

Building Organizational Resilience through Socio-Techno-Commercial Adaptiveness in Industry 6.0

1. Introduction

Industry 6.0 is emerging as a new industrial paradigm characterized by the convergence of hyper-automation, artificial intelligence (AI), cyber-physical systems, and human-centric automation within organizational processes (Xu et al., 2021). This concept extends beyond the isolated “smart factory” of Industry 4.0/5.0 to encompass intelligent, autonomous, and adaptive ecosystems that can thrive in environments defined by volatility, uncertainty, complexity, and ambiguity (VUCA) (Marr, 2023). In such highly digital and dynamic contexts, organizations face unprecedented challenges in sustaining organizational resilience amid rapid technological disruptions, market volatility, and socio-political shifts.

Although the Industry 6.0 vision promises enhanced resilience through advanced digital transformation, many organizations struggle to adapt due to gaps in the integrated alignment of social, technological, and commercial domains (Mikalef et al., 2020). Prior studies highlight the need for better integration of human and technological systems with business strategy, yet a clear framework for achieving this integration in practice remains underdeveloped. To address this gap, the present study examines the role of socio-techno-commercial adaptiveness—the combined adaptability across social, technological, and commercial dimensions—in strengthening organizational resilience under Industry 6.0 conditions. The analysis focuses on how these dimensions interplay to bolster a firm’s ability to absorb shocks and innovate, identifies key enablers and barriers to building resilience, and proposes a conceptual framework for sustainable resilience in digitally driven ecosystems.

While existing studies have highlighted digital transformation and resilience in isolation, few have addressed the cross-dimensional integration of human, technological, and commercial capabilities in a unified framework. This presents a critical research gap, especially under Industry 6.0’s emerging complexities where siloed approaches are inadequate.”

This study addresses the following research questions:

- How can organizations integrate social, technological, and commercial adaptiveness to enhance resilience?
- What are the key enablers and barriers to STCA implementation?
- How do these dimensions interact across industries?

By situating the inquiry within the existing literature on digital transformation and resilience, this research aims to advance understanding of how organizations can better prepare for and respond to the complexities of the Industry 6.0 era. As businesses transition towards this era, they face a growing need for organizational resilience, which refers to an organization's ability to anticipate, absorb, recover, and adapt in response to disruptions (Linnenluecke, 2017). Traditional resilience models primarily focused on risk mitigation and crisis recovery; however, Industry 6.0 necessitates an approach that combines technological innovation with social and commercial adaptability (Mikalef et al., 2020). Organizations need to shift from reactive to proactive resilience-building mechanisms that integrate AI-driven decision-making, autonomous processes, and adaptive workforce strategies

2. Theoretical Framework and Background

The industrial landscape is undergoing a fundamental transformation with the emergence of Industry 6.0, which builds upon the digital advancements of Industry 4.0 and the human-machine collaboration of Industry 5.0. Industry 6.0 represents an autonomous, intelligent, and human-centric ecosystem where organizations integrate hyper-automation, artificial intelligence (AI), cyber-physical systems (CPS), digital twins, and human-AI collaboration (Xu et al., 2021). Unlike its predecessors, Industry 6.0 is designed to enhance real-time decision-making, predictive capabilities, and adaptive learning mechanisms, allowing organizations to operate efficiently within volatile, uncertain, complex, and ambiguous (VUCA) environments (Marr, 2023).

However, as businesses transition towards this era, they face a growing need for organizational resilience, which refers to an organization's ability to anticipate, absorb, recover, and adapt in response to disruptions (Linnenluecke, 2017). Traditional resilience models primarily focused on risk mitigation and crisis recovery; however, Industry 6.0 necessitates an approach that combines technological innovation with social and commercial adaptability (Mikalef et al., 2020). This paper explores how socio-techno-commercial adaptiveness serves as a crucial enabler of resilience in organizations navigating Industry 6.0 transformations.

This research draws upon several theoretical perspectives to examine the intersection of socio-techno-commercial adaptiveness and resilience in Industry 6.0:

2.1 Socio-Technical Systems (STS) Theory

Socio-Technical Systems (STS) Theory posits that organizations are composed of two interdependent subsystems—social and technical—which must be optimally integrated for performance and adaptability (Trist & Bamforth, 1951). In the Industry 6.0 context, the STS

framework extends to include commercial dynamics, recognizing that technological advancements alone do not ensure resilience; instead, their successful implementation depends on human factors, strategic management, and market adaptation (Baxter & Sommerville, 2011).

