

INTEGRATING LEAN AND DIGITAL IN SERVICE SYSTEMS: ARCHETYPES, OUTCOMES, AND IMPLICATIONS

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Abstract

The rapid digitalization of service industries has intensified the need for the effective integration of lean principles and digital technologies to enhance both operational performance and customer outcomes. This study aims to develop a contingency-based understanding of Lean Digital Transformation (LDT) in service sectors by examining how different configurations of practices and technologies influence performance across various service archetypes. A systematic literature review was conducted using peer-reviewed studies published between 2015 and 2025, selected using a structured search strategy and rigorous inclusion criteria to ensure relevance and validity. The findings indicate that LDT significantly improves efficiency, service quality, customer experience, and cost performance when lean practices, such as value stream mapping, standardization, and continuous improvement, are effectively combined with digital technologies, including artificial intelligence, Internet of Things, robotic process automation, analytics, and cloud computing. The effectiveness of these implementations varies depending on the service archetypes, where high-contact services require flexible, human-centric approaches, whereas low-contact services benefit from automation and scalability. The study also identified the key enablers and barriers influencing LDT success. Overall, this study proposes an archetype-contingent framework, contributing both theoretical insights and practical guidance for sustainable service innovation.

Keywords: *Lean Digital Transformation; Service Operations; Digital Transformation; Contingency Theory; Service Archetypes; Process Improvement; Industry 4.0.*

INTRODUCTION

The rapid digitalization of economic activities has significantly transformed how organizations design, deliver, and improve their services. Service sectors, such as healthcare, finance, logistics, education, and public administration, increasingly adopt digital technologies to enhance efficiency, responsiveness, and customer experience. Simultaneously, organizations continue to implement lean principles to eliminate waste, improve process flow, and create value. The convergence of these two paradigms has led to the emergence of Lean Digital Transformation (LDT), which integrates lean thinking with advanced digital technologies such as artificial intelligence (AI), Internet of Things (IoT), robotic process automation (RPA), and data analytics. Previous studies indicate that LDT have a strong potential to improve operational performance and service quality when implemented effectively (Buer et al., 2018; G. L. Tortorella et al., 2023).

Despite its potential, LDT implementation in the service industry remains challenging and inconsistent. Service environments are inherently different from manufacturing environments owing to their characteristics, such as intangibility, heterogeneity, and high customer interaction. These characteristics create difficulties in directly applying lean tools and digital technologies developed the manufacturing context. Moreover, many digital transformation initiatives fail because of the misalignment between technological investments and organizational processes (Kane et al., 2015; Verhoef et al., 2021). This highlights the urgency of developing a more context-sensitive approach for LDT implementation in services. The main problem addressed in this study is the lack of a coherent framework that explains how LDT should be configured within diverse service contexts. Existing literature often treats lean practices and digital technologies as independent or universally applicable solutions, resulting in fragmented findings and inconsistent outcomes. In addition, the absence of standardized performance metrics further

complicates the evaluation and comparison of LDT initiatives across the service sectors. This gap emphasizes the need for systematic analysis and structured problem-solving approaches. To address this problem, this study adopts a contingency-based perspective, which emphasizes the alignment between organizational practices and contextual factors. Contingency theory suggests that there is no single best way to manage processes; instead, effectiveness depends on the fit between strategies, structures, and environmental conditions (Donaldson, 2001). Complementarity theory further supports this perspective by highlighting that the integration of mutually reinforcing practices can generate superior outcomes compared to isolated implementation (Milgrom & Roberts, 1995). These theoretical foundations provide the basis for designing context-sensitive LDT strategies.

Several studies have proposed specific approaches to improve LDT implementation in service settings. One approach involves adapting lean tools, such as value stream mapping, Kaizen, and standard work, to accommodate service variability and customer interaction (Hadid & Afshin Mansouri, 2014). Another approach focuses on leveraging digital technologies to enhance transparency, automation, and decision making. Technologies such as IoT, real-time analytics, and RPA enable continuous improvement and operational efficiency (Chiarini & Kumar, 2021; Ivanov et al., 2019). Additionally, the concept of service archetypes has been introduced to classify services based on characteristics such as customer contact and customization, which influence the appropriate configuration of LDT strategies (Sampson, 2012; Schmenner, 2004).

