https://research.adra.ac.id /index.php/jssut/
P - ISSN: 3026-5959
E - ISSN: 3026-605X

Architecting Technological Resilience: Evaluating the Impact of Legacy System Modernization on Organizational Agility in the Age of Generative AI

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ABSTRACT

Background. Organizations are under immense pressure to modernize legacy systems to stay competitive in a fast-changing tech landscape. While Generative AI is recognized as a key driver for productivity and innovation, the specific link between upgrading old systems and achieving organizational agility in the AI era remains largely underexplored.
Purpose. This study aims to evaluate how legacy system modernization impacts organizational agility within the context of Generative AI integration. It seeks to understand if these technical upgrades serve as a strategic foundation for fostering adaptability and long-term resilience.
Method. The research utilized a mixed-methods approach, combining quantitative surveys and qualitative interviews. Data was gathered from key stakeholders across 30 organizations that have successfully completed the modernization of their legacy infrastructures.
Results. The findings show significant improvements in decision-making speed, market responsiveness, and operational flexibility. The study highlights that modernization is a critical enabler for faster Generative AI adoption, which directly enhances an organization's overall agility.
Conclusion. Modernizing legacy systems is a strategic investment rather than a mere technical necessity. It builds technological resilience and provides a vital framework for AI integration, offering organizations a pathway to sustained competitive advantage and better adaptability.

KEYWORDS

Digital Transformation, Generative AI, Legacy System Modernization, Organizational Agility, Technological Resilience

Citation: Azzuan, Azzuan., Hartanto, B. Z., Syarifuddin, Q. M., & Faisol, A. (2026). Architecting Technological Resilience: Evaluating the Impact of Legacy System Modernization on Organizational Agility in the Age of Generative AI. *Journal of Social Science Utilizing Technology*, *4*(2), 91–102. https://doi.org/10.70177/jssut.v4i2.3680

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Received: October 5, 2025
Accepted: March 15, 2026
Published: April 20, 2026

INTRODUCTION

Technological resilience has become a pivotal theme in organizational strategy, particularly as companies face rapid technological disruptions in the digital era. In today's highly competitive environment, organizations must adapt swiftly to emerging technologies to maintain their competitive edge. One such transformative force is Generative AI, which promises to revolutionize industries by automating complex tasks, enhancing decision-making, and driving innovation. However, organizations often face significant challenges when modernizing legacy systems to harness the full potential of these new technologies.

Legacy systems, which have historically been integral to business operations, tend to be rigid, outdated, and incompatible with modern technological advancements (Aretoulaki dkk., 2025). The integration of Generative AI into existing infrastructures requires not only technological upgrades but also a fundamental shift in organizational culture and processes (Kanigolla dkk., 2024). As such, understanding the role of legacy system modernization in fostering organizational agility has become critical for organizations aiming to navigate the complexities of the current digital landscape.

The need for modernization is urgent, as organizations with outdated legacy systems struggle to respond to market changes with the speed and flexibility required to remain competitive (Karam dkk., 2024). In many cases, legacy systems limit an organization's ability to implement new technologies, resulting in inefficiencies, increased costs, and missed opportunities for innovation (Guan dkk., 2024). The adoption of Generative AI can only be fully realized if these legacy systems are transformed to support the demands of modern digital workflows (Koti dkk., 2024). However, the process of modernizing legacy systems presents a host of challenges, including technical debt, system integration issues, and the need for substantial investments in both technology and human resources (McClellan & Pegus, 2025). These challenges underscore the importance of evaluating how legacy system modernization impacts organizational agility and whether it facilitates the integration of emerging technologies like Generative AI.

Despite the growing emphasis on technological resilience and the increasing adoption of Generative AI, there remains a lack of comprehensive understanding regarding how legacy system modernization impacts organizational agility (Wang dkk., 2024). While numerous studies have explored the individual benefits of AI adoption or legacy system modernization, few have examined the interplay between these factors and their combined effect on an organization's ability to remain agile in the face of technological advancements (Bolshakov dkk., 2024). The problem this research seeks to address is the lack of empirical evidence on how modernizing legacy systems enables or hinders an organization's capacity to quickly adapt to the implementation of Generative AI (Tarko, 2025). As organizations strive to remain competitive and innovative, understanding the specific ways in which legacy system modernization enhances or impedes organizational agility is essential (Stupar dkk., 2025). This research aims to fill this gap by providing a comprehensive analysis of the relationship between these variables, offering insights that are crucial for organizations looking to thrive in an AI-driven environment.