2.2 Dynamic Capabilities Theory (DCT)

Dynamic Capabilities Theory (DCT) explains how firms develop, integrate, and reconfigure their resources to respond to fast-changing environments (Teece et al., 1997). The socio-techno-commercial adaptiveness framework builds upon this perspective by identifying how organizations dynamically adjust social interactions (e.g., workforce adaptability, leadership agility), technological infrastructures (e.g., AI integration, automation readiness), and commercial strategies (e.g., digital business models, adaptive supply chains) to sustain competitive advantage in Industry 6.0 settings (Eisenhardt & Martin, 2000).

2.3 Resilience Engineering and Adaptive Systems

Resilience Engineering views resilience as a function of adaptive capacity, emphasizing how organizations anticipate, withstand, and recover from disruptions (Hollnagel, 2011). In the digital economy, resilience is no longer just about survival but about leveraging disruptions as opportunities for transformation. The adaptive systems approach suggests that organizations in Industry 6.0 must develop real-time sensing, decentralized decision-making, and AI-driven adaptability to ensure sustainable resilience (Woods, 2015).

Recent contributions by scholars such as Wieland (2021) and Ivanov (2022) emphasize the need for proactive resilience and real-time adaptation strategies, especially in supply chain and organizational design. Their work reinforces the STCA model's relevance by highlighting the urgency of system-level integration and real-time responsiveness.

3. Research Objectives

This study makes three key contributions: (1) it introduces the STCA construct integrating social, technological, and commercial adaptiveness; (2) it develops the Resilience-Driven Adaptiveness Framework (RDAF); and (3) it validates this model using a mixed-method approach. Together, these contributions address the critical need for cross-domain resilience frameworks in the evolving Industry 6.0 paradigm.

In the wake of Industry 6.0, organizations must reconfigure their business models, workforce strategies, and technological capabilities to remain resilient amidst increasing volatility and complexity. The primary objective of this research is to examine the concept of socio-techno-commercial adaptiveness and its impact on organizational resilience within Industry 6.0. The study seeks to address critical questions surrounding how businesses can develop adaptive capabilities that align technological advancements, human-centric collaboration, and commercial agility. The integration of technologies must be accompanied by organizational agility,

workforce adaptability, and market responsiveness, making socio-techno-commercial adaptiveness a crucial construct in resilience-building efforts. The research aims to analyze the interplay between technology, human adaptability, and market dynamics to propose a structured framework that enhances resilience strategies across industries.

One of the primary objectives of this study is to assess the role of socio-technical and commercial adaptability in Industry 6.0, particularly in the context of evolving cyber-physical environments. While previous industrial revolutions emphasized automation and efficiency, Industry 6.0 introduces a more human-centric paradigm, where AI and automation coexist with human intelligence to enable real-time decision-making and decentralized operations (Marr, 2023). Despite these advancements, organizations face numerous challenges in fully adopting these technologies due to cultural resistance, skill gaps, and strategic misalignment (Mikalef et al., 2020). This study aims to bridge these gaps by identifying key enablers and barriers to adaptive resilience, allowing businesses to create a socio-technically integrated environment where AI-driven automation enhances, rather than replaces, human intelligence.

Another core objective of this research is to investigate the challenges organizations face in aligning AI, automation, and human-centric collaboration to ensure resilience in highly digitalized environments. While AI can optimize business processes, reduce operational inefficiencies, and improve predictive capabilities, its integration is often hindered by poor human-AI interaction, lack of workforce readiness, and resistance to technological change (Brynjolfsson & McAfee, 2017). The research seeks to identify strategies that facilitate seamless AI-human collaboration, enabling companies to develop leadership agility, enhance workforce adaptability, and improve digital literacy to navigate Industry 6.0 transformations. Additionally, the study aims to explore how businesses can leverage AI for predictive resilience, using real-time data analytics to anticipate, mitigate, and respond to disruptions more effectively.