However, the literature remains fragmented and lacks an integrative framework that combines lean practices, digital technologies, and service archetypes from a contingency perspective. This limitation creates a significant gap, as organizations require comprehensive and practical guidance to successfully implement LDT initiatives. Therefore, the objective of this study is to develop a contingency-based understanding of Lean Digital Transformation the service sector through a systematic literature review. This study aims to identify how different configurations of lean practices and digital technologies influence operational performance, service quality, and customer experience. In summary, this study not only addresses the urgency of improving LDT implementation in service industries but also proposes a structured problem-solving approach grounded in theory and empirical evidence. By synthesizing the relevant literature and analyzing specific service contexts, this research is expected to contribute both theoretically and practically to the development of effective and sustainable LDT strategies.

LITERATURE REVIEW

2.1 Lean in Service Operations

Lean thinking, which originated in the Toyota Production System, has been widely adopted in service operations to improve efficiency, eliminate waste, and enhance value delivery. Core lean principles, such as value identification, value stream mapping (VSM), continuous improvement (Kaizen), standardization, and flow optimization, have been applied across various service sectors, including healthcare, finance, and logistics (Hadid & Afshin Mansouri, 2014; James & Daniel, 1996). In service contexts, value extends beyond operational efficiency, and includes customer experience, responsiveness, and service quality.

However, previous studies have highlighted several limitations in transferring lean practices from manufacturing to services. Service processes are characterized by intangibility, variability, and high levels of customer interaction, making standardization more complex. For example, value stream mapping in services must incorporate information flows and customer interactions rather than physical materials. Furthermore, lean initiatives such as Kaizen rely heavily on employee involvement and frontline engagement in service settings (Radnor et al., 2012). While these studies demonstrate the adaptability of leanness, they also reveal a gap in the development of standardized approaches tailored specifically for service environments.

2.2 Digital Transformation in Services

Digital transformation has emerged as a critical driver of innovation in the service industry. It involves integrating digital technologies, such as artificial intelligence (AI), Internet of Things (IoT), robotic process automation (RPA), big data analytics, and cloud computing, into organizational processes to enhance efficiency and create new value propositions (Verhoef et al., 2021). These technologies enable real-time monitoring, predictive analytics, automation, and improved decision-making. Empirical studies have shown that IoT enhances process visibility, AI supports intelligent decision-making and personalization, and RPA reduces the administrative workload by automating repetitive tasks. Despite these advantages, several scholars have emphasized significant challenges, including data governance issues, cybersecurity risks, interoperability constraints, and resistance to organizational change (Kane et al., 2015). These limitations suggest that digital transformation alone is insufficient without proper alignment with organizational processes and strategies.

Critically, many studies have focused on technological adoption rather than its integration with operational frameworks, leading to fragmented outcomes. This indicates the need for more holistic approaches that combine digital innovation with established process improvement methodologies.

2.3 Lean-Digital Integration (LDT)

Lean Digital Transformation (LDT) represents an integrative approach that combines lean principles with digital technologies to achieve superior performance outcomes. The literature suggests that digital technologies can enhance lean practices by improving data visibility, enabling automation, and supporting continuous improvement. Conversely, lean principles provide a structured framework to guide digital implementation, ensuring that technology adoption focuses on value creation and waste reduction. The concept of complementarity is central to LDT, where the joint implementation of lean and digital practices produces synergistic benefits that are greater than isolated adoption (Milgrom & Roberts, 1995). Empirical evidence supports this claim; for instance, integrating value stream mapping with real-time analytics enables a more accurate identification of bottlenecks, whereas combining RPA with standardized processes enhances consistency and reduces variability. In specific sectors, such as healthcare, LDT, often referred to as Healthcare 4.0, has demonstrated improvements in patient flow, reduced waiting times, and enhanced service quality (G. Tortorella et al., 2021). However, despite these promising findings, existing research tends to be sector-specific and lacks generalizable frameworks, limiting its broader applicability.

2.4 Theoretical Foundations

The implementation of LDT in service contexts is supported by several theoretical frameworks. Contingency theory posits that organizational effectiveness depends on the alignment between practices and contextual factors, such as environment, technology, and structure (Donaldson, 2001). This theory suggests that there is no universal approach to LDT; instead, strategies must be tailored to specific service conditions. Complementarity theory further reinforces this perspective by emphasizing that mutually reinforcing practices yield greater performance benefits when implemented together (Milgrom & Roberts, 1995). This highlights the importance of integrating lean and digital approaches rather than treating them as separate initiatives. Additionally, service-dominant logic (SDL) introduces a customer-centric view of value creation in which value is co-created through interactions between service providers and customers (Vargo & Lusch, 2004). This perspective is particularly relevant in service environments where customer experience plays a critical role. While these frameworks provide strong conceptual foundations, prior research often applies them in isolation, indicating a lack of integrative theoretical models for LDT.

