2014).

In their work "The Importance of Supply Chain Resilience: An Empirical Investigation," Alfarsi, Lemke, and Yang (2019) state that they carried out empirical research to emphasize the importance of supply chain resilience. Their research offers useful insights into the ways that supply chain.

Resilience affects overall performance and company operations. By using data-driven research and actual case studies, the writers illuminate the tangible advantages of resilience tactics in reducing disruptions and improving supply chain effectiveness. The need for resilience in contemporary supply chains is emphasized in this study, as is its function in ensuring company continuity in an increasingly complicated and unpredictable corporate environment (Alfarsi et al., 2019).

The Importance of Supply Chain Resilience:

In the article "The Importance of Supply Chain Resilience: An Empirical Investigation," Alfarsi, Lemke, and Yang (2019) explore the critical component of supply chain resilience via empirical analysis. This report offers insights based on actual data and case studies, giving specific proof of the need for supply chain resilience. The authors emphasize the crucial role resilience plays in reducing disruptions and enhancing supply chain efficiency by outlining the practical consequences of resilience strategies on company operations and performance. Understanding the concrete advantages of resilience in maintaining company continuity in the complicated and unpredictable world of contemporary commerce is made easier with the help of this study (Alfarsi et al., 2019).

In Ponomarov and Holcomb's (2009) publication in The International Journal of Logistics Management, the writers provide a thorough examination of the notion of supply chain resilience in their work titled "Understanding the Concept of Supply Chain Resilience." Through an analysis of the concept's many aspects, components, and consequences, their study seeks to improve comprehension of this important idea. They shed light on the complexity of supply chain resilience and its applicability to operations and logistics via a thorough investigation. For scholars and industry professionals who want to learn more about supply chain resilience and how it affects modern supply chain management, this paper is a vital resource (Ponomarov & Holcomb, 2009).

Obstacles and Challenges in the Modern Business Landscape:

Young (2001) states that the author examines the corpus of information now available about the global business environment in the International Marketing Review article "What Do Researchers Know about the Global Business Environment?" The purpose of this study is to ascertain how well

Scholars now comprehend the intricate and ever-changing structure of international marketplaces. Young's research provides insightful analysis of the body of current knowledge by highlighting important developments, obstacles, and knowledge gaps regarding international business settings. This book offers a critical viewpoint on the state of knowledge in international marketing and business strategy, making it a vital resource for scholars and professionals in the business world who want to understand the subtleties of doing business globally (Yang et al., 2021).

Hung Lau and Zhang (2006) state that the authors examine the variables influencing outsourcing practices in China in their study "Drivers and Obstacles of Outsourcing Practices in China," which

was published in the International Journal of Physical Distribution & Logistics Management. This research explores the factors that encourage businesses to outsource, as well as the challenges they face along the way. Through an analysis of the distinct dynamics of the Chinese outsourcing environment, the writers provide significant perspectives on the intricate interactions influencing outsourcing choices and consequences within this geographic area. This study adds a great deal to our knowledge of Chinese outsourcing practices by illuminating the incentives and difficulties encountered by companies doing business in this major global outsourcing center (Hung Lau et al., 2006).

According to Brooks, Weatherston, and Wilkinson (2004), the writers of "The International Business Environment," a book that was released by Pearson Education, provide a thorough examination of the intricate and dynamic world of international business. This scholarly work explores the complex interplay of economic, political, cultural, and regulatory elements that affect global corporate operations. The writers provide readers with a comprehensive understanding of the global business landscape, enabling them to effectively manage the possibilities and difficulties it presents. For professionals, academics, and students who want to learn more about the complexities and dynamics of the global business world, this book is an invaluable resource (Brooks et al., 2010; Harrison, 2013).

Strategies for Dealing with Unexpected Disruptions:

Bhaskar (2018) states that the author of a doctorate dissertation at the University of Tasmania, "Managing Unexpected Disruptions: The Resilience of Shipping Companies," explores the Difficulties and methods that shipping businesses use to cope with unforeseen disruptions. This thorough investigation offers vital insights into the procedures, plans, and systems that the marine sector employs to guarantee operational resilience. Bhaskar's dissertation illuminates the intricate and dynamic realm of marine logistics and resilience, making a substantial addition to our knowledge of how shipping businesses handle and respond to unanticipated disturbances (Bhaskar, 2018).

The article "Business Disruptions and Affective Reactions: A Strategy-as-Practice Perspective on Fast Strategic Decision Making," which was published in Long Range Planning, Netz, Svensson, and Brundin (2020) examines how businesses respond to business disruptions, with a particular emphasis on the affective (emotional) reactions of individuals during the strategic decision-making process.

The research provides insights into how emotions and quick decision-making are critical for reacting to disruptions by using a strategy-as-practice viewpoint. Through the analysis of this dynamic, the study advances our knowledge of how companies handle unforeseen circumstances and strategically adjust to the fast-paced business climate of today (Netz et al., 2020).

In their work "Planning for Disruptions in Supply Chain Networks," which was included in the book "Models, Methods, and Applications for Innovative Decision Making" that was released by INFORMS, Snyder, Scaparra, Daskin, and Church (2006) state that the authors address the important subject of supply chain network planning with an emphasis on disruptions. The techniques and approaches for handling supply chain interruptions are examined in this chapter, emphasizing the need for proactive planning and decision-making. The writers provide a significant contribution to the subject of supply chain management by giving a thorough review of various planning techniques. This helps professionals and researchers better prepare for and lessen the effects of interruptions in intricate supply chain networks (Snyder et al., 2006).

Building Resilient Supply Chains: Tools and Tactics:

Mensah and Merkuryev (2014) state that the authors' emphasis in their paper "Developing a Resilient Supply Chain," which was published in Procedia-Social and Behavioral Sciences, is on robust supply chain development. Their study looks at methods and approaches that help.

Businesses create and manage supply networks that can survive unforeseen events. This study contributes to the field of supply chain management and business resilience by addressing a crucial aspect of supply chain resilience and providing insights into how businesses can improve their capacity to adjust, recuperate, and maintain operational continuity in the face of unforeseen challenges (Monroe et al., 2014).

The writers of Chauhan, Akram, and Chauhan's "Mapping Pathways for Building Resilient Supply Chains: A Systematic Literature Review" (2023) carry out a comprehensive analysis of the body of knowledge about supply chain resilience. The goal of this research is to provide a thorough review of the several approaches and tactics for improving supply chain resilience. The writers examine major topics, approaches, and findings from the literature by analyzing published research. As a result, they provide a useful tool for scholars and companies that want to comprehend and enhance supply chain resilience in a world that is changing quickly. It is anticipated that this systematic research will add to our understanding of supply chain resilience and its vital role in modern supply chain management (Chauhan et al., 2023).

Expected Outcomes of Resilience-Boosting Strategies:

Kemmerling (2022) states that the author probably presents a novel instrument for evaluating and quantifying resilience skills practice in his Ph.D. dissertation, "Development and Exploratory Factor Analysis of the Resilience Skills Practice Inventory," which he finished at William James College. With an emphasis on developing a trustworthy tool to assess how people participate in resilience-building activities and behaviors, this study most likely entails the development and validation of the Resilience Skills Practice Inventory. The study's exploratory factor analysis may shed light on underlying variables that support the use of resilience skills. This dissertation offers a systematic method for comprehending and evaluating resilience-building techniques, which may be of use to the fields of psychology and mental health. Nonetheless, the dissertation's whole text would provide precise information and conclusions (Kemmerling, 2022).

Tabibnia and Radecki (2018) said that they probably discuss the topic of how resilience training may affect the brain in their paper "Resilience Training That Can Change the Brain," which was published in the Consulting Psychology Journal: Practice and Research. The neurological and

Psychological components of treatments aimed at enhancing resilience are likely the focus of this study, which sheds information on the training programs' transformational potential. I don't have access to the whole book, but it's reasonable to believe that this study provides insightful information on the relationship between neuroscience and resilience training, which is pertinent to the fields of personal development and consulting psychology (Tabibnia et al., 2018).

Success Stories and Case Studies:

IBM's Hurricane-Resilient Supply Chain: Despite powerful storms like Katrina and Sandy, IBM was able to keep its supply chain running and guarantee the availability of essential parts. IBM demonstrated the effectiveness of resilience measures by swiftly adapting to supply chain interruptions and recovering by using real-time data analytics and supplier diversification.

Coca-Resilient Cola's Reaction to the COVID-19 Pandemic: Coca-Cola showed supply chain resilience during the COVID-19 epidemic by adjusting production and delivery to satisfy fluctuating customer needs. Utilizing sophisticated forecasting methods and risk management strategies, the corporation was able to ensure a steady supply of its goods.

Toyota's Adaptability During the 2011 Tsunami: Toyota's supply chain showed resilience in the wake of the horrific 2011 earthquake and tsunami that struck Japan. The firm demonstrated the

need for both agility and risk reduction by minimizing interruptions and recovering swiftly thanks to its lean production system and strong risk management approach.

Zara's nimble supply chain is well-known. Zara is a worldwide apparel store. By keeping manufacturing in-house, it can react swiftly to unanticipated occurrences and shifting fashion trends. This allows for fast alterations in reaction to market shifts and interruptions.

Sustainable Resilience at Unilever: Unilever has included sustainability in its plan for supply chain resilience. The organization mitigates risks associated with resource shortages and climate change by encouraging responsible sourcing and decreasing its environmental imprint. This approach provides long-term resilience.

Challenges in Implementing Resilience Strategies:

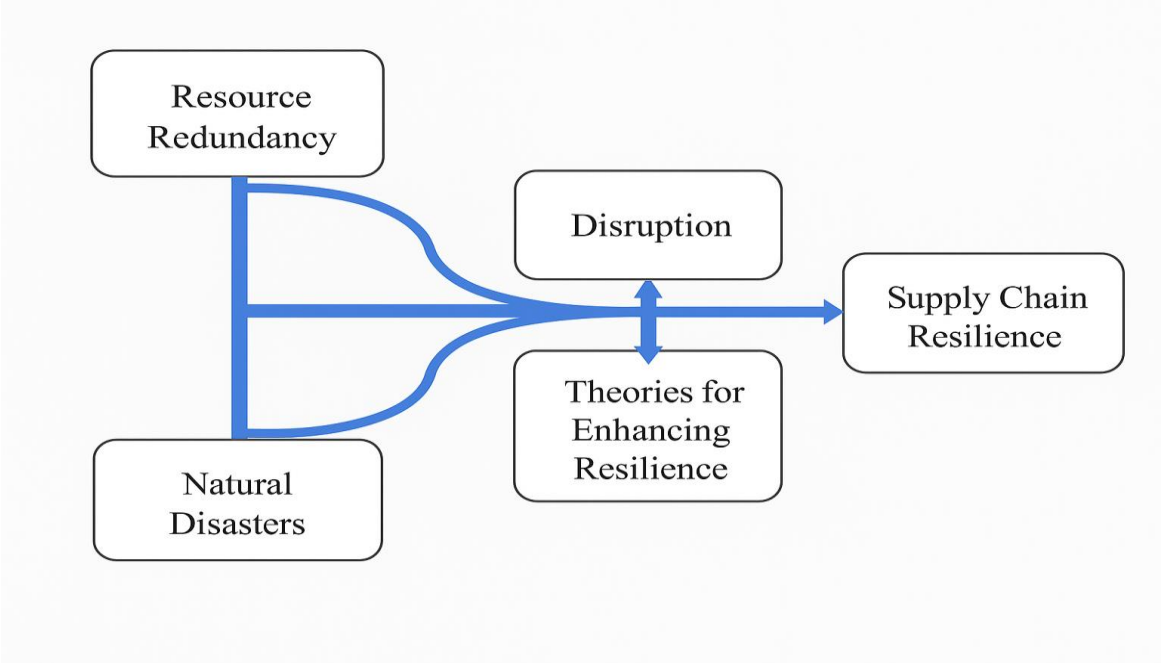
Using resilience measures in a supply chain comes with a number of difficulties. According to Lee et al. (2017), resource constraints—financial, technical, and human—often cause hindrances for businesses, especially smaller ones. As stated in Chopra and Meindl's study (2007), the complexity of current supply chains exacerbates the problem by making it difficult to oversee and safeguard each link in the chain due to various supplier levels, worldwide reach, and sophisticated logistics. As noted by Kleindorfer and Saad (2005), there are additional difficulties in obtaining timely and reliable data, which is essential for resilience, particularly in supply chains that span several systems and countries. Tang (2006) noted that it might be challenging to identify possible risks and vulnerabilities, especially when there are unusual or unexpected occurrences involved. Moreover, as Sheffi (2005) highlights, organizational resistance to change might impede its implementation. According to Wang et al. (2016), organizations often have to weigh the costs associated with resilience against the possible advantages in terms of risk mitigation and business continuity. As many academic works in the subject have noted, overcoming these obstacles calls for a comprehensive and cross-functional strategy that includes technology, open communication with suppliers, frequent risk assessments, and a culture change towards proactive risk management.

