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# Enabling digital Servitization in Philippine manufacturing: A business model innovation framework for MSMEs in the industry 4.0 ERA

Christina Y. Pacubas[1], Norberto M. Secretaria[2], Leoncio T. Lucero, Jr.[3], Najera R. Umpar[4], Kenneth L. Armas[5*]
[1,2,3]Cebu Technological University, Philippines.
[4]National University, Philippines.
[5]Nueva Ecija University of Science and Technology, Philippines; kennetharmas@neust.edu.ph (K.L.A.).

**Abstract:** This study explores the integration of digital servitization in Philippine manufacturing micro, small, and medium enterprises (MSMEs) amid the Industry 4.0 era. Combining the principles of servitization and digital transformation, the research aims to develop a Business Model Innovation (BMI) framework that enables MSMEs to shift from product-centric to service-oriented strategies supported by digital technologies. Employing a mixed-methods, exploratory sequential design, the study conducted policy analysis, surveys across three key regions, and qualitative case studies. Findings reveal that while many MSMEs remain reliant on manual operations, some are beginning to adopt basic digital tools and limited service innovations. Barriers to digital servitization include limited digital literacy, financial constraints, and infrastructural deficiencies, while key enablers include entrepreneurial motivation and pandemic-induced necessity. A four-phase BMI framework is proposed to guide MSMEs through assessment, strategic alignment, deployment, and continuous improvement in adopting digital servitization. This framework offers actionable insights for policymakers, industry leaders, and entrepreneurs aiming to enhance MSME competitiveness, resilience, and value creation in the context of a rapidly evolving digital economy.

***Keywords:*** *Business model innovation, Digital servitization, Industry 4.0, MSMEs, Philippine manufacturing.*

## 1. Introduction

In recent years, manufacturing industries across the globe have undergone fundamental transformations driven by two intersecting macro-trends: servitization and Industry 4.0. Servitization refers to the shift from a product-centric model to a product-service system (PSS), wherein firms provide value-added services alongside or in place of physical products [1, 2]. Concurrently, Industry 4.0 represents the rise of cyber-physical systems, Internet of Things (IoT), big data, and advanced analytics that enhance the digital capabilities of firms [3, 4]. When combined, these two trends enable what is now called digital servitization, offering new business opportunities through the integration of digital technologies and service-oriented strategies [5, 6].

The convergence of servitization and Industry 4.0 is not merely a technological transition but a form of business model innovation (BMI) that reconfigures how value is created, delivered, and captured Teece [7]. Frank, et al. [4] proposed a framework that conceptualizes this convergence along two dimensions: levels of servitization (smoothing, adapting, substituting) and levels of digitalization (manual, digital, and Industry 4.0-related services). They argue that firms operating at the highest levels of both dimensions realize the full potential of digital servitization, benefiting not only customers but also internal operations through enhanced productivity, responsiveness, and customization.


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* Correspondence: kennetharmas@neust.edu.ph

While this transformation has gained momentum in advanced economies, its diffusion in emerging economies like the Philippines remains limited, particularly among micro, small, and medium enterprises (MSMEs), which comprise 99.6% of business establishments in the country [8]. Despite their critical role in employment and economic development, Philippine MSMEs often lack the digital infrastructure, strategic orientation, and support systems to implement servitization or Industry 4.0 solutions [9, 10]. Most digital transformation efforts among local manufacturers are piecemeal or constrained to basic automation and do not fully explore business model innovation aligned with service-based strategies [11].

Moreover, national policies such as the Philippine Innovation Act (RA 11293) and the Inclusive Innovation Industrial Strategy (i3S) emphasize the need for an inclusive and regionally balanced innovation ecosystem. However, there is a significant knowledge gap on how these macro policies can be translated into firm-level transformation strategies, especially in the context of manufacturing MSMEs. Therefore, this study seeks to bridge that gap by developing a Business Model Innovation framework that enables Filipino MSMEs to converge servitization with Industry 4.0 through contextually relevant pathways.

## 2. Review of Related Literature

The integration of digital technologies into manufacturing enterprises, known as digital servitization, has garnered significant attention in recent years. This review synthesizes existing literature on digital servitization, with a particular focus on its application within Philippine manufacturing micro, small, and medium enterprises (MSMEs). The discussion is organized thematically, covering the conceptual foundations of digital servitization, its role in enhancing firm performance, the challenges faced by MSMEs in adopting these technologies, and the policy landscape influencing their implementation.

### *2.1. Conceptual Foundations of Digital Servitization*

Digital servitization refers to the transformation process wherein manufacturing firms integrate digital technologies into their service offerings, thereby enhancing value creation and competitive advantage. This evolution involves shifting from traditional product-centric models to service-oriented strategies enabled by digital innovations. Studies have highlighted that the convergence of digitalization and servitization presents unprecedented opportunities for manufacturers, allowing for more efficient processes and improved managerial decisions through richer, faster, and more accurate information. Despite its potential, the knowledge base regarding how digital technologies support service transformation in manufacturing remains in its nascent stages, indicating a need for further research to fully understand and harness these capabilities.