2.5 Service Archetypes and Contextual Variability

The service archetype framework provides a useful lens for understanding how different service characteristics influence LDT implementation. Services can be categorized based on dimensions such as customer contact, customization, and process complexity. For example, high-contact services such as healthcare require flexibility and personalized interactions, whereas low-contact services such as back-office operations benefit from standardization and automation (Sampson, 2012; Schmenner, 2004). Previous studies have highlighted that aligning lean practices and digital technologies with these archetypes leads to improved performance outcomes. However, there is limited research on the systematic design of these configurations. Moreover, inconsistencies across studies suggest ongoing debates regarding the optimal balance between standardization and flexibility in service operations.

2.6 Research Gaps and Contribution

Despite the growing body of literature on leanness, digital transformation, and their integration, several critical gaps remain. First, existing studies are fragmented and often focus on specific industries or technologies, which limits their generalizability. Second, there is a lack of unified frameworks that integrate lean practices, digital technologies, and service characteristics from a contingency perspective. Third, empirical evidence on the combined impact of LDT on operational performance, service quality, and customer experience remains limited. Furthermore, discrepancies exist regarding the extent to which digital technologies should replace or complement human-centered service processes. Some studies emphasize automation and efficiency, whereas others highlight the importance of human interaction and flexibility. This debate highlights the need for a more balanced and context-sensitive approach. Therefore, this study aims to address these gaps by developing an integrative, contingency-based framework for Lean Digital Transformation in service sectors. By synthesizing the existing literature and analyzing

different service contexts, this research contributes to a deeper understanding of how LDT can be effectively implemented to achieve sustainable performance improvements.

Based on a synthesis of the prior literature and the identified research gaps, this study proposes a conceptual framework that integrates lean practices, digital technologies, and service archetypes within a contingency perspective. The framework illustrates how the alignment and interaction among these elements influence performance outcomes in service systems.

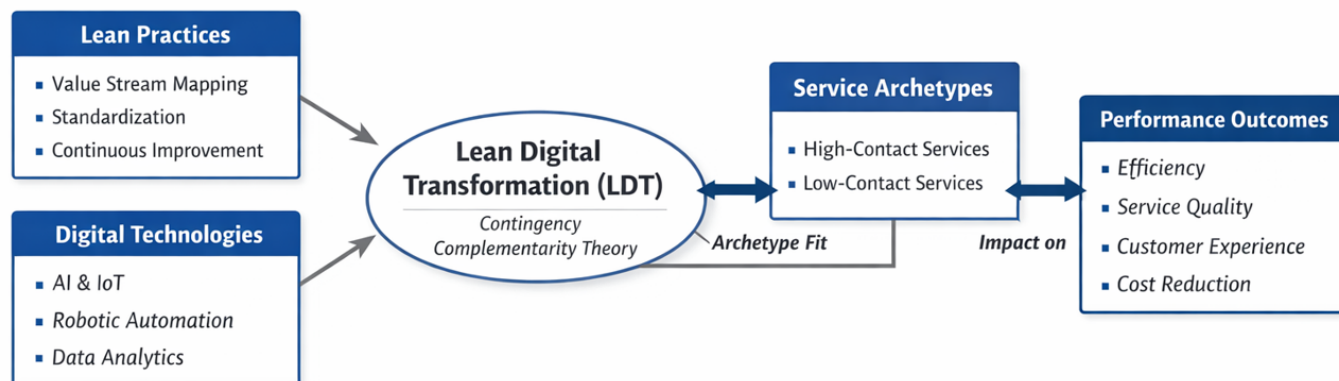


Figure 1. The proposed conceptual framework

The conceptual framework illustrates that Lean Digital Transformation (LDT) emerges from the integration of lean practices and digital technologies, where both elements function as complementary drivers of service improvement. Lean practices, such as value stream mapping, standardization, and continuous improvement, provide a structured approach to process optimization, whereas digital technologies, including artificial intelligence, Internet of Things, and robotic process automation, enhance data visibility, automation, and decision-making capabilities. The framework further emphasizes the moderating role of service archetypes, which shape how LDT configurations are applied across different service contexts, distinguishing between high- and low-contact services. This alignment, grounded in contingency theory, determines the effectiveness of LDT implementation. Ultimately, the interaction between these elements leads to improved performance outcomes, including operational efficiency, service quality, customer experience, and cost reduction.