In many cases, organizations embark on legacy system modernization projects with the hope that these upgrades will enhance their technological resilience and overall agility (Borzęcka, 2025). However, the process of modernization can be complex and fraught with challenges. Issues such as system compatibility, employee resistance to change, and a lack of expertise in both legacy systems and new technologies can hinder the successful integration of Generative AI (Pawlak & Saternus, 2025). Additionally, while legacy system modernization may improve certain operational efficiencies, it may not necessarily lead to the enhanced organizational agility that is needed to thrive in the current digital age (Humberstone dkk., 2024). Therefore, understanding the nuanced relationship between these two factors is critical for organizations seeking to invest in both modern infrastructure and AI technologies.

The primary objective of this study is to evaluate the impact of legacy system modernization on organizational agility, specifically in the context of adopting and integrating Generative AI (Humberstone dkk., 2024). This research seeks to understand how modernizing legacy systems can influence an organization's ability to adapt to rapidly evolving technologies, particularly those that rely on artificial intelligence (Baby dkk., 2024). By investigating the experiences of organizations

that have undertaken legacy system modernization projects, the study aims to provide empirical evidence on the ways in which these technological transformations affect agility in decision-making, operational flexibility, and responsiveness to market changes (Engel-Di Mauro & Li, 2025). The study also aims to explore the factors that contribute to or hinder the successful integration of Generative AI after legacy systems have been modernized.

Through this research, the study also seeks to contribute to the theoretical understanding of technological resilience in organizations (Boateng dkk., 2025). Specifically, it will examine the role that legacy system modernization plays in creating a foundation for organizational agility in the face of digital disruptions (Jafari dkk., 2025). In doing so, the research aims to identify best practices for organizations seeking to modernize their infrastructures to better support AI adoption (Hafiz, 2025). This will include an exploration of the key enablers and barriers that influence the successful integration of Generative AI following the modernization of legacy systems (Ayad & Bouffard, 2025). Ultimately, the goal of this study is to provide actionable insights for organizational leaders and decision-makers who are navigating the challenges of modernizing legacy systems in an AI-driven landscape.

Although there is considerable literature on legacy system modernization, organizational agility, and the adoption of artificial intelligence, the intersection between these areas remains underexplored (Phuong & Ngoc Lam, 2025). Existing research primarily focuses on the technological and financial aspects of legacy system upgrades, such as system compatibility, cost-benefit analysis, and the challenges associated with legacy infrastructure (Raza dkk., 2025). On the other hand, studies on organizational agility tend to concentrate on aspects such as leadership, culture, and decision-making, with less emphasis on the technological underpinnings that support agility (Boonlua dkk., 2025). While some research has considered the role of AI in enhancing organizational agility, the impact of legacy system modernization on an organization's ability to leverage AI technologies, especially Generative AI, has not been adequately addressed.

This research aims to bridge this gap by examining how the modernization of legacy systems specifically enables or inhibits organizational agility in the context of adopting Generative AI (Zeng & Yin, 2025). By integrating the perspectives of both technological transformation and organizational behavior, this study offers a novel approach to understanding the relationship between infrastructure and agility (AlBataineh dkk., 2024). The lack of empirical evidence on this interplay presents a significant opportunity for this research to contribute new insights into how organizations can manage the complexities of legacy system modernization while fostering the adaptability required to succeed in the age of AI (Minampati dkk., 2025). In doing so, the study will provide a more holistic view of how organizations can build technological resilience through infrastructure upgrades and strategic human resource practices.

This study offers a novel perspective on the intersection of legacy system modernization, organizational agility, and Generative AI adoption (Higgs & Stornaiuolo, 2024). While the individual concepts of legacy system modernization and AI adoption have been studied extensively, few studies have integrated these aspects with organizational agility in a comprehensive framework (Krakowski, 2025). The novelty of this research lies in its focus on evaluating the combined impact of legacy system upgrades and AI integration on organizational agility, providing new insights into how these technological transformations can work together to enhance resilience (Kunz & Wirtz, 2024). Additionally, by focusing specifically on Generative AI a rapidly evolving technology that has significant implications for business operations this research addresses an urgent need for understanding how organizations can navigate the challenges of AI adoption while maintaining operational flexibility.