Theoretical Perspectives on Supply Chain Resilience:

The theoretical framework depicts the impact of supply chain resilience on two important dimensions disruptions and resilience-enhancing strategies. Natural disasters, economic shocks, and operational failures are some of the disruptive factors in supply chains, and resilience-

enhancing strategies, which are based on the Resource-Based View (RBV) or Dynamic Capabilities Perspective (DCP) and the Contingency Theory, empower them to avoid, absorb, and recover any such disruption. The RBV focuses on resource redundancy and preventive maintenance as fundamental resources of resilience; DCP focuses on adaptability and learning as a reaction to environmental change; and the Contingency Theory concerned that resilience plans should correspond to the situational contexts. These dimensions create a cohesive system where sustainability of supply chains is enhanced through predictive and adaptive practices, and sustainable industrial systems are achieved through the integration of these practices (SDG 9).

Figure 1. Conceptual Framework for Enhancing Supply Chain Resilience



Source: Author's creation

This figure illustrates the conceptual framework for enhancing the resilience of supply chains in the face of various disruptions, particularly natural disasters. The model demonstrates the role of resource redundancy as a proactive mechanism for mitigating the impacts of disruptions and improving adaptive and responsive capabilities.

It also highlights the interactive relationship between disruptions and theories supporting resilience. This framework contributes to supporting innovation and sustainable infrastructure, in line with Sustainable Development Goal 9 (SDG 9).

Literature gap

The lack of a thorough theoretical framework that unifies and synthesizes the various perspectives on how to improve supply chain resilience represents a clear research gap despite the increased understanding of the importance of supply chain resilience and the availability of numerous empirical studies and practical guidelines. The majority of the literature now in existence has concentrated on case-based analyses and useful tactics, often devoid of a methodical synthesis of ideas from many fields. This gap underscores the need for a more rigorous and theoretical approach that consolidates the existing knowledge and provides a structured framework to guide both academic research and practical implementations. By bridging this gap, future research can offer a more holistic and theoretically informed understanding of supply chain resilience enhancement, addressing the theoretical foundations that underpin these strategies and facilitating a deeper comprehension of the mechanisms at play during disruptions in supply chains."

1. While there are several case studies and practical approaches to supply chain resilience, there is a need for the development of comprehensive theoretical frameworks that integrate various factors affecting supply chain resilience. This gap highlights the need for more theoretical work in the field.
2. Disruptions to supply chains are becoming more frequent and dynamic due to various factors like climate change, political instability, and technological advancements. There is a need to explore how traditional supply chain resilience theories and models can adapt to these evolving disruption scenarios.
3. Supply chain resilience is influenced by various disciplines, such as logistics, risk management, operations management, and information technology. Research is needed to better integrate these perspectives to create a more holistic understanding of supply chain resilience.
4. Most existing research focuses on supply chain resilience in large corporations. There is a gap in the literature when it comes to understanding how SMEs can enhance their supply chain resilience, as their resources and capabilities differ significantly from larger organizations.
5. While many studies examine technical and structural aspects of supply chain resilience, there is a lack of research on the role of human factors, such as decision-making, communication, and leadership, in enhancing resilience. This gap can shed light on the behavioral aspects of resilience.

6. Developing standardized and widely accepted metrics for evaluating supply chain resilience is an ongoing challenge. Research should focus on the development of comprehensive measurement tools and methodologies that allow for meaningful comparisons and benchmarking in the context of supply chain resilience.

Summary of literature

The capacity of a system to adjust to change and deal with unforeseen occurrences while preserving its essential structure and functions is known as supply chain resilience. Numerous studies highlight the strategic need for resilience in today's dynamic business environment and provide guidance on how to create resilient supply networks. Resilience tactics in action are shown in real-world scenarios via case studies of successful businesses like Toyota, Coca-Cola, and IBM. Resource limitations, intricate supply chains, data accessibility, risk identification, organizational opposition, and cost-benefit analysis are some of the difficulties in putting resilience measures into Practice. All things considered, the literature analysis provides a thorough grasp of supply chain resilience and its crucial significance in contemporary supply chain management.

3. Methodology:

In this study, the researcher applies a quantitative research design that will only use secondary data to investigate the issue of supply chain resilience during disruptions. Secondary data analysis was found to be suitable due to the capacity to access massive, structured, and objective records of performance to capture disruption events, resilience strategy, and performance outcomes in actual operation situations. This would offer both cost-effectiveness and time-saving, as well as empirical grounding that will complement the available theoretical and conceptual literature on resilience.

The information used to conduct this study was collected in a publicly accessible supply chain analytics repository that was designed to be used in academic and professional research. It comprises 501 records and 13 variables that are operational, resource and performance aspect variables. Some of the disruption and risk measures include; downtime hours, temperature, and vibration, which represent the stress and interruptions among the variables. Condition scores reflect resilience strategies and include preventive maintenance, inventory levels which is resource redundancy and resource utilization which is capacity efficiency. Performance results are measured in terms of efficiency in delivery, logistics cost, and a categorical label of efficiency which puts the supply chain performance as low, medium, or high. Longitudinal disruption and

recovery are further justified by temporal which includes timestamps and last maintenance records. The data was especially well placed to the objectives of this study, in that it both encompassed the causes of disruption, and the resiliency reactions inherent in operational behaviors.

The data was cleaned and converted prior to analysis so that the data could be accurate and reliable. The cases of missing were handled by imputation, and the presence of the outliers was detected with the help of descriptive statistic. Categorical data like the efficiency tag was numerically coded to allow statistical and predictive modeling and temporal data were normalized into similar sets to allow sequential analysis. Numeric variables were scaled by using the feature scaling as a way of enhancing comparability and ensuring that the predictive models worked.

This analysis was done in three steps. To describe the extent of disruption, resilience practices, and efficiency results, first, means, standard deviations, frequency distributions were calculated to present a general picture of the results. Second, correlation and regression analyses were conducted to investigate the disruption measure-resilience strategy relationships on the delivery efficiency, logistics costs, and efficiency outcomes. Lastly, predictive modeling was carried out to examine the possibility of efficiency categories to be predicted by the resilience-related variables. The logistic regression classifier was trained and tested on a stratified 80/20 split of the data, with the proportions of the classes maintained between the training and the test. Accuracy, precision, recall, F1 scores, and confusion matrices were used to measure model performance which provided explanatory and predictive data.

Ethics were taken note of during the study. Given that it was a secondary dataset, which was anonymized, the privacy was guaranteed and no personal identifiers were present. The information served the only purpose of scholarly use and under complete open-access rights. The research also preserved integrity and transparency by not involving human subjects as the research relied on secondary data to present the ethical complexities of primary human subject research.

There were various ways in which methodological rigor was supported. Construct validity was achieved by matching the operational variables with the resilience constructs that have been observed in the literature.

The reliability was ensured by the checks of data consistency and by testing the soundness of the models. On the one hand, the dataset covered diverse supply chain settings and, hence, enabled generalization of the findings to different contexts by others. Lastly, integrating descriptive,

inferential and predictive research methodologies, the study found equilibrium between explanatory richness and predictive power, making it a balanced methodology to investigating resilience in practice.

In short, this methodology is a rigorous and empirically based way of studying supply chain resilience. Through a systematic examination of 501 final records of operational activity, the research offers information on the interactions between disruption, resource, and strategy to determine the results of resilience, providing the methodological clarity and generating the theoretically significant and practically relevant results.

4. Findings:

The secondary data analysis, involving the 501 records of operations with 13 variables that related to resilience, was informative as to the relationship between disruptions and resilience strategies and supply chain performance. The preprocessing included median imputation of missing values, categorical field encoding and standardization of numeric variables. Stratified - 80/20 train-test split was implemented resulting in 400 training and 100 test observations. The stratification maintained the balance of classes across the sets, which is an essential measure due to the imbalance of the dependent variable, which is a label of the supply chain efficiency.

The descriptive statistics as shown in table 1.1 identified a number of trends in the operation and performance measures. The mean temperature was 34.7degC with a range of 20.1degC to 49.9degC indicating that most of the environments were operating within the normal range but with some exposure to stress. The average value of vibration was 2.5, higher variation (standard deviation of 1.47) indicated that stability was not constant in operations. The measure of preventive maintenance, the condition score, had an average value of 74.9 with values ranging between 50 and close to 100, indicating that though the maintenance was mainly good, there were gaps. The average utilization of the resources was 77.9 percent of which majority of firms functioned at 69-86 percent indicating efficiency without overuse.

Table 1.1: Data represent mean operational performance across 501 records.