METHOD

This study employs a systematic literature review (SLR) as the primary research design to analyze the implementation of Lean Digital Transformation (LDT) in service sectors. The SLR approach was selected because of its ability to provide a structured, transparent, and reproducible process for synthesizing multidisciplinary knowledge from operations management, digital transformation, and service management domains. This research adopts an inductive and interpretive design, aiming to develop a conceptual understanding of how lean practices and digital technologies interact across different service contexts (Tranfield et al., 2003). The target of this study is the scholarly literature relevant to LDT in service industries. The data source was derived from the Scopus database, chosen for its comprehensive coverage of peer-reviewed journals. The selection of studies followed a structured search strategy using keywords such as “lean service,” “digital transformation,” “Industry 4.0,” “IoT,” “AI,” and “RPA,” combined with Boolean operators to refine results. This study focuses on publications from 2015 to 2025 to capture recent developments in the field. Inclusion criteria included peer-reviewed articles related to service sectors and LDT integration, while exclusion criteria removed non-English, low-quality, or manufacturing-only studies.

The materials and tools used in this research consisted of a coding framework designed to extract and categorize key information from selected studies. The framework includes variables such as the service sector, lean practices, digital technologies, service archetypes, performance outcomes, and implementation challenges. The lean tools analyzed include value stream mapping, Kaizen, and standardization, whereas digital technologies include IoT, AI, RPA, analytics, and cloud computing. The design of this analytical tool ensures systematic comparison and supports the identification of patterns and relationships across studies. Data collection was conducted through a multi-stage screening process following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency and reproducibility. The process consisted of four main stages: identification, screening, eligibility, and inclusion. Initially, records were identified from the Scopus database based on predefined keywords. Duplicate records were then removed, followed by title and abstract screening to assess relevance. Subsequently, full-text articles were evaluated to ensure methodological quality and alignment with the

research objectives. Finally, only studies that met all inclusion criteria were selected for analysis. The detailed study selection process is illustrated in Figure 2.