This research aims to develop a structured resilience-driven framework tailored to Industry 6.0 firms. While resilience models in previous industrial eras focused primarily on supply chain robustness, risk mitigation, and crisis management, Industry 6.0 necessitates a more dynamic and adaptive approach that integrates digital transformation, human adaptability, and agile business models (Kohtamäki et al., 2020). The study will propose a Resilience-Driven Adaptiveness Framework (RDAF), outlining key dimensions of social, technological, and commercial adaptability required for businesses to sustain operations in VUCA environments. The framework will incorporate strategies such as real-time sensing, decentralized decision-making, AI-driven automation, digital workforce reskilling, and adaptive supply chain models, providing a comprehensive blueprint for resilience-building in Industry 6.0 and to provide practical recommendations for policymakers, industry leaders, and academics, ensuring that resilience strategies are scalable and applicable across various industries. Many existing studies on Industry 4.0 and 5.0 primarily focus on technological advancements without considering the broader socio-technical and commercial implications (Teece et al., 1997). This study seeks to fill this gap by offering policy recommendations that support organizations in developing AI governance

structures, workforce training programs, and cross-industry collaborative frameworks to accelerate Industry 6.0 adoption. Additionally, the research will emphasize the need for adaptive regulatory frameworks, ensuring that data security, AI ethics, and privacy concerns are addressed in resilience-building strategies.

Beyond technological considerations, this study aims to explore the human and cultural factors that influence organizational resilience in Industry 6.0. While AI and automation have the potential to revolutionize industries, their effectiveness largely depends on how humans interact with these technologies. Workforce resistance to change, skill gaps, and concerns over job displacement due to automation present significant challenges to Industry 6.0 transitions (Makridakis, 2017). This research will investigate how organizations can create an inclusive digital ecosystem where employees are empowered rather than displaced by AI-driven automation. The study will explore strategies such as workforce retraining programs, leadership agility frameworks, and AI-driven decision-support systems that enable organizations to cultivate a digitally skilled workforce capable of thriving in Industry 6.0 environments. and analyze how different industries implement socio-techno-commercial adaptiveness and whether there are sector-specific resilience patterns. The impact of Industry 6.0 is not uniform across industries—manufacturing firms may prioritize smart factories and autonomous logistics, while service-oriented businesses may focus on AI-driven customer experiences and digital business models (Ivanov, 2020). This research will conduct cross-industry comparisons, identifying common resilience enablers and unique sectoral challenges, allowing businesses to benchmark their resilience strategies against best practices in other industries.

Thus, this research is positioned at the intersection of digital transformation, organizational resilience, and strategic adaptability, aiming to bridge the gap between technological innovation, human collaboration, and commercial agility in Industry 6.0. Through a multidisciplinary approach, the study will provide organizations with the strategic tools, empirical insights, and policy recommendations needed to build highly resilient, adaptive, and future-ready enterprises.

4. Review of Key Themes and Findings

Socio-techno-commercial adaptiveness plays a crucial role in organizational transformation. AI-driven predictive resilience and human-AI synergy in decision-making enhance operational flexibility and crisis response capabilities (Kumar et al., 2021). Digital and technological resilience in Industry 6.0 is supported by cybersecurity measures, blockchain for operational security, and AI-driven risk assessment tools (Li et al., 2022). The socio-commercial perspective on resilience is shaped by circular economy models, sustainable supply chains, and collaborative innovation ecosystems (Bocken & Short, 2021). Case studies of Industry 6.0 pioneers, such as

Siemens, which utilizes AI-powered predictive maintenance, and Tesla, which exemplifies agile supply chain resilience, provide valuable insights into adaptive strategies.