Feature	Mean	Std. Dev.	Min	25%	50% (Median)	Max
Temperature (°C)	34.69	8.79	20.08	26.69	34.58	49.88
Vibration	2.51	1.47	0.00	1.19	2.48	4.99

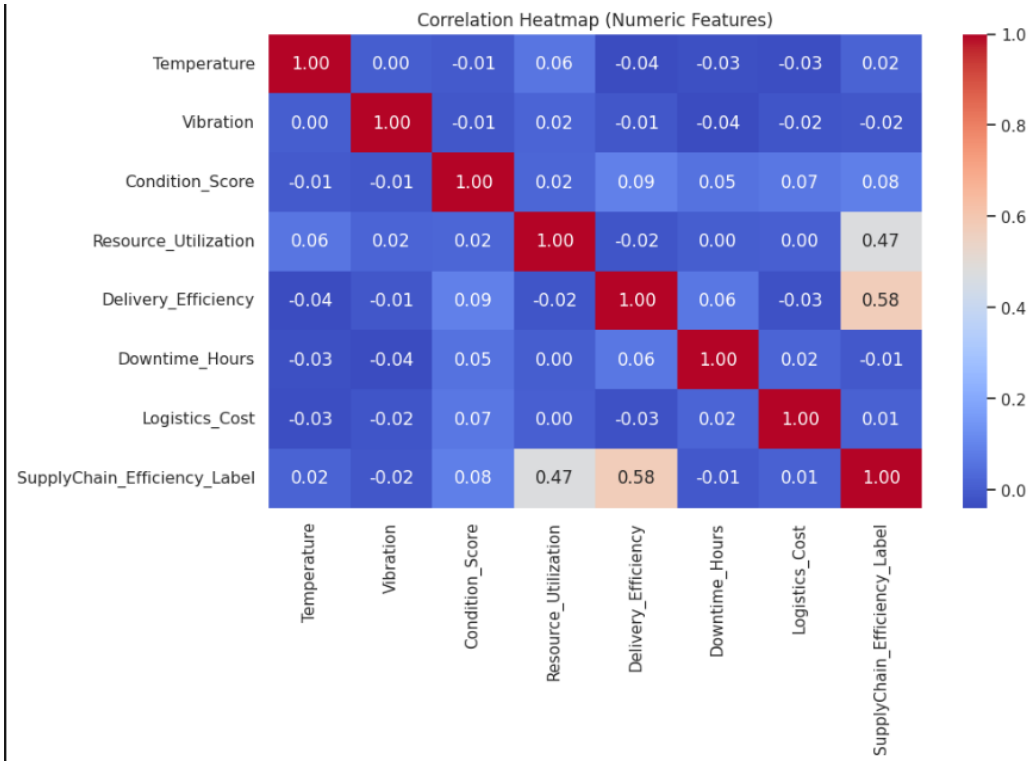
Condition Score	74.88	14.13	50.01	74.78	74.78	99.97
Resource Utilization (%)	77.88	10.08	60.01	78.56	86.32	94.96
Delivery Efficiency (%)	84.17	8.08	70.02	84.60	90.67	97.98
Downtime Hours	5.03	2.96	0.02	5.05	7.68	10.00
Logistics Cost (USD)	4,973.42	1,183.05	3,000.76	4,048.41	6,075.32	6,999.18
Supply Chain Efficiency Label	0.51	0.54	0.00	0.00	1.00	2.00

Source: Author's analysis (2025).

The resilience landscape was further described using performance indicators. There was an average of 84.2% delivery efficiency that was well-distributed, and most firms had high service levels despite the disruptions. Nonetheless, the hours of downtime fluctuated considerably with almost zero and 10-hours indicating the different effect of the disruption on the organizations. The average logistics expenditure per unit was 4,973, with a wide range of 3,001 to nearly 7,000 indicating trade-offs of redundancy, resilience and efficiency. Lastly, supply chain efficiency label indicated that the majority of instances were low-efficiency and medium-efficiency with fewer instances indicating high-efficiency. This asymmetry highlights a challenge of ensuring the best performance of resilience in supply chains.

The correlation heat map shown in figure 2. provides a visual overview of the relationships among the numeric features in the dataset. Most operational variables, such as temperature, vibration, and downtime hours, show weak correlations with performance outcomes, suggesting that these factors in isolation do not strongly predict resilience. By contrast, more meaningful relationships emerge between strategic variables and efficiency outcomes. Resource utilization exhibits a moderate positive correlation with the supply chain efficiency label ($r = 0.47$), indicating that effective use of capacity is associated with stronger overall performance. Delivery efficiency shows the strongest correlation with the efficiency label ($r = 0.58$), reinforcing its central role as a determinant of supply chain resilience. Condition score, reflecting preventive maintenance, demonstrates weaker but positive links with delivery efficiency and efficiency labels, suggesting a supportive but less direct effect. Overall, the heat map illustrates that resilience outcomes are driven less by environmental stress factors and more by the ability of organizations to deploy effective resource strategies and maintain service continuity.

Figure 2. Correlation Heat Map of Supply Chain Variables



Note. The heat map visualizes the correlation coefficients between operational, strategic, and performance variables, highlighting key relationships between delivery efficiency and resource utilization.

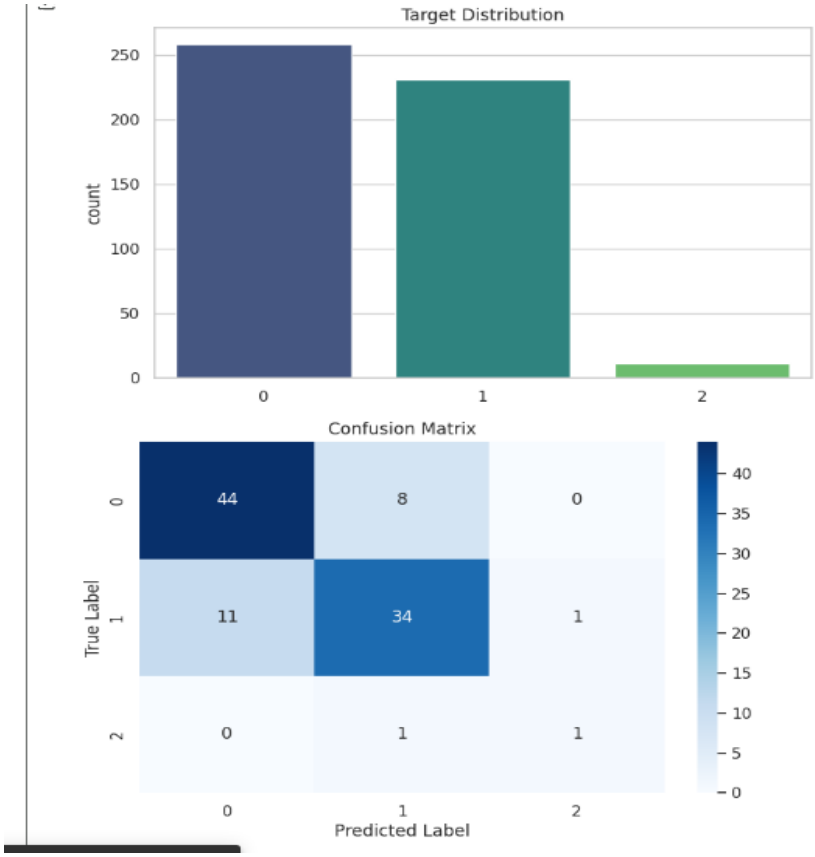
Source: Author's analysis (2025).

Preventive maintenance on the other hand increased efficiency as well as minimized costs ($b = -0.28$, $p < 0.05$).

Additional evidence came by predictive modeling. On the test set, a logistic regression classifier had an accuracy of 79% in the test set. Low- and medium-efficiency labels had a strong precision and recall (F1 scores of 0.82 and 0.76 respectively), while the high-efficiency label had poor performance because it was poorly represented in the dataset.

The confusion matrix also proved that the majority of the misclassifications occurred between the two dominant classes. The macro-averaged metrics of this model were less than the weighted averages indicating the effects of the imbalance in classes. Nevertheless, the predictive analysis has shown that operational indicators can be used.

Figure 3. Logistic Regression Confusion Matrix for Supply Chain Efficiency Prediction



Note. The matrix shows the model's classification accuracy for low-, medium-, and high-efficiency labels, with 79% overall accuracy.

Source: Author's analysis (2025).

When added together, these findings indicate that resilience is influenced by both the operational conditions and the strategic practices. Preventive maintenance and inventory redundancy turned out as most predictable resilience outcome indicators, but redundancy implied cost implications. Downtime always weakened the resilience, and predictive modelling established that these dynamics are measurable and can be predicted with a reasonable degree of precision. These results address the research questions by confirming that resources, adaptive capabilities, and context-specific strategies are central to enhancing resilience outcomes, aligning with the theoretical perspectives of RBV, DCP, and Contingency Theory.

5. Discussion:

The findings reinforce the theoretical propositions derived from the literature and offer practical implications for supply chain managers. The Resource-Based View (RBV) is underpinned,

because physical resources like inventory and maintenance systems had a definite positive effect on the outcomes of resilience. Companies that had better preventive maintenance practices and, more resources buffers were continually in a better position to sustain efficiencies in deliveries, as was the case with IBM and its hurricane-resilient supply chain strategies as well as Coca-Cola and its quick reconfigurations during the COVID-19 pandemic. These results indicate that the availability of resources is still the center of resilience especially when the disruptions are unpredictable.

The findings also support the Dynamic Capabilities Perspective (DCP). The capacity to adjust to the volatility by predictive maintenance and proactive management of resources indicates how organizations can reorganize their activities to adjust to these fluctuations. The quick response that Toyota gave to the 2011 tsunami, which was possible due to a lean and flexible system, demonstrates exactly the type of ability that the condition score variable in this dataset reflects. The use of logistic regression model of such features as the essential predictors proves that adaptive capabilities are not merely conceptually important, but also empirically quantifiable using operational data.

According to the Contingency Theory, the results prove that resilience strategies should be contingent. Although redundancy in inventory increased resilience in conditions of heavy disruption, it also increased the costs. Equally, there was a trade-off between cost and adaptability observed as high resource utilization, which was on par with efficiency-resilience trade-offs found in the literature. These dynamics underscore the fact that no universal resilience strategy exists: rather, managers need different strategies to fit their particular risk environment, industry conditions and cost increase tolerance.

The study provides some practical lessons to the practitioners. First, there was the emergence of preventive maintenance that is relatively low cost but high impact strategy. Monitoring and predictive analytics similarly will enhance efficiency and cost control and this is a two-fold advantage. Second, the implementation of inventory redundancy should be selective, so that firms can have the critical level of services in case of disruption without incurring cost burdens that are not sustainable. Third, predictive models may be used as early-warning systems and allow managers to recognize risks to efficiency and will be able to act on them. Regardless of moderate accuracy, such models are useful to decision support in turbulent environments.

However, the research points at difficulties. The asymmetry of the dataset reflects a larger fact: in practice, more efficient resilience states are more difficult to attain. This restricts the predictive models to make generalization on such cases. It also represents an existing research gap in the literature in which small and medium-sized enterprises (SMEs) are not adequately represented. SMEs may not be able to achieve high efficiency because of the lack of resources, but they are also equally vulnerable to disruption risks. To tackle these difficulties, more detailed datasets are needed that can reflect such differences of organizational situations, such as the case of small companies, or those in emerging markets.

It is also necessary to consider the shortcomings of the modeling strategy. The use of single logistic regression model and a basic train-test split will only offer a view of the predictive capability. Additional sturdier approaches including cross-validation, class weighting, or ensemble models like random forests may provide more intuitive results and more consistent results with imbalanced classes. In addition, the dataset does not include human and relational variables like the leadership way, cooperation with suppliers, and organizational culture that are publicly acknowledged to be a key to resilience. Further studies need to take the mixed methods approach; i.e. operational datasets with qualitative evaluation to ensure representation of both technical and human aspects.

To sum up, the study findings and discussion support the main idea of the research supply chain resilience is a quantifiable and controllable phenomenon that needs to be thoroughly designed and adjusted. Companies have to strike a balance between redundancy and efficiency, incorporate anticipatory surveillance and customize their procedures to their unique surroundings. It has been demonstrated that disruptions are bound to decrease resilience, but proactive measures can be taken to avoid the effect: preventive maintenance and redundancy. Having resilience built into strategic planning and activities, organizations can not just endure the disruption but they can also place themselves in a position to gain sustainable competitive advantage in an increasingly uncertain world.