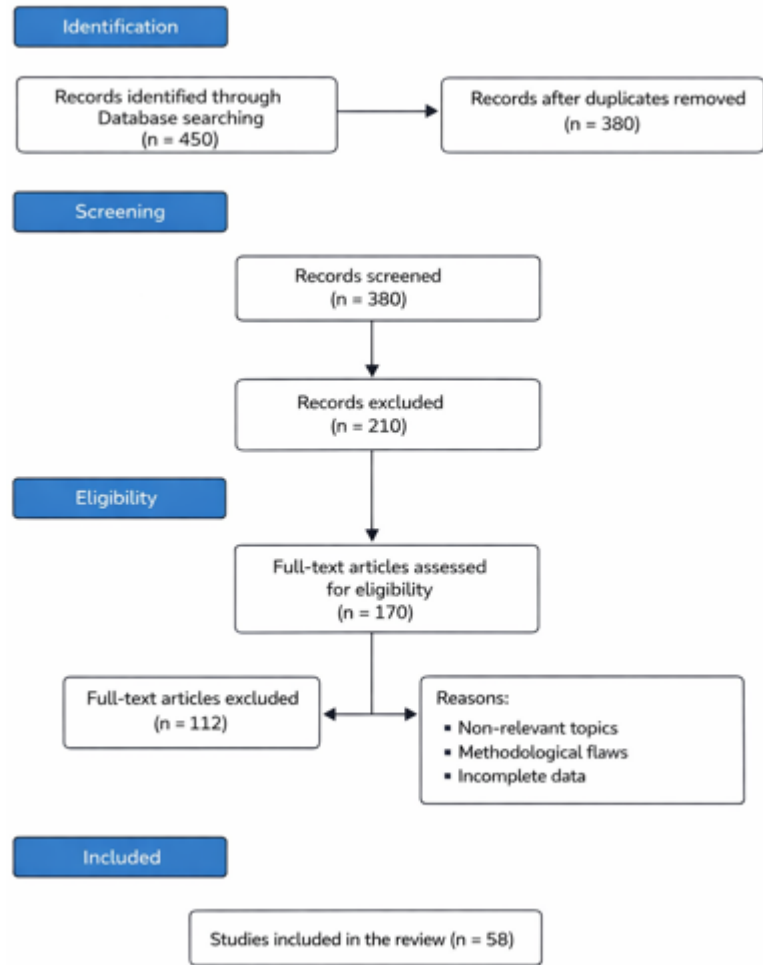


Figure 2. PRISMA Diagram Flow

The data analysis combines descriptive and thematic approaches. Descriptive analysis was used to examine the distribution of studies across sectors, time periods, and research methods. Thematic analysis was applied to identify recurring themes related to LDT configurations, performance outcomes, and contextual factors. In addition, a configurational analysis perspective was employed to examine how combinations of lean practices and digital technologies influence outcomes under different service conditions. This approach emphasizes the interaction between variables rather than isolated effects. To ensure validity and reliability, this study applied a transparent review protocol, clearly defined selection criteria, and an iterative coding process. Consistency checks were conducted to minimize subjectivity and enhance accuracy. Overall, this methodological approach enables a comprehensive and systematic understanding of LDT in the service sector, supporting the development of a contingency-based framework.

RESULTS AND DISCUSSION

4.1 Results

The systematic literature review resulted in 58 selected studies published between 2015 and 2025. The number of publications shows a significant increase after 2018, indicating the growing importance of Lean Digital Transformation (LDT) in service sectors, particularly in the context of Industry 4.0. These studies cover various service industries, including healthcare, logistics, finance, education, and public administration, with healthcare and logistics being the most dominant sectors. In terms of methodological approaches, the reviewed studies consisted of case studies, surveys, conceptual frameworks, and empirical analyses. This diversity highlights the multidisciplinary nature of LDT research, but also indicates fragmentation in the existing body of knowledge.

The findings show that commonly used lean practices include value stream mapping (VSM), kaizen, standard work, and visual management. Meanwhile, digital technologies frequently applied are the Internet of Things (IoT), artificial intelligence (AI), robotic process automation (RPA), big data analytics, and cloud computing. These practices and technologies are rarely implemented independently; instead, they are increasingly being integrated to enhance performance outcomes. The results further revealed that LDT implementation varied significantly across service archetypes. High-contact and customized services, such as healthcare, emphasize flexibility, personalization, and human-centered approaches. In contrast, low-contact and standardized services, such as financial and administrative processes, prioritize automation, efficiency, and scalability. Hybrid services require a balance between the two approaches. To provide a clearer visualization of how lean practices and digital technologies are configured across different service archetypes, a heatmap is presented in Figure 3.



Figure 3. Heatmap of Lean and Digital Configurations across Service Archetypes

The heatmap highlights distinct configuration patterns across the service archetypes. High-contact services tend to rely more on human-centric lean practices combined with selective digital support, whereas low-contact services show a stronger concentration of automation-oriented technologies, such as RPA and analytics. Hybrid services demonstrate a balanced integration of both approaches. These findings further reinforce the contingency-based nature of LDT implementation. The performance outcomes of LDT implementation are consistently positive across studies. Improvements in operational efficiency include reductions in turnaround (up to 35%) and waiting times (up to 40%). Service quality improvements are reflected in increased accuracy (approximately 8%), while customer satisfaction indicators, such as NPS and CSAT, improve by up to 10 points. Additionally, cost reductions of approximately 15% and energy savings of approximately 12% have been reported. To further examine the relationship between the magnitude of performance improvements and the time required to achieve these benefits across different service archetypes, a bubble chart analysis is presented in Figure 4.