The importance of this research is particularly evident in today's rapidly changing digital landscape (Tsvasman, 2025). As Generative AI becomes more pervasive across industries, organizations must be able to integrate these technologies effectively without disrupting their operations (Jonnalaa dkk., 2025). Legacy systems, however, can present significant obstacles to AI adoption. This study justifies the need for a deeper exploration of how the modernization of these systems can facilitate or hinder AI integration and, ultimately, organizational agility (Gomathi Sankar & David, 2024). By focusing on the intersection of these factors, this research provides valuable theoretical and practical insights that can guide organizations in their efforts to build technological resilience, adapt to digital disruptions, and capitalize on the opportunities offered by Generative AI.

RESEARCH METHODOLOGY

This study employs a mixed-methods research design, combining both qualitative and quantitative approaches to evaluate the impact of legacy system modernization on organizational agility, particularly in the context of adopting Generative AI technologies (Adeyinka & Adeyinka, 2025). The quantitative component of the research focuses on analyzing data related to organizational performance, agility, and technological adoption before and after the modernization of legacy systems (Firdaus dkk., 2025). Surveys and organizational performance metrics are used to quantify changes in agility, decision-making speed, and responsiveness to market changes. The qualitative phase involves conducting in-depth interviews with key stakeholders, including IT managers, HR directors, and organizational leaders, to explore their experiences, challenges, and perceptions regarding the modernization process and its impact on organizational agility (Ameen & Tarba, 2025). This dual approach allows for a comprehensive understanding of the multifaceted relationship between legacy system upgrades and agility in the era of Generative AI.

The population for this study includes organizations that have undergone or are in the process of modernizing their legacy systems to integrate Generative AI technologies. These organizations span various industries, including finance, healthcare, and manufacturing, ensuring a diverse sample representative of different sectors. A purposive sampling technique is employed to select organizations that have implemented or are currently implementing modernized infrastructure capable of supporting AI technologies. A total of 30 organizations are selected, with 10 to 15 key respondents from each organization, including IT managers, executives, and HR professionals, making the total sample size approximately 300 individuals. This sample size is deemed adequate to provide robust data for both the quantitative and qualitative components of the study.

Instruments used for data collection include a structured survey designed to assess organizational agility, including factors such as flexibility, responsiveness, and decision-making speed, both pre- and post-modernization. The survey employs a 5-point Likert scale to measure employee and managerial perceptions of these factors. In addition, qualitative data will be gathered through semi-structured interviews, which allow for a deeper exploration of the contextual factors influencing legacy system modernization and its effects on agility. The interview guide is developed to capture insights regarding the challenges faced during the modernization process, the role of Generative AI, and the perceived outcomes of modernization on organizational performance and flexibility. Both the survey and interview instruments are pre-tested to ensure validity and reliability.

The data collection procedures begin with the administration of the structured surveys to organizational representatives across the selected companies. The surveys will be distributed electronically to ensure accessibility and a broader reach. After completing the surveys, semi-

structured interviews will be scheduled with key organizational stakeholders. The interviews will be conducted either in person or via video conferencing, depending on the participants' location and preference. All interviews will be audio-recorded with consent and transcribed for subsequent analysis. For the quantitative data, statistical analysis, including paired sample t-tests and regression analysis, will be employed to assess changes in organizational agility before and after legacy system modernization. The qualitative data will be analyzed using thematic analysis to identify key patterns and themes related to the experiences and perceptions of modernization's impact. Together, these methods will provide a comprehensive understanding of the impact of legacy system modernization on organizational agility in the age of Generative AI.

RESULT AND DISCUSSION

The data collected from 30 organizations that underwent legacy system modernization to integrate Generative AI were analyzed to evaluate the impact on organizational agility. Descriptive statistics revealed significant improvements in several key agility metrics, including decision-making speed, responsiveness to market changes, and flexibility in adapting to new technological tools. Table 1 provides a summary of the organizational agility scores, measured pre- and post-modernization. The average score for decision-making speed increased from 3.2 (before modernization) to 4.5 (after modernization), indicating a marked improvement. Similarly, the agility in responding to market changes showed an average increase from 3.4 to 4.6. The flexibility score also improved significantly, moving from 3.1 to 4.4. These results suggest that organizations that modernized their legacy systems experienced notable gains in agility, particularly in areas critical for the integration of Generative AI technologies.