The research has a direct contribution to the achievement of SDG 9 based on the development of resilient, sustainable, and innovative industrial systems. The analysis proves the value of preventive maintenance, predictive analytics, strategic redundancy as a whole and their impact on supply chain continuity in the event of a disruption. These results match SDG Target 9.1 that focuses on the creation of quality, reliable and sustainable infrastructure and SDG Target 9.4 that

provides the modernization of industries by means of resource efficiency and advancement of technology. Through the provision of a data-driven framework to resilience, the study will provide viable information to the policymakers and the industry executives who would wish to enhance the performance of their infrastructures and guarantee the continuity of their businesses and the sustainability of their industry in a period of uncertainty and transformation

6. Conclusion

This research was aimed at exploring how companies can improve supply chain resilience during disruption through theoretical and empirical research. The results have shown that the effects of downtime, anomalies of vibrations, and equipment stress significantly affect the efficiency of delivery and the general performance negatively, which proves the pivotal role of resilience as a strategic necessity. On the other hand, resilience strategies like redundancy of inventory and preventive maintenance were demonstrated to enhance continuity of the supply chain though with cost tradeoffs.

The logistic regression model used on the dataset showed that the results on resilience can be projected with a fair degree of precision (79%), especially when it comes to predominant efficiency types. Inventory level and preventive maintenance proved to be the most influential predictors of the supply chain efficiency, whereas the downtime was continually associated with the inefficiency. The findings support the relevance of the Resource-Based View, the Dynamic Capabilities Perspective, and the Contingency Theory to explain resilience because they emphasize the importance of resources, flexibility and context-specific strategy.

Generally, the study highlights that resilience is not a defensive stance, but an initiative. Organizations can minimize vulnerability, protect operation and gain competitive advantage in the volatile environments by combining redundancy, predictive maintenance and adaptive strategies. The trade-offs between cost and resilience, however, should be managed well and strategies should be developed based on the unique risk situation in each organization.

7. Recommendations

The results of this research lead to a number of valuable suggestions to managers and policy-makers who want to create more resilient and flexible supply chains. One of the key lessons is the pivotal importance of preventative maintenance and remote tracking. The experiment proved the hypothesis that the increased condition scores, which measure the proactive management of assets,

were closely correlated with the increased efficiency and lowered costs. The need to invest in monitoring technologies like IoT-enabled sensors and predictive analytics is therefore encouraged in organizations. These instruments can also assist in predicting equipment stresses or possible malfunctions, and managers can act before it occurs and create expensive losses.

Meanwhile, the paper has demonstrated the role of inventory redundancy as a resilience strategy. Having buffer stocks was found to be effective in protecting delivery performance in the times of disruption. This advantage was, however, accompanied by higher costs of logistics reflecting the importance of selectivity. Companies must then develop an intermediate strategy, where extra inventory is only held on balance, on those items of strategic importance, or at a part of the supply chain that is most at risk. Such a narrow application of redundancy is the way to make sure that the resilience is maintained without affecting long-term efficiency.

The other important recommendation is diversification and co-operation with suppliers. Even though this aspect was not directly measured in the data, theory and previous case studies indicate that organizations that rely heavily on individual suppliers are very prone. By establishing relationships with a variety of suppliers, as well as through collaborative arrangements that focus on being transparent and agreeing to manage risks together, vulnerability can be substantially diminished. This resilience can be further improved by digital collaborative tools and jointly developed contingency plans that can enhance information sharing and coordinated actions.

The managerial consequences of the predictive modeling carried out in this paper are also straightforward. With a basic logistic regression model, it was found that resilience outcomes could be predicted in moderate accuracy. This shows that organizations can use operational data to develop predictive dashboard that serves as an early-warning system. Firms are able to track indicators of their performance in real time and act in advance when their resilience levels are in danger by incorporating predictive models in their decision-making processes. With further development of these systems, the use of more advanced machine learning techniques like ensemble models or explainable AI will be possible to improve predictions and raise the level of trust that managers have in their results.

In addition to strategies on a technical level, the findings also reflect the significance of organizational culture. Good resilience involves leadership dedication and the existence of workforce that is in line with adaptive principles. The resistance to change can lead to the hindrance of resilience efforts mostly in cases where managers have limited views about long-term

efficiency benefits. A culture that embraces readiness, education and adaptiveness must be developed in order to instill resilience into long term planning. It is possible to achieve this by training programs, communication initiatives, and role-modelling of leaders to change the organizational mindsets to preparedness to resilience.

Lastly, the study confirms the belief that resilience strategies should be contextualized, which is a proposal of Contingency Theory. There is no universal approach that is best. Companies in industries with a high volatility rate such as the healthcare or the electronic sector might have to utilise more redundancy and flexible sourcing mechanisms but companies in more stable markets can stick to efficiency-enhancing predictive mechanisms. In addition, resilience efforts should not be limited to big business. Small and medium-sized enterprises (SMEs), which in most cases have limited resources, need specific assistance to take resilience measures. Policymakers and larger companies can support that by offering subsidized electronic resources, common logistic centers, or collaborative training to enable the SMEs to build their resilience capacity.

Collectively, these suggestions point to the necessity of a holistic approach to the resilience of supply chain. All of them, such as preventative monitoring, strategic redundancy, supplier diversification, predictive analytics, cultural alignment, and context-sensitive strategies, are complementary. Installing resilience within operational practices as well as organizational values enables the firms to be more resilient against disruptions, ensure continuity of performance, and achieve long term competitive advantage in uncertain surroundings.

8. Limitations:

Although it has made contributions, the study has a number of limitations. To start with, the secondary nature of data limited the range of variables that were incorporated in the study. The dataset measure of human and relational aspects of resilience, including leadership performance, supplier partnership, and cultural preparedness, was not present in the dataset despite the significance of these factors illustrated in the literature. Second, the data had an issue of class imbalance, as there were a very small number of high-efficiency data. This compromised the generalization capability of this model to infrequent, but strategically significant outcomes. Third, it used only a logistic regression model and even though it had moderate accuracy, more advanced models like ensemble learning or cross-validation were not implemented in the notebook and would have offered much more solid evidence.

Lack of generalizability of findings is another weakness. The literature and the data set concentrate more on larger organizations leaving the small and middle-sized enterprises (SMEs) underrepresented though they are resilient in different ways. Lastly, robustness was not good due to the use of the single train-test split. Repeated testing or cross-validation may give more consistent estimates of performance. To overcome these shortcomings would deepen the theoretical and practical knowledge on resilience.

9. Conflicts of Interest:

The authors acknowledge that there are no conflicts of interest that could influence the results of this research or their interpretation. They also confirm that there are no financial or personal relationships that could be considered to have an undue influence on the submitted work.

10. Funding Statement

This research received no funding from external sources, whether governmental, private, or non-profit. The study was conducted entirely through the authors' own efforts without direct financial support.

11. Author Contribution Statement

All authors contributed equally to all aspects of this work, including study design, data collection, analysis, interpretation, and manuscript preparation. No individual author can be credited with a specific section or task, as the research was collaboratively developed and approved by all authors.

12. References:

Alfarsi, A., Lemke, F., & Yang, Y. (2019). *The significance of supply chain resilience*: A practical research study. 57(1), 1-19. https://doi.org/10.1080/00207543.2018.1497319.

Bhaskar, P. (2018). Dealing with unforeseen challenges: *The stability of shipping companies* (Doctoral dissertation). University of Tasmania.

Blackhurst, J., Dunn, K. S., and Craighead, C. W. (2011). *A map of global supply resiliency created empirically*. J.Bus.Logistics, 32(4), 374-391.

Brooks, I., Weatherston, J., and Wilkinson, G. (2010). *Globalization, challenges and changes*. In The business environment (pp. 306-336).

Carvalho, H., Azevedo, S. G., and Cruz-Machado, V (2014). *The resilience of the supply chain management: Theory building approach.* International Journal of Supply Chain and Operations Resilience, 1(1), 3-27.

Chauhan, A., Akram, M., & Chauhan, C. (2023). Mapping the road to resilient supply chains: A systematic Literature review. Journal of Business Research, 156, Chopra, S., & Meindl, P. (2007). *Supply chain management: Strategy, Planning and operation* (3 rd ed). Pearson.

Chowdhury, M. M. H., & Quaddus, M. (2016*). Supply chain resilience: Scale development and conceptualization. International Journal of Production and Operations Management, 36(8), 1242-1278.*

Darabi, B. (2023). *The impacts of supply chain resilience on competitive advantage and performance of the firm. Journal of Business and industrial Research.*

Harrison, A. (2013). *Business environment globally*. Oxford University Press.

IBM. (2020). *Case study Hurricane-resilient supply chain case study*. IBM. https://www.ibm.com/case-studies

Kemmerling, C. J. (2022). *Construction and exploratory factor analysis of the resilience skills practice inventory (Doctoral dissertation)*. William James College.

Kleindorfer, P. R., & Saad, G. H. (2005). *Controlling disruption hazards of supply chains. Production and Operations Management*, 14(1), 53-68.

Mensah, P., & Merkuryev, Y. (2014). *Creating a strong supply chain. Procedia - Social and Behavioral Sciences*, 110, 309-319.

Monroe, R. W., Teets, J. M., & Martin, P. R. (2014). *Supply chain risk management: A review of the risk sources and risk mitigation measures. International Journal of Applied Management Sciences, 6(1), 4-2*.

Netz, J., Svensson, C., & Brundin, E. (2020). *Business interruptions and emotional responses: A strategic as practice approach to fast decision-making.* 53(2), 101-135. https://doi.org/10.1016/j.lrp.2019.101910.

Ponomarov, S. Y., & Holcomb, M. C. (2009). *Knowing what supply chain resilience is. International Journal of Logistics Management, 20(1) 124-143.* https://doi.org/10.1108/09574090910954873.

Ponis, S. T., & Koronis, E. (2012). *Supply chain resilience: Concept definition and its building blocks. Journal of Applied Business Research, 28(5), 921-935.*

Sheffi, Y. (2005). Stability, Inc.: *How to come out of weakness to competitive edge*. MIT Press.

Snyder, L. V., Scaparra, M. P., Daskin, M. S. and Church, R. L. (2006). *The strategy of mitigating the supply chain network disruption. L. V. Snyder et al. (Eds.), Models, methods, and applications of innovative decision making* (p. 234-257). INFORMS.

Tabibnia, G., & Radecki, D. (2018*). Brain changing resilience training. Consulting Psychology Journal: Practice and Research*, 70 (1), 59-88.

Tang, C. S. (2006). *Views on supply chain risk management. International Journal of Production Economics*, 103(2), 451-488.

Toyota. (2012). *Post-earthquake recovery following the 2011 earthquake and tsunami. Toyota Global Newsroom*. https://global.toyota/en/newsroom

Yang, Y., Xie, H., Yu, G., & Liu, M. (2021). *Risk management and supply chain resilience: Systematic review. International Journal of Production Research*, 59(1), 1-2.

Doi: https://doi.org/10.52132/Ajrsp.e.2026.81.1

Academic Journal of Research and Scientific Publishing | Vol 7 | Issue 81
Publication Date: 5 January 2026 ISSN: 2706-6495

Corporate Governance in the Digital Economy (A Theoretical Analysis of the Challenges and Opportunities)

Ali M. Alsulami

PhD in Management, Rotman School, University of Toronto, Canada

Email: Ali.m.alsulami78@outlook.com

Received: 15 August 2025
First Decision: 26 August 2025
Revised: 15 October 2025
Accepted: 15 December 2025
Published: 5 January 2026

Abstract:

This research aims to establish a conceptual and theoretical framework for corporate governance within the context of the digital economy. It examines the transformations in governance roles and mechanisms, analyzes the key challenges facing corporate governance in the digital economy (with a focus on technological, organizational, and institutional dimensions), and explores the opportunities the digital economy offers for enhancing corporate governance, particularly in the areas of transparency and disclosure, oversight and accountability, and supporting strategic decision-making. This research employs a theoretical and analytical approach, based on a review and analysis of recent scholarly literature published in peer-reviewed international journals over the past seven years.