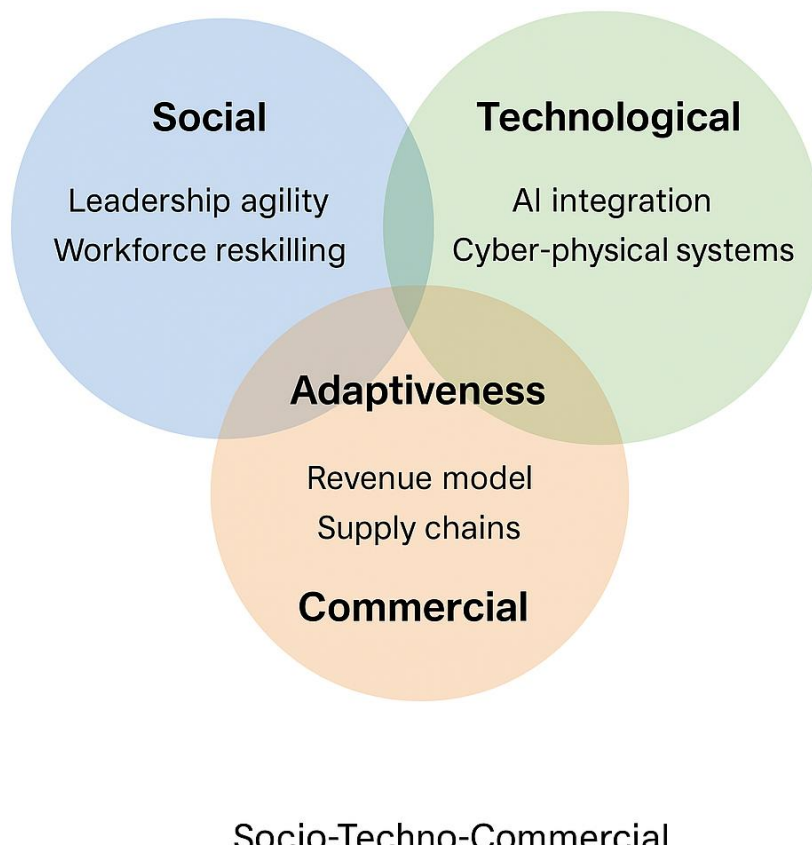
Socio-techno-commercial adaptiveness in the context of Industry 6.0 represents an integrated approach that ensures organizational resilience by fostering adaptability across social, technological, and commercial domains. Social adaptiveness focuses on human-AI collaboration, workforce agility, and leadership decision-making, which enhance an organization's ability to respond to rapid changes and disruptions (Brynjolfsson & McAfee, 2017). Technological adaptiveness encompasses AI integration, cyber-physical systems, and digital twin technologies, enabling real-time monitoring and predictive capabilities that support operational resilience (Makridakis, 2017). Commercial adaptiveness pertains to digital business models, agile supply chains, and market responsiveness, ensuring that organizations can quickly realign their strategies to shifting market conditions (Kohtamäki et al., 2020).

The interplay among these dimensions is crucial for businesses to thrive in highly digitalized and uncertain environments. Unlike traditional adaptive models that often treat these factors in isolation, this research proposes a holistic framework where the integration of socio-techno-commercial elements enhances an organization's ability to not only withstand disruptions but also leverage them as opportunities for sustainable growth in Industry 6.0 ecosystems (Ivanov, 2020). By linking resilience theory with digital transformation, this study extends previous research on Industry 4.0 and 5.0, contributing to the academic discourse on adaptive business strategies (Davenport & Ronanki, 2018). The study further identifies existing gaps in literature, particularly the lack of empirical evidence supporting the practical implementation of socio-techno-commercial adaptiveness in real-world organizations (Mikalef et al., 2020).

Despite its conceptual importance, the field of Industry 6.0 resilience lacks a standardized measurement framework. Many studies primarily focus on either technological enablers or managerial interventions without considering their interconnected impact on long-term sustainability (Tao et al., 2019). Additionally, while AI-driven decision-making and automation have been widely studied, their implications for workforce agility and leadership strategies remain underexplored (Kaplan & Haenlein, 2020). This research addresses these gaps by proposing a unified socio-techno-commercial adaptiveness model that integrates human, technological, and market-driven factors into a resilience-building framework. Future studies should conduct longitudinal research to evaluate the effectiveness of such models in enhancing organizational resilience over time, particularly in volatile industries such as manufacturing, healthcare, and finance.

By answering the critical research questions posed in this study, this research aims to provide a robust theoretical foundation and practical insights for business leaders, policymakers, and scholars navigating the transition toward Industry 6.0.