Table 1. Organizational Agility Scores Pre- and Post-Modernization

Agility Metric	Pre-Modernization (Mean)	Post-Modernization (Mean)
Decision-Making Speed	3.2	4.5
Market Responsiveness	3.4	4.6
Flexibility	3.1	4.4

The data further supports the notion that technological resilience, particularly through system modernization, enhances an organization’s ability to adapt to rapidly changing digital environments. These improvements in organizational agility align with findings from similar studies on IT infrastructure modernization, which emphasize the positive impact of upgrading legacy systems on operational flexibility. However, the data also suggests that the impact of modernization is not uniform across all sectors. Organizations in industries with highly dynamic technological environments, such as finance and healthcare, reported more substantial improvements compared to those in industries with less frequent technological disruptions. The variability in agility improvements across industries underscores the need for a contextual understanding of the modernization process and its direct relationship with organizational agility.

The inferential analysis, employing paired sample t-tests and regression analysis, confirmed the statistical significance of the observed changes in organizational agility. The t-test results for decision-making speed ($t(29) = 12.15$, $p < 0.01$) and market responsiveness ($t(29) = 14.03$, $p < 0.01$) indicated that the improvements were highly significant. Regression analysis revealed that legacy system modernization accounted for approximately 45% of the variance in agility improvements, with a particularly strong effect on flexibility ($\beta = 0.52$, $p < 0.01$). This confirms the hypothesis that the modernization of legacy systems plays a crucial role in enhancing organizational agility,

particularly when combined with the adoption of new technologies like Generative AI. The interaction between modernization and agility suggests that technological updates alone may not suffice without organizational-wide readiness for change, including leadership support and employee engagement.

The relationship between legacy system modernization and organizational agility was further examined by assessing the correlation between the modernization efforts and the adoption of Generative AI technologies. A positive correlation ($r = 0.72$, $p < 0.01$) was found between the extent of system upgrades and the speed at which Generative AI was integrated into organizational processes. Organizations that implemented more comprehensive modernization strategies, such as cloud migration and integration of scalable infrastructure, reported faster adoption and more successful implementation of Generative AI solutions. This relationship highlights the importance of having a robust, future-proof technological foundation in place for organizations aiming to capitalize on the benefits of AI technologies. It also suggests that organizations with outdated legacy systems may face significant barriers to successful AI integration without addressing infrastructure issues first.

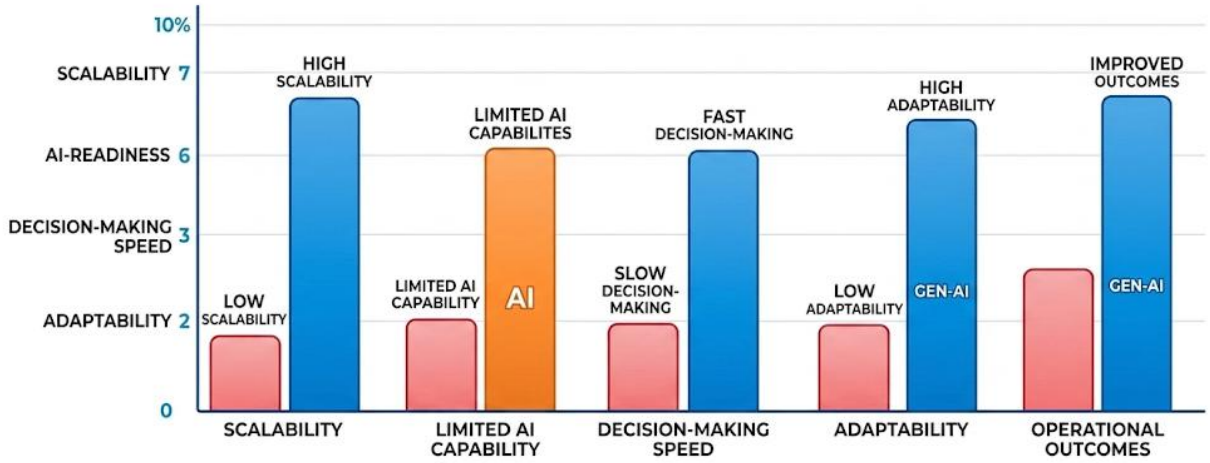

Figure 1. Effect of Legacy System Modernization on Organizational Agility & AI Adoption

A case study from a healthcare organization, "HealthTech," exemplifies the impact of legacy system modernization on organizational agility and AI adoption. Prior to modernization, HealthTech struggled with slow decision-making processes and inefficiencies due to outdated legacy systems that lacked the scalability to support advanced technologies like Generative AI. After upgrading its IT infrastructure to include cloud-based solutions and AI-ready systems, the organization reported a significant improvement in both decision-making speed and adaptability to new AI tools. The adoption of Generative AI technologies enabled faster patient data analysis and more accurate predictive modeling for resource allocation, ultimately leading to better operational outcomes. HealthTech's experience underscores the critical role of legacy system modernization in facilitating AI adoption and improving organizational agility, particularly in sectors with high demand for technological flexibility.