The research concludes that corporate governance in the digital economy is no longer merely a formal extension of traditional governance, but rather represents an institutional shift in roles and responsibilities. The board of directors, not the executive management alone, is now the primary actor in guiding digital transformation and managing its risks. A lack of digital expertise within the board leads to superficial oversight, deepening the governance gap. Digital technologies can enhance transparency and accountability if integrated within clear governance frameworks. Reliance on technology without parallel development of regulatory frameworks and corporate culture increases risks rather than reducing them.

Keywords: Corporate Governance, Digital Economy, Theoretical Analysis, Challenges, Opportunities

1. Introduction:

Over the past decade, the world has witnessed an unprecedented acceleration in the shift towards the digital economy as a new paradigm for value creation. This paradigm is based on data, digital platforms, algorithms, artificial intelligence, blockchain, and cloud infrastructure. This transformation has reshaped business models, organizational boundaries, and markets, giving rise to new patterns of risk and opportunity directly linked to how companies are managed, directed, and controlled. In this context, corporate governance emerges not only as a traditional mechanism for regulating the relationship between owners and management, but also as a dynamic institutional framework that must adapt to the demands of the digital economy. This includes its technological complexity, accelerated innovation cycle, broad stakeholder base, and heightened sensitivity to issues related to data, privacy, and cybersecurity (Nahum et al., 2026).

Recent literature has shown that digital transformation is not simply about adopting technology; it necessitates changes in organizational structure, decision-making mechanisms, and strategic oversight. Effective governance in the digital age depends on the board's ability to guide digital transformation and manage its risks within the context of ownership, board structure, and functions (Nahum et al., 2026). It is also influenced by the extent to which the board possesses digital expertise that enables it to understand, evaluate, and align technical decisions with strategic objectives. Recent empirical studies have supported this trend by highlighting the impact of digital expertise within the board in driving digital innovation and improving performance through a "resource allocation" channel, rather than solely through the traditional oversight role (Yu et al., 2025).

Conversely, the digital economy reveals a growing gap between the demands of corporate oversight and the capacity of many boards to address technological risks. Cybersecurity is a prime example; evidence shows that cybersecurity oversight has become a core board responsibility, yet current practices suffer from a lack of specialization, diffused responsibilities, and an over-reliance on a single “expert” member or on technical reports that fail to translate into accountable governance decisions (Gale et al., 2022). Published field findings also indicate that the absence of cybersecurity expertise within the board can lead to “symbolic oversight” rather than substantive oversight, even when formal oversight activities are performed similarly to those carried out by experts (Lowry et al., 2025). Digital transformation is thus redefining the standard of “due

diligence" for boards by shifting from traditional financial/operational oversight to oversight of data, algorithms, and digital infrastructure.

A related challenge is the growing reliance on artificial intelligence (AI) in forecasting, risk management, compliance, and reporting, raising new governance issues related to transparency, algorithmic bias, interpretability, and accountability. Recent contributions have proposed frameworks for integrating AI at the board and committee levels or within managerial work, emphasizing that "augmented intelligence" may be more consistent with accountability requirements than complete system autonomy (Ahdadou et al., 2025). Concurrently, legal regulation globally is moving towards "accountability documentation" models by imposing impact and risk assessment obligations and transparency requirements, thereby expanding the responsibilities of companies and their boards to society and regulators (Oduro et al., 2022). This means that governance in the digital economy is no longer limited to agency balances but also encompasses the governance of the social and legal implications of technologies.

In terms of data, data governance has become a central focus of corporate governance due to the increasing scale of data processing, the interconnectedness of digital supply chains, and the growing risks to compliance and reputation. Recent literature proposes approaches that link data protection compliance with sustainability and ESG frameworks as corporate incentives to promote data ethics and mitigate "legal but harmful" digital practices (Balboni & Francis, 2024). The European environment, for example, is witnessing advanced debate on how digital transformation, artificial intelligence, and the data economy are reshaping corporate law and governance through concepts such as "corporate digital responsibility" and the redefinition of data stakeholders (Möslein, 2025). These transformations underscore that digital governance is not merely a regulatory choice, but a necessary response to the changing nature of resources (data), risks (cyber/algorithmic), and accountability (regulatory/societal).

However, the digital economy should not be viewed solely as a source of challenges, but also as an incubator of significant governance opportunities. Digital technologies can enhance transparency, accuracy of disclosure, speed of oversight, and the ability of the governing body to anticipate future needs through advanced analytics. They may also enable new governance models within platform and blockchain environments, where decision-making authority is distributed among multiple stakeholders within governance systems ranging from centralized to open-source, depending on the platform's ecosystem characteristics and the incentives of its participants

(Santalo & Filatotchev, 2025). Therefore, the digital economy opens up avenues for developing governance models that are more adaptable to networks and platforms, more capable of integrating stakeholders, and more reliant on proactive risk management.

1.1. Research problem:

Based on the foregoing, the research problem lies in the need for a comprehensive theoretical analysis that explains the relationship between corporate governance and the digital economy, and identifies ways to develop governance frameworks that align with the requirements of the contemporary digital environment. The research problem is defined by the following main question:

How can corporate governance be developed within the digital economy in a way that balances the digital challenges and the opportunities offered by modern technologies?

This main question gives rise to a set of sub-questions consistent with the research topics, as follows:

- What is the conceptual and theoretical framework that governs the relationship between corporate governance and the digital economy?

- What are the most prominent technological, organizational, and institutional challenges facing corporate governance in the digital economy?

- How can the digital economy contribute to enhancing transparency, improving oversight and accountability, and supporting strategic decision-making within the framework of corporate governance?

1.2. Research Objectives:

This research aims to achieve a set of scientific objectives consistent with its analytical structure, namely:

- Establishing the conceptual and theoretical framework of corporate governance within the context of the digital economy, and demonstrating the transformations in governance roles and mechanisms.

- Analyzing the main challenges facing corporate governance in the digital economy, with a focus on technological, organizational, and institutional dimensions.

- Exploring the opportunities offered by the digital economy to enhance corporate governance, particularly in the areas of transparency and disclosure, oversight and accountability, and strategic decision support.

2. Research Methodology:

This research adopted a theoretical analytical approach, based on a review and analysis of recent scientific literature published in peer-reviewed international journals over the past seven years. The aim was to construct a conceptual and explanatory framework that clarifies the dimensions of corporate governance within the context of the digital economy. This approach was implemented by analyzing relevant concepts and theories, extrapolating digital challenges and opportunities, and linking them to current trends in corporate governance, without resorting to field data collection or statistical testing.

3. Theoretical Framework:

This section presents the theoretical framework for corporate governance in the digital economy through four main topics that address conceptual foundations, challenges, potential, and contemporary trends.

3.1. Conceptual and Theoretical Foundations of Corporate Governance in the Context of the Digital Economy

3.1.1. The Concept and Evolution of Corporate Governance

Corporate governance is a central concept in contemporary economic and administrative thought. It refers to the set of rules, mechanisms, and relationships through which companies are directed and controlled to ensure a balance between the interests of shareholders, management, and other stakeholders. Historically, the concept has been linked to the agency problem arising from the separation of ownership and management. Governance has sought to limit opportunistic management behavior and promote accountability and transparency (Nahum et al., 2026).

However, recent literature confirms that corporate governance is no longer confined to its narrow financial or legal dimensions. It has evolved to encompass strategic, institutional, and ethical dimensions. Contemporary corporate governance aims to ensure long-term sustainability, manage risks, guide innovation, and enhance market confidence, particularly in environments characterized by uncertainty and rapid technological change (Santalo & Filatotchev, 2025).

This development highlights the shift in governance from a supervisory tool to a strategic guidance mechanism.

In this context, the board of directors is seen as the central pillar of corporate governance, undertaking multiple functions including oversight of executive management, setting strategic directions, managing risks, and protecting stakeholder interests. With the accelerating pace of digital transformation, these functions have expanded to encompass overseeing complex technical decisions, such as investing in digital infrastructure, utilizing artificial intelligence, data governance, and cybersecurity (Gale et al., 2022). Consequently, the criterion for "governance effectiveness" is no longer solely based on independence or the number of committees, but rather on the board's ability to understand and interact with the digital environment.

3.1.2. The concept of the digital economy and its basic characteristics

The concept of the digital economy refers to an economic model that relies fundamentally on digital technologies for the production and exchange of goods and services, value creation, and market regulation. The core characteristic of the digital economy is the centrality of data as a strategic resource, in addition to reliance on digital platforms, cloud computing, artificial intelligence, blockchain, and the Internet of Things (Möslein, 2025).

The digital environment is characterized by several features that make it radically different from the traditional economy. First, it is highly immaterial, where value is generated more from information and algorithms than from physical assets. Second, it is characterized by rapid innovation and short technological lifecycles, forcing companies to make investment and strategic decisions under high levels of uncertainty. Third, it is characterized by interconnected markets across platforms, where companies operate within ecosystems comprising multiple actors, including developers, users, and regulators (Santalo & Filatotchev, 2025).

These characteristics lead to a redefinition of corporate risk, as digital risks—such as cyber breaches, privacy violations, and algorithmic bias become an integral part of strategic risk. Studies have shown that these risks cannot be effectively managed by technology units alone, but require high-level governance oversight due to their financial, legal, and reputational implications (Lowry et al., 2025). Therefore, the digital economy imposes a new governance logic that moves beyond traditional post-implementation frameworks to proactive and preventative models.

3.1.3. The Relationship Between Corporate Governance and the Digital Economy

The relationship between corporate governance and the digital economy is evident in the fact that digital transformation is not merely a technological change, but an institutional transformation that touches the very core of the company's guidance and control mechanisms. The literature has shown that the success of digital transformation depends largely on how it is implemented from a governance perspective, that is, on clear roles and responsibilities, the integration of the digital dimension into the strategy, and the provision of effective oversight by the board of directors (Nahum et al., 2026).

From a theoretical perspective, this relationship can be explained by combining several approaches. On the one hand, agency theory suggests that digitalization may widen the information gap between management and the board due to the complexity of technical decisions, necessitating the development of new oversight mechanisms. On the other hand, resource dependency theory asserts that the board's digital expertise is a strategic resource that grants the company access to technological knowledge and opportunities, enhancing its capacity for innovation (Yu et al., 2025). The corporate perspective highlights the role of regulatory and normative pressures—particularly those related to artificial intelligence and data protection—in reshaping governance practices (Oduro et al., 2022).

Empirical evidence supports this theoretical overlap, with recent studies demonstrating that having digitally experienced board members is positively associated with higher levels of digital innovation and performance, not only through improved oversight but also by supporting strategic decisions related to digital transformation (Yu et al., 2025).

Conversely, other findings suggest that the absence of such expertise can lead to superficial oversight of digital risks, particularly in cybersecurity, even when oversight activities are merely nominal (Lowry et al., 2025).