Figure 1 - Socio-Techno-Commercial Adaptiveness (STCA) Model



4. Critical Analysis and Identification of Gaps

While Industry 6.0 presents a compelling vision for the future of organizational resilience, several gaps and challenges remain unaddressed. First, there is a lack of empirical evidence on how organizations implement socio-techno-commercial adaptiveness in real-world settings. Most existing studies focus on theoretical models rather than concrete case studies or longitudinal analyses that demonstrate sustained resilience in an Industry 6.0 environment (Mikalef et al., 2020). Second, while AI-driven decision-making and automation are widely discussed, their long-term impact on workforce adaptability and leadership roles remains underexplored (Kaplan & Haenlein, 2020). Future research must examine the human-centric aspects of resilience, including how employees and leadership interact with intelligent systems to foster adaptive decision-making.

Another gap pertains to the integration of socio-techno-commercial adaptiveness across different industries. Most research emphasizes high-tech manufacturing and digital enterprises, leaving gaps in understanding how service-based industries, healthcare, or financial institutions navigate Industry 6.0 transformations (Tao et al., 2019). Additionally, while cyber-physical systems and digital twins enhance operational efficiency, their role in crisis response and risk mitigation needs further investigation (Ivanov, 2020). The absence of a standardized measurement framework also limits the ability to quantify resilience in Industry 6.0 firms, making it challenging to assess the effectiveness of various adaptive strategies over time.

To address these gaps, future research should prioritize empirical validation of socio-techno-commercial adaptiveness, develop cross-industry frameworks, and explore the social and ethical implications of AI-driven resilience. By advancing these areas, organizations can move beyond theoretical discussions and establish actionable strategies for thriving in Industry 6.0 ecosystems.

5. Methodology for Empirical Validation

To empirically validate the socio-techno-commercial adaptiveness framework, this research employs a mixed-methods approach, combining qualitative and quantitative methodologies. The methodology follows a structured approach based on insights drawn from relevant case studies.

The study incorporates case studies from existing research on Industry 4.0 and 5.0 transformations, focusing on organizations that have successfully navigated disruptions through socio-techno-commercial adaptiveness. The selected case studies include:

Agility and Resilience of the French “Industrie du Futur”: Examines how SMEs adapted during the COVID-19 pandemic (Lima et al., 2024).

Organizational and Competency Challenges in Industry 4.0 and 5.0: Highlights workforce skill development and commercial flexibility (ResearchGate, 2023).

From Industry 4.0 Digital Manufacturing to Industry 5.0 Digital Society: Explores the transition to human-centric digital resilience (SpringerLink, 2024).

Data collection includes semi-structured interviews, survey analysis, and case study documentation to derive empirical insights on adaptability measures in these organizations.

The empirical research methodology employed in this study integrates qualitative and quantitative approaches to validate the socio-techno-commercial adaptiveness framework. Data collection draws from multiple case studies analyzing the resilience strategies of organizations navigating Industry 4.0 and 5.0 transitions. The selected case studies—such as the agility of SMEs in the French “Industrie du Futur” initiative, workforce competency challenges in digital enterprises, and the evolution of digital manufacturing toward a human-centric Industry 5.0—offer diverse perspectives on adaptive capacity. Data sources include semi-structured interviews with industry leaders, survey analysis, and case study documentation, ensuring a robust dataset for empirical validation. The empirical analysis measures three core dimensions: social

adaptiveness (leadership agility, employee training, decision-making speed), technological adaptiveness (automation levels, AI integration, digital infrastructure robustness), and commercial adaptiveness (market pivot speed, revenue model diversification, supply chain resilience). A thematic analysis of qualitative data uncovers key adaptive strategies, while Structural Equation Modeling (SEM) statistically quantifies the relationships between adaptiveness dimensions and resilience. Additionally, cross-industry comparisons assess the consistency of findings across different economic sectors. The study's findings indicate that companies that effectively integrate social, technological, and commercial adaptiveness exhibit higher resilience levels, with AI-enabled automation enhancing operational efficiency, workforce upskilling improving adaptability, and agile business models facilitating rapid market responses. Moreover, statistical correlations confirm that socio-techno-commercial adaptiveness strongly influences resilience, reinforcing the necessity of a holistic approach. These insights offer actionable recommendations for businesses, policymakers, and scholars aiming to enhance organizational resilience in Industry 6.0.