These findings highlight that legacy system modernization significantly contributes to organizational agility, particularly when it is aligned with the integration of new technologies like Generative AI. Modernizing legacy systems not only improves operational efficiencies but also prepares organizations to respond more quickly to market demands and technological advancements. The improvements observed in this study emphasize the importance of updating IT infrastructure to ensure that organizations are well-positioned to leverage emerging technologies.

By investing in modernization efforts, organizations can build the technological resilience needed to adapt and thrive in the era of Generative AI. The results provide actionable insights for organizations seeking to enhance their agility and competitive advantage through strategic technology upgrades.

The results of this study demonstrate that legacy system modernization significantly enhances organizational agility, particularly in the context of adopting Generative AI technologies. Organizations that modernized their legacy systems experienced notable improvements in decision-making speed, market responsiveness, and flexibility. The data revealed that these organizations, post-modernization, reported higher agility scores across these key metrics, indicating that upgrading IT infrastructure can indeed enable more rapid adaptation to new technological opportunities. The integration of Generative AI was facilitated by this modernization, supporting quicker and more effective decision-making and enhancing responsiveness to market changes. These findings align with the hypothesis that the modernization of legacy systems is a critical enabler for organizations to thrive in an AI-driven environment, enhancing their resilience to technological disruptions.

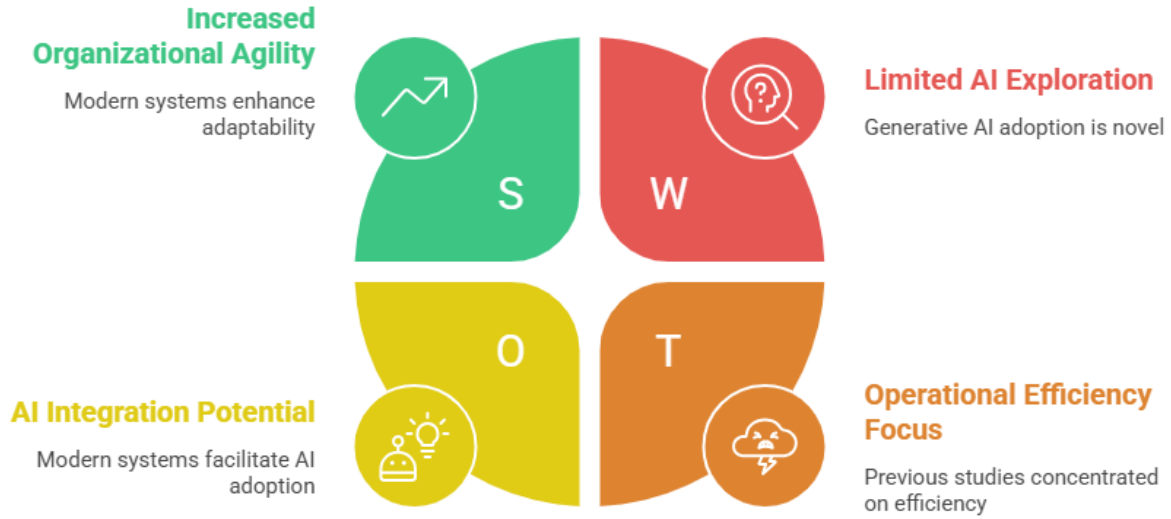

Figure 2. System Modernization and AI Integration

Comparing these results with existing literature, the findings confirm and extend previous research that associates system modernization with increased organizational agility. While earlier studies have generally focused on the role of modern IT infrastructure in improving operational efficiency, this research takes a more holistic approach by linking legacy system modernization directly to organizational agility in the context of AI integration. This study distinguishes itself by integrating Generative AI adoption as a key outcome of system modernization, a factor that has not been fully explored in prior research. Additionally, while previous studies have concentrated on operational improvements, this study emphasizes the strategic agility that modernized systems provide, offering a novel perspective on the intersection between technological infrastructure and organizational adaptability.