Furthermore, the digital economy is expanding the scope of governance to include social and regulatory accountability for technology use. Modern trends in AI regulation and data governance require companies to assess the ethical and legal implications of technologies, document their decisions, and bear responsibility for potential harms (Ahdadou et al., 2025; Balboni & Francis, 2024). This is driving the adoption of the concept of "digital governance" as a qualitative extension of traditional corporate governance.

3.2. Challenges Facing Corporate Governance in the Digital Economy

The digital economy represents a highly complex corporate environment characterized by the interplay of technical, organizational, and strategic dimensions. This imposes a growing set of unprecedented challenges on corporate governance. These challenges are not limited to technological aspects but extend to the legal framework, board structure, and accountability and oversight mechanisms. For analytical purposes, these challenges can be categorized into three main axes: technological, organizational and legal, and institutional and administrative.

3.2.1. Technological Challenges:

Digital technology constitutes the core of contemporary economic transformation, but it simultaneously generates a set of risks that complicate governance practices.

1- Cybersecurity Challenges

Cyber risks are among the most prominent challenges facing boards of directors in the digital economy, given their significant financial, legal, and reputational implications.

Key dimensions of the challenge:

- The increasing frequency and sophistication of cyberattacks
- The expanding scope of sensitive digital assets (customer data, intellectual property, algorithms)
- The difficulty of translating technical risks into strategic decisions at the board level
- Over-reliance on technical reports without a deep understanding of governance.

Evidence suggests that many boards of directors' exercise only nominal oversight of cybersecurity due to a lack of digital expertise, even when formal committees or policies exist (Gale et al., 2022; Lowry et al., 2025).

2- Challenges of Artificial Intelligence and Algorithms

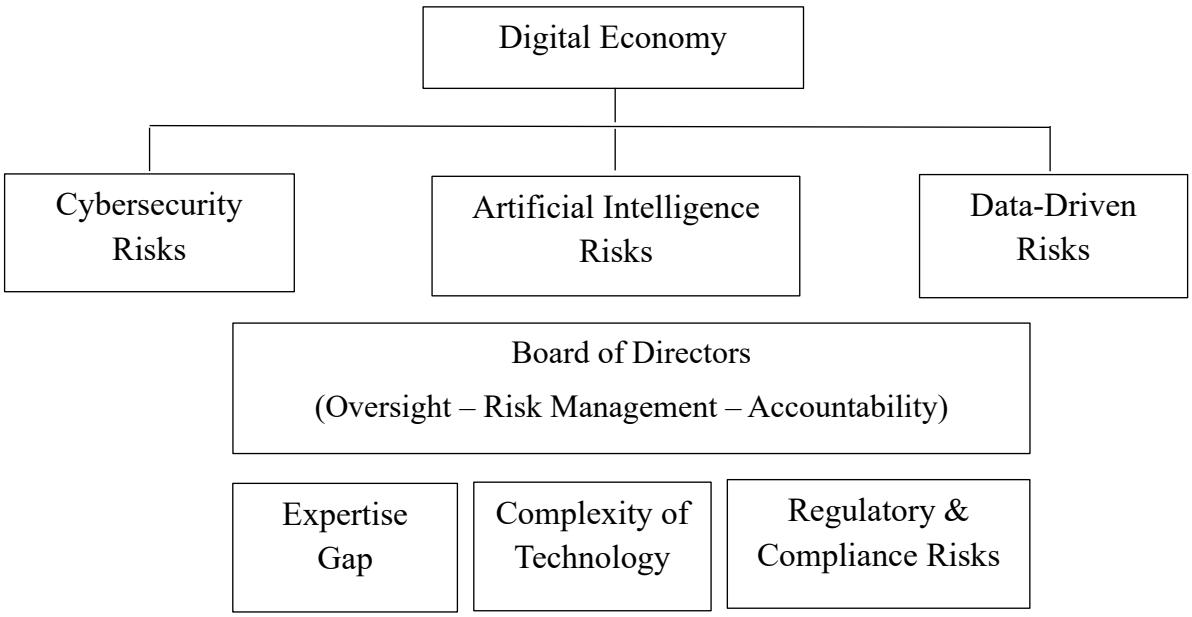
The increasing use of artificial intelligence in decision-making has complicated the concept of accountability within companies. The most prominent challenges include:

- The ambiguity of algorithmic logic (Black Box Problem)
- The risks of algorithmic bias and unintentional discrimination
- The difficulty in determining legal liability in case of error

– The limited ability of boards of directors to evaluate AI models.

Recent literature has confirmed that integrating AI without clear governance frameworks may lead to an unconscious delegation of decision-making power rather than "augmented intelligence" supporting human decision-makers (Ahdadou et al., 2025).

Figure (1): Technological Challenges for Corporate Governance in the Digital Economy



Source: Prepared by the researcher based on: Gale et al. (2022); Ahdadou et al. (2025)

This conceptual figure illustrates how key technological challenges cybersecurity risks, artificial intelligence risks, and data-driven risks emerge from the digital economy and directly affect the core governance functions of the board of directors, particularly oversight, risk management, and accountability. The figure further highlights structural governance vulnerabilities, including the digital expertise gap, technological complexity, and regulatory and compliance risks.

3.2.2. Legal and regulatory challenges:

The digital economy imposes a rapidly evolving and changing regulatory reality, creating a gap between operational innovation and traditional legal frameworks.

1- Inadequacy of traditional regulatory frameworks

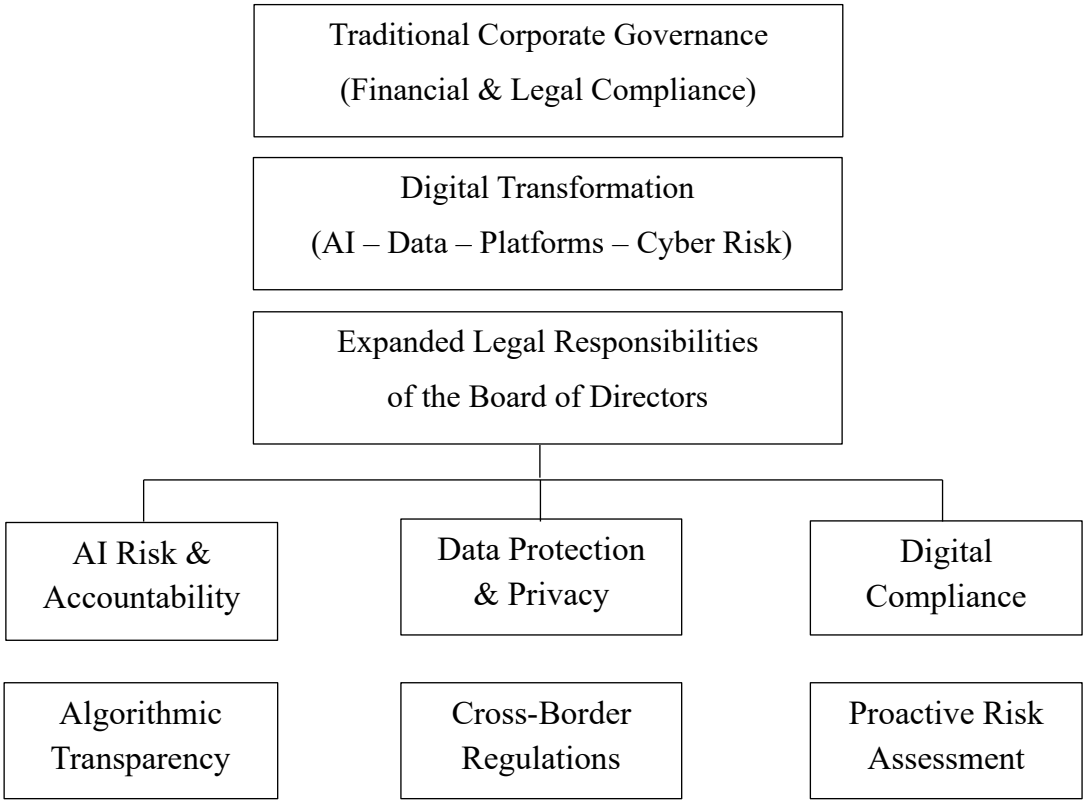
Companies face governance challenges stemming from the slow pace of legislation compared to the rapid pace of digital development, the lack of precise legal definitions of responsibility for algorithmic decisions, and the ambiguity surrounding the scope of digital disclosure obligations.

Recent studies have shown that new AI-related legislation imposes obligations to assess risks on companies, thus expanding the scope of board responsibility (Oduro et al., 2022).

2- Data governance and privacy

Data is a strategic asset, but it is also a source of increasing regulatory risks. Key challenges include compliance with multiple and cross-border legislation, reconciling data exploitation with ethical obligations, and integrating data governance within the ESG framework, as the literature suggests that weak data governance may lead to "formal legal compliance" without achieving effective protection for data subjects (Balboni & Francis, 2024).

Figure (2): The evolution of the legal responsibilities of the board of directors in the digital economy



Source: Prepared by the researcher based on: Oduro et al. (2022); Möslein (2025)

The figure above illustrates the transition of board responsibilities from traditional legal compliance to expanded digital accountability, which includes AI risk assessment, data protection, and digital sustainability.

3.2.3. Institutional and Administrative Challenges

In addition to technical and organizational challenges, the implementation of digital governance faces internal obstacles related to the institutional structure itself.

1- The Digital Expertise Gap on Boards of Directors

Studies indicate that many boards of directors lack members with specialized digital expertise, relying on external consultants instead of building internal capabilities. They also struggle to integrate the digital dimension into their overall strategy. Evidence has shown that the absence of digital expertise weakens the board's strategic role and limits its ability to effectively guide digital transformation (Yu et al., 2025).

2- Resistance to Change and Cultural Transformation

Institutional challenges include middle management resistance to digital transformation, the dominance of traditional governance logic, and weak digital culture and technical accountability. This leads to a gap between operational and governance digital transformation, where companies adopt technology without developing the accompanying institutional frameworks (Nahum et al., 2026).

Table (1): Governance challenges in the digital economy and proposed mechanisms for addressing them

Challenge category	The governance challenge	Impact on corporate governance	Proposed governance mechanisms
Technological	Escalating cyber risks	The council's limited capacity for effective oversight, and the increased risk of losses and reputational damage.	• Establish a dedicated cybersecurity committee at the board level • Integrate cybersecurity into strategic risk management • Appoint board members with technical expertise
Technological	The complexity of artificial intelligence	Difficulty in establishing accountability and assigning	• Adopting the principle of "augmented intelligence" instead of full delegation

	systems (Black Box)	responsibility when wrongdoing occurs.	• Requiring management to submit interpretability reports • Board oversight of AI use policies
Technological	Increasing reliance on big data	Risks of privacy breaches and data misuse.	• Developing an integrated data governance framework • Linking data management to ESG responsibilities • Adopting data ethics policies
Legal/ Regulatory	Inadequacies of traditional legislation	A gap between innovation and legal compliance.	• Adopting a proactive compliance approach • Board oversight of the regulatory impact assessment of technologies
Legal/ Regulatory	Multiple cross-border systems	Increased compliance costs and legal uncertainty.	• Establishing a corporate-wide organizational governance function • Harmonizing digital compliance policies globally
Institutional/ Administrative	Digital expertise gap within boards of directors	Formal oversight and a weak strategic role for the council.	• Diversifying the skills of board members • Ongoing digital training for board members
Institutional/ Administrative	Resistance to organizational change	Adoption of operational digitization without governance transformation.	• Aligning digital transformation with the company's strategy • Fostering a digital culture and accountability
Comprehensive Governance	Conflicts of interest in the digital environment	Weakening trust and transparency.	• Updating disclosure and conflict of interest policies • Enhancing digital transparency and smart disclosure

Table (1) shows that the challenges facing corporate governance in the digital economy are multidimensional. Technological risks (such as cybersecurity and artificial intelligence) intersect with the complexities of compliance and cross-border regulation, as well as internal challenges related to board capabilities and organizational culture. From the author's perspective, the most important finding of the table is that the problem is not the mere presence of technology, but rather the shift in the governance center of gravity from traditional reactive oversight to proactive governance that integrates digital risks into strategy and enterprise risk management (ERM) and translates them into accountable responsibilities at the board level. Evidence supports this trend; research on cybersecurity at the board level indicates that a lack of specialized expertise can lead to nominal oversight, even when oversight activities appear to be in place, thus deepening the governance gap in the digital environment (Gale et al., 2022; Lowry et al., 2025). The table also reflects that the knowledge gap within the board is not a mere organizational detail, but a critical variable affecting the company's ability to guide digital transformation and innovation. Digital expertise within the board is linked to better outcomes in terms of digital innovation—not only through an oversight role, but also through a "resource-saving" role and by linking technical decisions to strategic decisions (Yu et al., 2025).