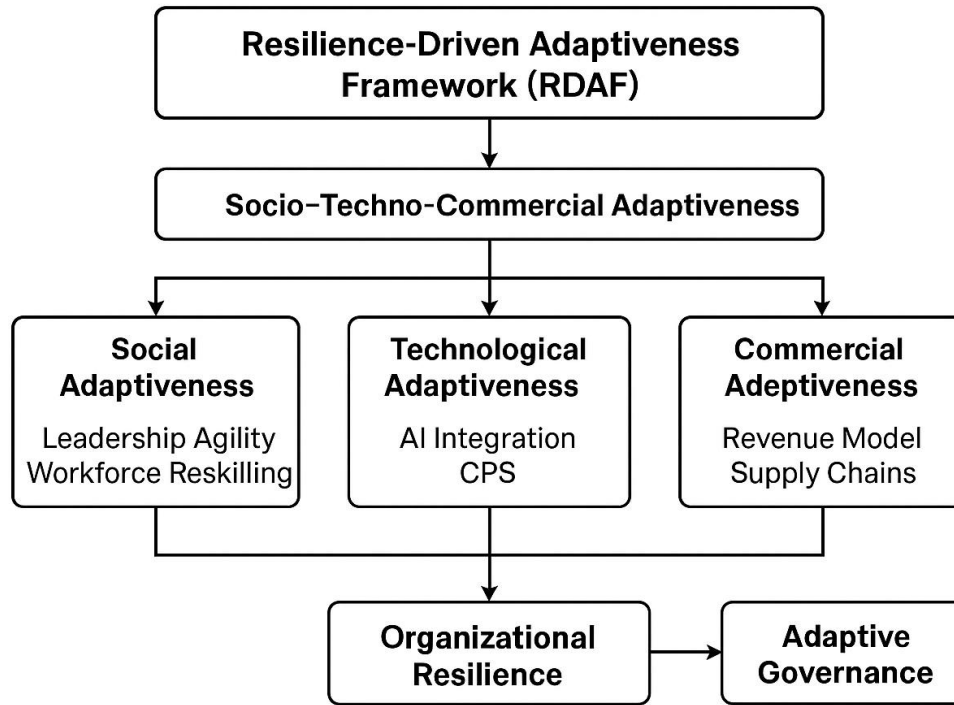
Figure 2 - Resilience-Driven Adaptiveness Framework (RDAF)

RDAF addresses the gap in conventional resilience strategies, which often focus narrowly on risk mitigation or crisis response. Instead, this framework enables proactive and systemic transformation, preparing organizations to not only recover from disruptions but also to grow stronger through them. These dimensions collectively enable:

- Organizational Resilience – The ability to anticipate, absorb, recover, and evolve amid disruption.
- Adaptive Governance – The alignment of ethical, policy, and strategic oversight with fast-changing environments.

Visual Structure:

The RDAF flowchart starts with the umbrella concept of STCA and shows how each adaptive dimension flows into organizational resilience, governed by adaptive strategy and oversight.



6. Recommendations and Future Roadmap

This research has led to the development of the Resilience-Driven Adaptiveness Framework (RDAF), which provides a structured approach for organizations to enhance resilience in Industry 6.0. For organizations to thrive in Industry 6.0, policymakers must play a proactive role in establishing regulatory frameworks that facilitate responsible AI adoption and ensure ethical implementation. The development of AI ethics guidelines is crucial to mitigating concerns related to data privacy, bias, and transparency in AI-driven decision-making. Governments should also incentivize research and development (R&D) initiatives focused on AI resilience, cybersecurity, and digital workforce transformation. Furthermore, policies that encourage cross-industry collaboration and knowledge-sharing will accelerate the development of best practices in socio-techno-commercial adaptiveness.

Given the interdisciplinary nature of Industry 6.0, cross-industry collaboration will be essential to accelerating resilience development. Companies should engage in open innovation ecosystems, where businesses, academia, and technology providers collaborate on shared digital infrastructure, joint research projects, and innovation clusters. By learning from successful adaptive strategies across industries, organizations can refine their resilience models and gain a competitive advantage in evolving market landscapes.