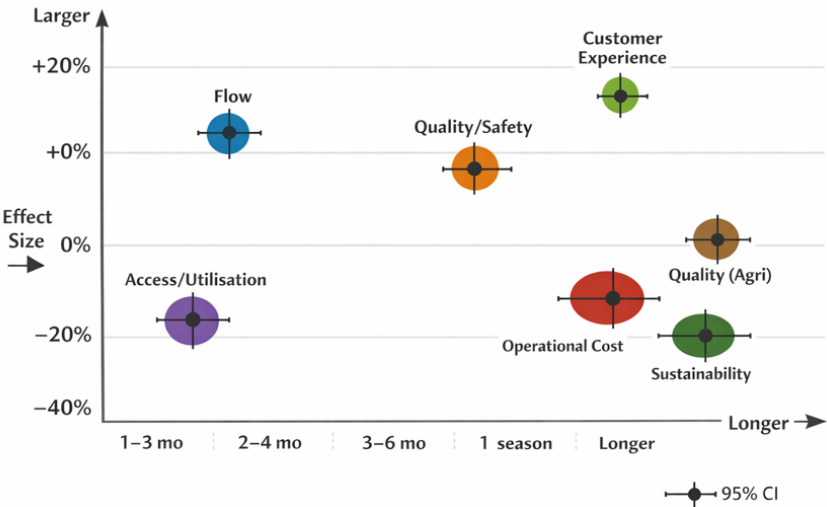


Figure 4. Bubble Chart of Effect Size versus Time-to-Benefit across Service Archetypes

The bubble chart reveals distinct patterns in the trade-off between effect size and time-to-benefit. Low-contact services tend to achieve faster gains with moderate to high effect sizes, primarily driven by automation and standardization. In contrast, high-contact services demonstrate longer time-to-benefit but potentially higher impact on customer experience and service quality owing to the complexity of human-centric processes. Hybrid services exhibit a balanced profile and achieve moderate improvements within a relatively reasonable timeframe. These findings further support the contingency-based nature of LDT implementation and highlight the importance of aligning transformation strategies with service characteristics.

Key enablers include leadership commitment, employee digital capabilities, organizational culture, and data governance. Conversely, major barriers include technological challenges (e.g., interoperability and cybersecurity), resistance to change, and a lack of standardized performance metrics. To synthesize the findings into a structured and actionable framework, this study adopts the context–intervention–mechanism–outcome (CIMO) logic. The CIMO configuration provides a comprehensive representation of how Lean Digital Transformation operates across different service contexts, as illustrated in Figure 5.

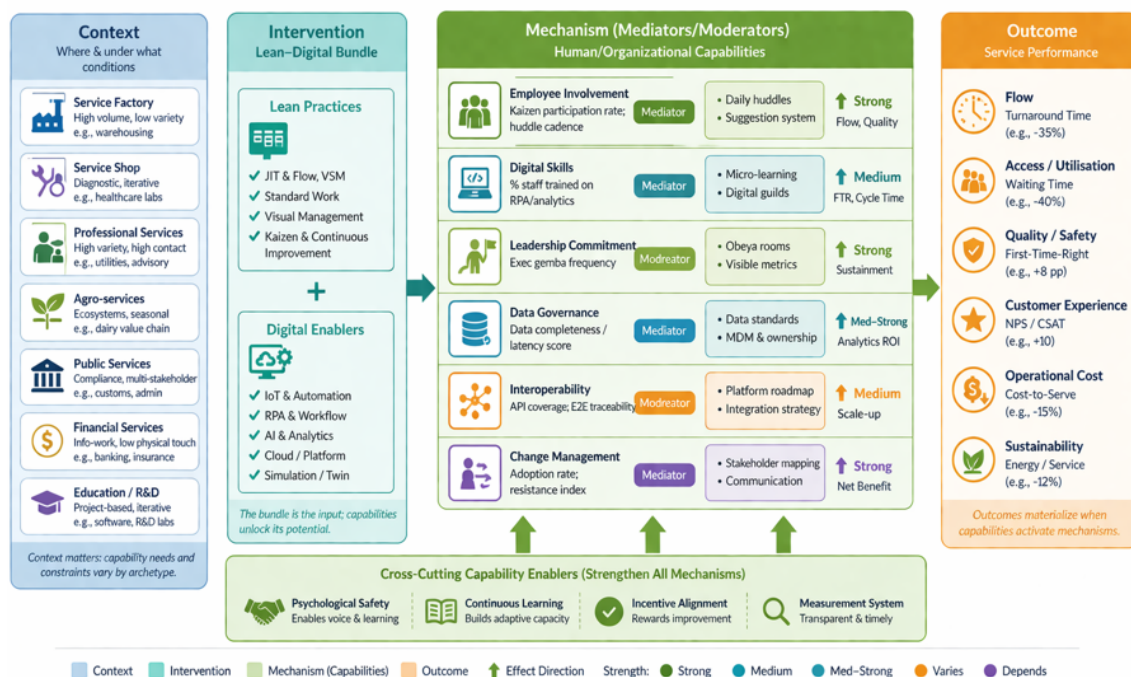


Figure 5. CIMO Diagram

The CIMO diagram illustrates that the effectiveness of Lean Digital Transformation depends on the alignment between service context (e.g., high-contact vs. low-contact environments), appropriate interventions (lean practices and digital technologies), and underlying mechanisms such as process integration, data-driven decision-making, and continuous improvement. These mechanisms lead to various performance outcomes, including efficiency gains, improved service quality, and enhanced customer experience. This framework highlights that different service archetypes require distinct configurations of interventions and mechanisms, reinforcing the contingency-based nature of LDT implementation.