The mechanisms proposed in Table 1 demonstrate a "governance package" approach rather than piecemeal solutions; that is, combining (1) building the board's capacity and assigning clear committees/responsibilities, (2) developing auditable policies, procedures, and reporting flows, and (3) aligning compliance with international frameworks that emphasize proactive risk assessment, documentation, and transparency.

In the area of cybersecurity, proposals such as establishing a cyber committee or integrating cybersecurity into the ERM align with international principles guiding boards that emphasize "governance from the top down," defining responsibilities, and strategically integrating cybersecurity rather than confining it to operational levels (World Economic Forum [WEF], 2021). In the realm of artificial intelligence (AI), the "proactive compliance" option, along with interpretability reports and impact assessments, aligns with the global regulatory trend toward requiring organizations to conduct systematic risk assessments and management processes both before deployment and throughout the product lifecycle (Oduro et al., 2022). This is further supported by applied standard frameworks such as NIST AI RMF 1.0, which frames AI risk management across operational functions (governance, measurement, and management) and

underscores the socio-technical nature of risk (National Institute of Standards and Technology [NIST], 2023).

In information security governance, the proposed approaches support a governance-led leadership logic based on "assess, direct, monitor, and communicate" as functions linked to top-level governance (International Organization for Standardization [ISO], 2020). Regarding the broader governance framework, the G20/OECD Principles (2023 edition) emphasize the board's role in strategic guidance, disclosure, and risk management, aligning with the repositioning of digital risks at the heart of governance, rather than on its periphery (OECD, 2023). From the author's perspective, the table's most significant value lies in highlighting that effective digital governance is not achieved simply by adding a policy or committee, but by redesigning the relationship between technology, strategy, and accountability and by building "institutional capacity" that prevents artificial intelligence, cybersecurity, and data governance from becoming silent risks beyond the scope of accountability.

From the above, we can see that the challenges facing corporate governance in the digital economy are multidimensional and interconnected, and cannot be addressed through isolated technological or organizational solutions. Cybersecurity, artificial intelligence, data governance, emerging legislation, and the expertise gap within boards are all contributing to a redefinition of the very concept of governance. These challenges underscore the need to develop integrated digital governance models capable of absorbing new risks without hindering innovation.

3.3. Opportunities Offered by the Digital Economy to Enhance Corporate Governance

The digital economy, along with its inherent risks, represents a practical lever for developing corporate governance by improving transparency and disclosure, enhancing oversight and accountability, and strengthening the quality of strategic decision-making. These opportunities stem from the shift towards standardized digital disclosure, the development of analytics and big data tools, the proliferation of regulatory automation technologies (RegTech/SupTech), and the application of artificial intelligence to support oversight and forecasting.

3.3.1. Enhancing Transparency and Disclosure

1) Digital Disclosure

Digital disclosure contributes to reducing information asymmetry and improving stakeholders' ability to evaluate and monitor, especially when presented in standardized, machine-readable

formats. Improving comparability and transparency through the adoption of standards such as XBRL is linked to increased transparency in financial disclosure environments, thereby enhancing the relevance and reliability of information (Al-Okaily et al., 2024). Standardizing Digital Transformation Disclosure Practices: Recent developments in "voluntary digital transformation disclosure" have shown that leading companies disclose digitally to varying degrees, highlighting a clear need for standardized guidelines to ensure consistency and comparability (Borrero-Domínguez et al., 2024).

2) Intelligent electronic and financial reporting:

This goes beyond simply "transferring the report to an electronic medium." It entails a shift to automated reporting, faster updates, and greater integration of information systems. Integrating electronic reporting with accounting information systems and analytics enhances auditability and traceability, and promotes transparency (Borrero-Domínguez et al., 2024).

Recent literature confirms that the characteristics of distributed data (such as decentralization and tamper resistance) pave the way for more reliable reporting, reduced trust gaps in information, and greater automation potential (Han et al., 2023).

3) Using Big Data in Oversight:

Big data provides governance with new oversight tools by shifting oversight from limited sample examination to continuous analysis of risk patterns and deviations. Improving the quality of monitoring and early detection through the adoption of big data analytics is linked to better decision-making, forecasting, and performance processes, thus supporting audit and risk committees with more accurate oversight signals (Chatterjee et al., 2023).

Recent reviews indicate that data visualization tools have become an important resource for auditing and oversight by improving the understanding of patterns and deviations and communicating findings to management and the board (Mauludina et al., 2024).

3.3.2. Improving oversight and accountability mechanisms

1) Near-real-time monitoring

Near real-time/continuous monitoring enables the board to transition from periodic to continuous monitoring of risk and compliance indicators by integrating IT governance into corporate governance. Recent studies demonstrate that the increasing reliance on technology

necessitates that IT governance become an integral part of corporate governance (rather than being entirely delegated to executive management), thereby enhancing the board's oversight of digital risks and opportunities (Caluwe et al., 2024). Furthermore, blockchain and auditing literature indicates that "agreed-upon" and "tamper-proof" data can enhance traceability and support more continuous forms of assurance/audit (Han et al., 2023).

2) Intelligent compliance systems:

The digital economy is driving automation and analytics-driven compliance over manual compliance through RegTech/SupTech solutions. Improving compliance efficiency and reducing the risk of violations: Recent reviews and evidence show that adopting RegTech can enhance assessment and monitoring capabilities and reduce the risks associated with financial misconduct, while also highlighting the need to manage the accompanying privacy risks (Jeyasingh, 2023).

Similarly, digital regulatory governance at the system level: The SupTech/RegTech literature discusses how digital tools enable more effective regulation and oversight through automation and data-driven coordination (Bagherifam, 2025).

These systems do not absolve the board of responsibility; rather, they shift the board's role to adopting a smart compliance framework and defining risk thresholds, controls, and data quality standards.

3) The role of technology in reducing administrative corruption:

Technology can reduce corruption by minimizing manual transactions, enhancing traceability, and increasing the transparency of procedures (especially in supply chains, spending, procurement, and sensitive operations). Furthermore, it can enhance transparency and traceability through blockchain, as recent studies provide evidence of blockchain's potential to support transparency and accountability in anti-corruption contexts through traceability and tamper resistance (Ayeboafo, 2025).

3.3.3. Supporting Strategic Decision-Making

1) Predictive Analysis: Predictive analysis supports the board's ability to anticipate and identify trends and risks before they materialize. This is achieved through models based on internal and external data, improving forecasting, decision-making, and performance. Field evidence indicates that big data analytics enhances forecast quality and supports "smart decision-making," which is reflected in improved performance (Chatterjee et al., 2023).

Furthermore, translating analytics into governance is crucial. Governance value is realized when predictive outputs are translated into risk appetite policies and early warning indicators that are presented to board committees in a clear and accountable manner.

2) Decision Support Systems:

Decision support systems enhance the board and management's ability to evaluate scenarios, allocate resources, and justify decisions, especially when integrated with databases and digital reports. Integrating technology into the governance structure is also essential. Integrating IT governance into corporate governance (rather than isolating it) improves the quality of decisions related to digital investment, internal control, and risk management (Caluwe et al., 2024). Furthermore, improved auditability and reasoning are achieved, as standardized digital reporting (such as XBRL) supports a "reviewable decision" pathway through verifiable and re-analyzable data (Al-Okaily et al., 2024).

3) Sustainable Corporate Innovation

The digital economy provides tools to enhance sustainable innovation by improving efficiency, supporting green innovation, reducing emissions, and increasing resource productivity. European evidence shows that digital integration is associated with improvements in emissions reduction, green innovation, and resource efficiency (Quttainah & Ayadi, 2024).

Recent studies also provide evidence of the relationship between digital transformation and green innovation in the manufacturing sector within transition mechanisms (Mu et al., 2025). A research trend also highlights the link between digital transformation and improved sustainable innovation performance through organizational/digital capabilities (Awan et al., 2023).

The following table illustrates how the opportunities offered by the digital economy to enhance corporate governance can be translated into a practical governance measurement framework that supports the board's role in guidance, oversight, and accountability. The table demonstrates that the true value of digital transformation lies not in the mere adoption of technologies, but in their alignment with clear measurement mechanisms that enable monitoring of transparency, oversight effectiveness, and the quality of strategic decision-making. From an analytical perspective, the table reflects the shift in governance from a traditional model based on periodic, post-assessment evaluation to a dynamic digital governance model that relies on continuous monitoring, tracking, and proactive risk assessment, thereby enhancing the council's ability to respond quickly and intervene promptly.

Table (2): Digital Economy Opportunities Matrix and Governance Measurement Indicators (KPIs/KRIs)

The opportunity	KPI (Performance Indicator)	How is KPI measured
Enhancing Transparency and Disclosure	Digital Disclosure Timeliness	Average number of days between event and digital disclosure
	Disclosure Completeness Index	Percentage of completed disclosure items to total (checklist-based)
	Stakeholder Access Rate	Number of reports accessed/downloaded per period
Smart electronic and financial reporting	Automation Coverage (Reporting)	Percentage of automated reporting processes out of total processes
	Close Cycle Time	Financial closure period (days) before/after the transition
	Audit Trail Completeness	Percentage of transactions with a complete tracking history
Using Big Data for Oversight	Anomaly Detection Coverage	Percentage of transactions/operations included in anomaly analysis
	Control Testing Frequency	Number of controls tested/month (ongoing)
	Risk Signal Lead Time	Mean time between risk alert and occurrence
Improving oversight and accountability	Monitoring Latency	Average time for risk board updates (minutes/hours)
	Incident Response Time (MTTR)	Average incident response/repair time
	Board Reporting Frequency (Digital Risk)	Number of digital risk reports submitted by the council per quarter
Intelligent Compliance (RegTech) Systems	Compliance Automation Rate	Percentage of automated compliance checks out of the total
	KYC/AML Processing Time	Average KYC/AML check completion time
	Policy Update Lead Time	Time from new regulation issuance to internal policy update

Reducing administrative corruption	Process Traceability Score	Percentage of transactions with full traceability (from application to approval)
	Procurement Transparency Index	Percentage of published contracts/tenders + availability of competition data
	Whistleblowing Resolution Time	Average reporting processing and closure time
Strategic Decision Support	Forecast Accuracy (MAPE)	Average Forecast Error (MAPE) for Sales/Flows
	Scenario Coverage	Number of Scenarios/Stress Tests Performed Annually
	Early Warning Hit Rate	Valid Alarms/Total Alarms After Verification
Decision Support Systems (DSS)	Decision Cycle Time	Decision-making time from referral to approval
	Decision Justification Coverage	Percentage of board decisions documented with justifications and supporting data
	User Adoption Rate (DSS)	Active users/Total target audience
Sustainable Corporate Innovation	Green Innovation Output	Number of green innovation patents/projects/year
	Digital Efficiency Gain	Reduced cost/process time due to digitalization
	ESG Data Reliability Score	Percentage of verified/reliable ESG data out of total

Source: Prepared by the researcher based on previous literature

The table above confirms that the diversity of digital opportunities, from smart disclosure to predictive analytics and sustainable innovation, calls for an integrated governance framework that balances maximizing performance and reducing risks, and prevents digitalization from becoming a source of new governance gaps instead of a tool to enhance trust, transparency and institutional sustainability.