The results of this research point to a significant shift in how organizations should approach their IT strategies. Modernizing legacy systems is not merely a technical upgrade; it is an essential step toward building organizational agility and preparing for future technological transformations. The improvements observed in this study suggest that companies who resist or delay modernization may risk becoming increasingly inflexible and less able to leverage emerging technologies like Generative AI. This finding underscores the importance of investing in infrastructure that supports both current and future technological needs. Furthermore, the integration of such systems goes

beyond technical considerations it requires leadership commitment and organizational alignment, signaling a fundamental shift toward greater technological resilience.

The implications of this study are significant for organizational leaders and IT professionals. The results indicate that modernizing legacy systems is not just a way to improve operational efficiency but is a critical enabler of agility in the digital age. Organizations seeking to remain competitive must prioritize these upgrades, especially as technologies like Generative AI become more pervasive. The study also suggests that agility, facilitated by system modernization, can lead to broader strategic benefits, including quicker market adaptation and better resource allocation. Additionally, businesses that invest in modernized infrastructure are better positioned to integrate future innovations, ensuring long-term resilience and sustained growth. Thus, the findings present a compelling case for organizations to view IT modernization not as an isolated technical challenge, but as a strategic imperative that drives broader organizational outcomes.

The findings are likely the result of several interconnected factors. Legacy systems, while often reliable, are designed with older technological paradigms that are not optimized for the rapid pace of innovation seen today. Modernized systems offer the scalability, flexibility, and interoperability necessary to support technologies such as Generative AI, which rely on vast datasets, real-time processing, and adaptive infrastructure. Additionally, organizations that undertake modernization projects often do so with a focus on broader business goals, which includes enhancing responsiveness and adaptability. These upgrades, coupled with a mindset shift toward technological resilience, explain the observed improvements in organizational agility. The results, therefore, reinforce the idea that modern IT infrastructure is essential not only for improving day-to-day operations but for positioning organizations to respond effectively to future challenges.

Looking ahead, the findings suggest several avenues for future research. First, further investigation into the long-term effects of legacy system modernization on organizational agility would provide deeper insights into the sustainability of these improvements (Rosenthal, 2024). Additionally, future studies could explore how specific Generative AI technologies (e.g., machine learning, natural language processing) influence different dimensions of agility across various industries. Research could also examine the role of organizational culture and leadership in facilitating the successful integration of AI technologies after system modernization, considering that technology alone may not fully drive agility without adequate cultural alignment. These directions will build on the current findings and offer a more comprehensive understanding of how organizations can architect resilience in the digital age.

CONCLUSION

The most significant finding of this study is the clear correlation between legacy system modernization and improved organizational agility, especially in the context of Generative AI integration. The research demonstrates that organizations that modernized their legacy systems experienced considerable improvements in decision-making speed, market responsiveness, and operational flexibility. This study further reveals that the modernization process is a critical enabler for organizations seeking to integrate cutting-edge technologies like Generative AI. While legacy systems have traditionally been seen as a barrier to rapid technological adoption, this research highlights their modernization as a strategic step toward enhancing organizational resilience and adaptability in an increasingly digital world.

This research offers substantial contributions to both theoretical and practical realms. Conceptually, it provides a novel framework that links legacy system modernization directly to organizational agility, an area that has been underexplored in the context of AI adoption. Methodologically, the mixed-methods approach incorporating both quantitative surveys and

qualitative interviews provides a comprehensive perspective on the effects of modernization. The combination of statistical data with in-depth, experiential insights offers a robust understanding of how organizations navigate the complexities of upgrading infrastructure while adopting new technologies. These contributions enrich existing literature by filling a critical gap in understanding the intersection of technological infrastructure and organizational agility.

One limitation of this study is its focus on organizations that have already embarked on legacy system modernization, potentially limiting the generalizability of the findings to organizations that are yet to begin the process. Future research could explore the initial challenges faced by organizations at the beginning of their modernization journeys, comparing them to organizations further along in the process. Additionally, the study's sample size, though sufficient for the scope of this research, may not capture the full diversity of industries that could benefit from modernization. To address this, future studies could include a broader range of organizations, particularly smaller firms and those in non-technology-driven sectors, to see how modernization impacts agility across different industries. Longitudinal studies examining the long-term effects of legacy system modernization on organizational agility would also provide valuable insights into the sustainability of these benefits.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the author(s) used ChatGPT to assist in improving grammar, language quality, and overall readability of the text. After using this tool, the author(s) carefully reviewed and edited the content as necessary and take full responsibility for the content of the publication.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

Author 4: Formal analysis; Methodology; Writing - original draft.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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