4.2 Discussion

The findings indicate that Lean Digital Transformation is not a one-size-fits-all approach, but a context-dependent strategy. This supports contingency theory, which emphasizes that organizational effectiveness depends on the alignment between practices and contextual factors (Donaldson, 2001). The variation in LDT configurations across service archetypes demonstrates that different service characteristics require different combinations of lean practices and digital technologies. Furthermore, the results confirm complementarity theory, where the integration of lean and digital approaches produces synergistic benefits. Digital technologies enhance lean practices by providing real-time data, automation, and improved decision-making, whereas lean principles ensure that digital implementation remains focused on value creation and waste reduction. Without this integration, digital transformation initiatives may lead to inefficiencies rather than improvements.

The role of service archetypes is particularly significant in shaping LDT strategies. High-contact services require flexible, adaptive, and human-centric solutions, where technology supports rather than replaces human interaction. In contrast, low-contact services benefit from automation and standardization, enabling scalability and efficiency. This finding highlights the importance of designing LDT strategies based on service characteristics rather than adopting generic solutions. Another important insight is the critical role of human and organizational factors. Leadership commitment, employee engagement, and digital skills are essential for successful LDT implementation. This aligns with prior studies emphasizing that digital transformation is not solely a technological change, but also an organizational transformation involving culture, capabilities, and processes (Kane et al., 2015).

From a managerial perspective, the findings suggest that organizations should adopt a holistic approach to LDT by aligning processes, technologies, and human resources. Managers should also use service archetypes as a framework to design context-specific strategies and invest in building digital capabilities and a culture of continuous improvement. From a theoretical perspective, this study contributes to the integration of contingency, complementarity, and service-dominant logic theories. This highlights that LDT success should be evaluated not only based on efficiency but also on customer value co-creation and experience. However, the study also identifies limitations in existing research, particularly the lack of standardized performance metrics and heterogeneity of methodologies. These gaps suggest the need for future research to develop consistent evaluation frameworks and conduct empirical studies to validate the proposed configurations.

4.3 Implications of Findings

This study has both theoretical and practical implications. Theoretically, this approach provides a more comprehensive understanding of LDT by integrating multiple perspectives into a contingency-based framework. Practically, it offers guidance for organizations in designing and implementing LDT strategies that are aligned with their specific service contexts. To translate the findings into actionable guidance for practitioners, this study proposes a roadmap for implementing Lean Digital Transformation across different service archetypes, as illustrated in Figure 6.