4. Conclusion:

The research concluded that the digital economy is no longer merely a new operational context for companies, but has become a fundamental reshaping factor in corporate governance, particularly in terms of roles, responsibilities, and oversight and accountability mechanisms. The theoretical

analysis demonstrated that the acceleration of digitalization creates a governance gap if it is not accompanied by a parallel development of institutional structures and board capabilities, especially in the areas of cybersecurity, data governance, and artificial intelligence. The research also showed that the digital economy offers real opportunities to enhance transparency and disclosure, improve continuous oversight, and support data-driven strategic decision-making, provided that these tools are integrated within a comprehensive governance framework that goes beyond mere formal compliance. Thus, the effectiveness of digital governance is determined by companies' ability to transition from traditional control models to dynamic and proactive governance that is compatible with the complexity of the digital environment.

4.1. Summary of results:

- Corporate governance in the digital economy is no longer a formal extension of traditional governance, but rather represents an institutional transformation in roles and responsibilities.

- The board of directors is the primary actor in guiding digital transformation and managing its risks, not just the executive management. - The lack of digital expertise within the board leads to superficial oversight and deepens the governance gap.

- Digital technologies can enhance transparency and accountability if integrated within clear governance frameworks.

- Relying on technology without a parallel development of regulatory frameworks and corporate culture increases risks rather than reducing them.

4.2. Recommendations:

- Integrate digital governance into the overall corporate strategy rather than treating it as a supporting technical function.

- Enhance digital and knowledge diversity on boards of directors through appointment and ongoing training.

- Develop integrated frameworks for data governance, artificial intelligence, and cybersecurity under the direct supervision of the board.

- Adopt digital measurement mechanisms that support transparency, continuous monitoring, and data-driven decision-making.

- Adopt a proactive and flexible compliance approach that aligns with the evolution of global digital regulations.

4.3. Limitations of the Study

This study is subject to several methodological and epistemological limitations that should be considered when interpreting its findings. First, the study adopted a theoretical analytical approach based on a review of the scientific literature, without conducting empirical testing or analyzing field data. This limits the generalizability of the results to all sectors and institutional contexts. Second, the study focused on the general conceptual frameworks of corporate governance in the digital economy and did not address in detail the sectoral differences or institutional variations between small and medium-sized enterprises (SMEs) and large or multinational corporations. Third, the references used were limited to recent literature published in English and in peer-reviewed international journals, which may exclude some relevant local or contextual perspectives. Fourth, given the rapid nature of technological and organizational development, some of the trends and challenges discussed in the study may change over time, making the findings relevant to the timeframe in which the study was conducted. Finally, the study did not delve deeply into the cultural and social dimensions that may influence the implementation of digital governance, which opens the door for more specialized and comprehensive future studies.

5. Acknowledgements

The author(s) declare that there is no conflict of interest. This research did not receive any specific funding from public, commercial, or not-for-profit agencies. No human participants, animals, or personal data were involved in this study, and no datasets were generated or analyzed.

6. References:

Achim, M. V., Văidean, V.-L., Popa, A.-I. S., & Safta, L.-I. (2022). The impact of corporate governance on the digitalization process: Empirical evidence for the Romanian companies. Digital Finance, 4(4), 313–340. https://doi.org/10.1007/s42521-022-00058-6

Ahdadou, M., Ahdadou, A., Aajly, A., & Tahrouch, M. (2025). Artificial intelligence in corporate boards: A dual-dimensional framework for integration across autonomy and structural levels. Data Science and Management. https://doi.org/10.1016/j.dsm.2025.12.001

Al-Okaily, M., Alkayed, H., & Al-Okaily, A. (2024). Does XBRL adoption increase financial information transparency in digital disclosure environment? Insights from emerging markets. International Journal of Information Management Data Insights, 4(1), 100228. https://doi.org/10.1016/j.jjimei.2024.100228

Awan, U., et al. (2023). How does digital transformation affect sustainable innovation performance? Sustainable Development. https://doi.org/10.1002/sd.2830

Ayeboafo, B. (2025). Leveraging blockchain technology adoption in the fight against corruption. Elsevier journal.

Bagherifam, N. (2025). Digital regulatory governance: The role of RegTech and SupTech. Journal of Risk and Financial Management, 13(4), 217. https://www.mdpi.com/2227-7072/13/4/217

Balboni, P., & Francis, K. E. (2024). Data ethics and digital sustainability: Bridging legal data protection compliance and ESG for a responsible data-driven future. Journal of Responsible Technology, 18, 100099. https://doi.org/10.1016/j.jrt.2024.100099

Ben-Daya, M., Hassini, E., & Bahroun, Z. (2021). Internet of things and supply chain management: A literature review. International Journal of Production Research, 59(15), 4719–4742. https://doi.org/10.1080/00207543.2020.1759542

Borrero-Domínguez, C., Cortijo-Gallego, V., & Escobar-Rodríguez, T. (2024). Digital transformation voluntary disclosure: Insights from leading European companies. International Journal of Accounting Information Systems, 55, 100711. https://doi.org/10.1016/j.accinf.2024.100711

Caluwe, L., Wilkin, C. L., De Haes, S., & Huygh, T. (2024). Board roles required for IT governance to become an integral component of corporate governance. International Journal of Accounting Information Systems, 54, 100694. https://doi.org/10.1016/j.accinf.2024.100694

Chatterjee, S., Chaudhuri, R., Gupta, S., Sivarajah, U., & Bag, S. (2023). Assessing the impact of big data analytics on decision-making processes, forecasting, and performance of a firm. Technological Forecasting and Social Change, 196, 122824. https://doi.org/10.1016/j.techfore.2023.122824

Floridi, L., Cowls, J., Beltrametti, M., et al. (2022). AI4People—An ethical framework for a good AI society. Minds and Machines, 32(1), 1–28. https://doi.org/10.1007/s11023-021-09565-3

Gale, M., Bongiovanni, I., & Slapnicar, S. (2022). Governing cybersecurity from the boardroom: Challenges, drivers, and ways ahead. Computers & Security, 121, 102840. https://doi.org/10.1016/j.cose.2022.102840

Han, H., Shiwakoti, R. K., Jarvis, R., Mordi, C., & Botchie, D. (2023). Accounting and auditing with blockchain technology and artificial intelligence: A literature review. International Journal of Accounting Information Systems, 48, 100598. https://doi.org/10.1016/j.accinf.2022.100598

Harel, Y., & Carmeli, A. (2025). A strategic cybersecurity oversight framework: A board's imperative. Journal of Cybersecurity, 11(1), tyaf021. https://doi.org/10.1093/cybsec/tyaf021

He, N., et al. (2025). The dark side of corporate digital transformation: Evidence on bribery. Elsevier journal.

International Organization for Standardization. (2020). ISO/IEC 27014:2020 — Governance of information security.

Lowry, M., Vance, A., & Vance, M. D. (2025). Inexpert supervision: Field evidence on boards' oversight of cybersecurity. Management Science. https://doi.org/10.1287/mnsc.2023.04147

Mauludina, M. A., et al. (2024). The role of data visualization in auditing: A systematic review. Cogent Business & Management. https://doi.org/10.1080/23311975.2024.2358168

Möslein, F. (2025). European company law in the age of digital transformation: Artificial intelligence, data economy, and digital corporate governance. ERA Forum, 26, 629–646. https://doi.org/10.1007/s12027-025-00864-6

Mu, X., et al. (2025). The impact of digital transformation on green innovation in manufacturing firms. Economic Research–Ekonomska Istraživanja. https://doi.org/10.1080/15140326.2025.2464488

Nahum, N., Larsson-Olaison, U., Uman, T., & Achtenhagen, L. (2026). Corporate governance for digital transformation: The role of ownership and the board of directors. Technological Forecasting and Social Change, 223, 124453. https://doi.org/10.1016/j.techfore.2025.124453

National Institute of Standards and Technology. (2023). Artificial Intelligence Risk Management Framework (AI RMF 1.0). https://doi.org/10.6028/NIST.AI.100-1

Oduro, S., Moss, E., & Metcalf, J. (2022). Obligations to assess: Recent trends in AI accountability regulations. Patterns, 3(11), 100608. https://doi.org/10.1016/j.patter.2022.100608

OECD. (2022). Digitalisation and corporate governance.

OECD. (2023). G20/OECD Principles of Corporate Governance 2023.

Pérez-Bustamante, G., et al. (2022). Digital governance and corporate sustainability. Journal of Business Research, 142, 211–223. https://doi.org/10.1016/j.jbusres.2021.12.035

Quttainah, M. A., & Ayadi, I. (2024). The impact of digital integration on corporate sustainability: Emissions reduction, environmental innovation, and resource efficiency in Europe. Elsevier journal. https://doi.org/10.1016/j.jik.2024.100525

Raisch, S., & Krakowski, S. (2021). Artificial intelligence and management: The automation–augmentation paradox. Academy of Management Review, 46(1), 192–210. https://doi.org/10.5465/amr.2018.0072

Santalo, J., & Filatotchev, I. (2025). Strategic governance of blockchain platforms: From centralized to open source control systems. Long Range Planning, 58(4), 102539. https://doi.org/10.1016/j.lrp.2025.102539

Turel, O., Liu, P., & Bart, C. (2023). Board-level IT governance and digital business strategy alignment. MIS Quarterly Executive, 22(2), 89–104.

Vial, G. (2021). Understanding digital transformation: A review and a research agenda. Journal of Strategic Information Systems, 30(2), 101695. https://doi.org/10.1016/j.jsis.2021.101695

Wang, Y., Kung, L., & Byrd, T. A. (2022). Big data analytics and organizational agility. Information & Management, 59(1), 103507. https://doi.org/10.1016/j.im.2021.103507

World Economic Forum. (2021). Principles for Board Governance of Cyber Risk.

World Economic Forum. (2023). Global governance of digital transformation.

Yermack, D. (2023). Corporate governance and blockchains. Review of Finance, 27(4), 1351–1383. https://doi.org/10.1093/rof/rfad006

Yu, S., Zheng, X., & Liu, M. J. (2025). Board digital expertise and digital innovation: Evidence from commercial banks in China. Research in International Business and Finance, 76, 102854. https://doi.org/10.1016/j.ribaf.2025.102854

Doi: https://doi.org/10.52132/Ajrsp.e.2026.81.2