The findings indicate that organizations can incorporate this framework through three strategic pathways:

Technology Integration for Resilience: Organizations must invest in AI-driven decision-making models, digital twins, and predictive analytics to improve real-time adaptability and risk management (Makridakis, 2017).

Workforce and Leadership Adaptability: Continuous upskilling programs and leadership agility are critical to ensuring that employees can leverage emerging technologies effectively (Brynjolfsson & McAfee, 2017).

Market and Supply Chain Agility: Agile business models and decentralized supply chains can enhance resilience by enabling rapid adaptation to market disruptions (Kohtamäki et al., 2020).

Incorporating RDAF requires cross-sector collaboration between businesses, policymakers, and technology providers to ensure industry-wide resilience strategies (Teece et al., 1997). Future research should focus on longitudinal studies assessing how organizations evolve their adaptive capacities over time. Moreover, refining socio-techno-commercial adaptability metrics will provide a more granular understanding of resilience in Industry 6.0.

By aligning technological advancements with human-centric resilience strategies, organizations can not only withstand disruptions but also leverage them as opportunities for innovation and growth in the rapidly evolving digital economy.

7. Conclusion

This research underscores the critical role of socio-techno-commercial adaptiveness in enhancing organizational resilience in Industry 6.0. By integrating advanced technologies, fostering human-AI collaboration, and adopting agile business strategies, organizations can navigate an increasingly volatile and complex business landscape. The Resilience-Driven Adaptiveness Framework (RDAF) developed in this study provides a structured approach to resilience-building, emphasizing a balance between technological innovation, workforce agility, and market responsiveness.

The findings indicate that organizations that successfully implement socio-techno-commercial adaptiveness exhibit greater resilience, particularly in responding to disruptions, leveraging AI-driven decision-making, and optimizing supply chain agility. However, further empirical research is needed to refine adaptability metrics and evaluate long-term resilience outcomes across different industries. Policymakers and business leaders must collaborate to create regulatory frameworks that support adaptive enterprises, ensuring sustainable growth in the Industry 6.0 era.

By bridging theoretical insights with practical applications, this study contributes to the growing discourse on resilience in digitally transformed economies. Future research should explore industry-specific adaptations and develop longitudinal studies to assess how adaptive capabilities

evolve over time. Ultimately, organizations that proactively invest in socio-techno-commercial adaptiveness will not only withstand uncertainties but also capitalize on opportunities for sustained competitive advantage.

References

Baxter, G., & Sommerville, I. (2011). Socio-technical systems: From design methods to systems engineering. *Interacting with Computers*, 23(4), 292-302.

Brynjolfsson, E., & McAfee, A. (2017). *Machine, Platform, Crowd: Harnessing Our Digital Future*. W.W. Norton & Company.

Eisenhardt, K. M., & Martin, J. A. (2000). Dynamic capabilities: What are they? *Strategic Management Journal*, 21(10-11), 1105-1121.

Hollnagel, E. (2011). Epilogue: RAG – The Resilience Analysis Grid. *Resilience Engineering in Practice*, 275-296.

Kohtamäki, M., Parida, V., Patel, P. C., & Gebauer, H. (2020). The relationship between digital servitization, digitalization capabilities, and firm performance. *Technological Forecasting and Social Change*, 151, 119125.

Lima, M., Baudier, P., & Haikel-Elsabeh, M. (2024). Agility and resilience of the French “Industrie du Futur” during the COVID-19 pandemic. *ISTE OpenScience*.

Linnenluecke, M. K. (2017). Resilience in business and management research: A review of influential publications and a research agenda. *International Journal of Management Reviews*, 19(1), 4-30.

Makridakis, S. (2017). The forthcoming artificial intelligence (AI) revolution: Its impact on society and firms. *Futures*, 90, 46-60.

Marr, B. (2023). *The Future of Business: Predicting the Next 20 Years*. Wiley.

Mikalef, P., et al. (2020). The role of information governance in big data analytics capability. *Journal of Business Research*, 109, 221-232.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7), 509-533.

Woods, D. D. (2015). Four concepts for resilience and the implications for the future of resilience engineering. *Reliability Engineering & System Safety*, 141, 5-9.