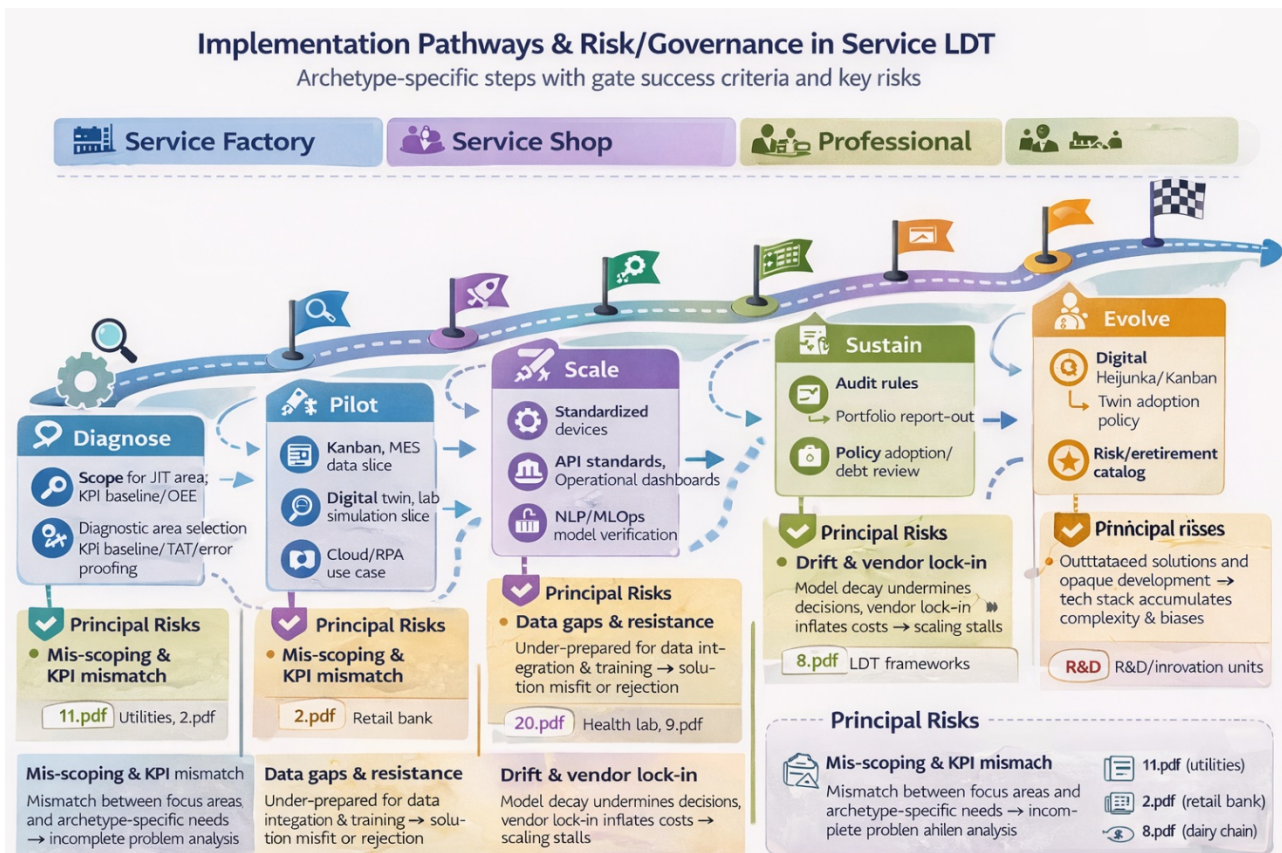


Figure 6. Roadmap for Lean Digital Transformation across Service Archetypes

The proposed roadmap outlines a phased approach to LDT implementation, starting from the initial assessment and alignment of service characteristics, followed by the selection of appropriate lean practices and digital technologies. The roadmap emphasizes the importance of building organizational readiness, including

leadership commitment and digital capabilities, before scaling transformation initiatives. It also highlights that implementation strategies should differ based on service archetypes, where high-contact services require gradual and human-centric transformation, whereas low-contact services can adopt more automation-driven approaches. This roadmap provides practical guidance for organizations to systematically design and implement LDT in a context-sensitive manner. Overall, the findings emphasize that successful Lean Digital Transformation requires not only technological adoption but also strategic alignment, organizational readiness, and continuous adaptation to service characteristics.

CONCLUSION

This study set out to address the growing need for an integrated and context-sensitive approach to Lean Digital Transformation (LDT) in service sectors, as highlighted in the Introduction. The findings confirm that LDT is not a universal solution but is highly dependent on the alignment between service archetypes, lean practices, and digital technologies. By synthesizing evidence from 58 studies, this study demonstrates that organizations achieve the most significant improvements when digital technologies are used to enhance lean principles rather than replace them. The results show that LDT contribute to substantial improvements in operational efficiency, service quality, customer experience, and cost performance, with additional sustainability benefits in certain contexts. However, these outcomes vary depending on service characteristics, such as customer contact, customization, and process complexity. The discussion further emphasizes that successful implementation requires strong leadership, employee capabilities, and effective data governance, reinforcing the importance of integrating human, organizational and technological dimensions.

From a theoretical perspective, this study extends contingency theory and complementarity logic within service operations by proposing an archetype-contingent framework to explain how different LDT configurations lead to distinct performance outcomes. From a practical standpoint, the findings provide guidance for managers in designing tailored transformation strategies that align with their specific service contexts. For future development, organizations should focus on building adaptive and scalable LDT systems by investing in digital capabilities, fostering a culture of continuous improvement, and establishing standardized performance metrics. Future research should conduct longitudinal and empirical studies across multiple sectors, as well as explore the potential of emerging technologies, such as digital twins and advanced artificial intelligence, in enabling more flexible, human-centric, and sustainable service systems.

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