### *2.2. Impact on Firm Performance*

The interaction between digitalization and servitization has been shown to positively influence firm financial performance. Empirical studies suggest that when manufacturing firms effectively combine digital technologies with service-oriented strategies, they experience enhanced innovation performance, which in turn contributes to improved financial outcomes. This synergistic effect underscores the importance of adopting both digitalization and servitization concurrently to maximize organizational benefits.

### *2.3. Challenges in Adoption Among Philippine MSMEs*

Philippine MSMEs, which constitute a significant portion of the country's economy, face several challenges in adopting digital servitization. A notable barrier is the limited awareness and readiness for Industry 4.0 technologies. Many enterprises are still transitioning from earlier industrial stages, with a considerable number only beginning to automate their production and business processes. This gradual progression indicates a gap in the adoption of advanced digital technologies necessary for servitization.

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Furthermore, MSMEs encounter constraints such as lack of funding, insufficient innovation culture, and limited access to government support programs. These factors hinder their capacity to pursue digital transformation initiatives effectively. Addressing these challenges requires targeted interventions to enhance digital literacy, provide financial assistance, and foster a culture of innovation within the MSME sector.

*2.4. Policy Landscape and Government Initiatives*

Recognizing the critical role of MSMEs in the national economy, the Philippine government has initiated policies to support their digital transformation. The MSME Development Plan 2023-2028, for instance, focuses on leveraging science, technology, and innovation to facilitate the transition of MSMEs to digital platforms. This plan underscores the government's commitment to creating an enabling environment for MSMEs to adopt digital technologies and enhance their competitiveness in the Industry 4.0 era.

The literature indicates that while digital servitization offers substantial benefits for manufacturing firms, including enhanced innovation and financial performance, Philippine MSMEs face significant challenges in its adoption. Limited awareness, financial constraints, and infrastructural issues impede their readiness for Industry 4.0 technologies. Government initiatives play a crucial role in addressing these barriers, but further efforts are necessary to equip MSMEs with the resources and knowledge required for successful digital transformation. Future research should focus on developing tailored strategies that consider the unique contexts of MSMEs to facilitate their integration into the digital economy.

## 3. Theoretical Framework

The theoretical foundation of this study is built upon the Technology-Organization-Environment (TOE) framework, which offers a comprehensive lens to examine the adoption of digital servitization among Philippine manufacturing micro, small, and medium enterprises (MSMEs). The TOE framework posits that technological, organizational, and environmental contexts collectively influence a firm's technological innovation decisions. This model is particularly pertinent for understanding the multifaceted factors that impact MSMEs' integration of digital technologies into their service offerings.

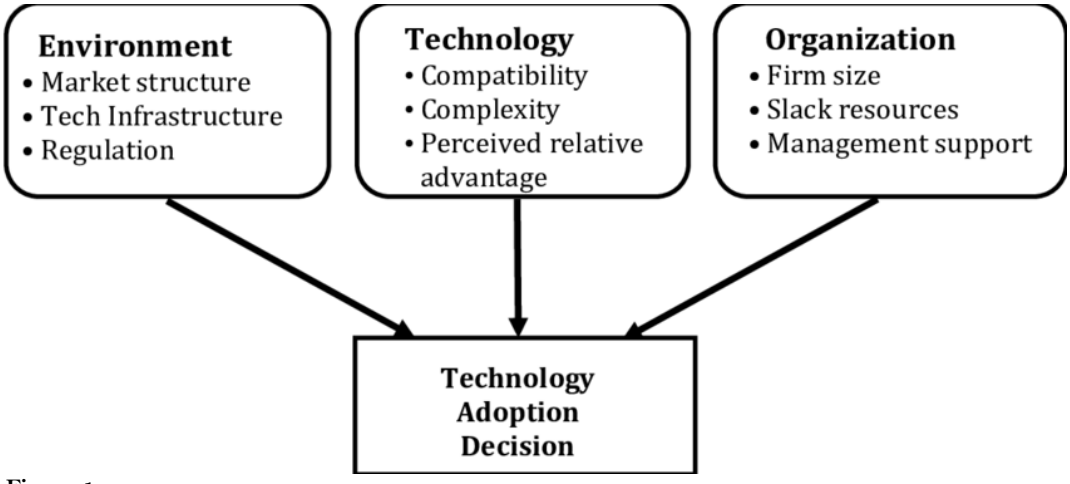


**Figure 1.**
Technology-Organization-Environment (TOE) framework.

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*3.1. Technological Context*

The technological aspect of the TOE framework considers both the existing and emerging technologies relevant to an organization. For MSMEs, this includes the availability, compatibility, and complexity of digital tools such as the Internet of Things (IoT), cloud computing, and data analytics.

The adoption of these technologies can enhance operational efficiency and enable the development of innovative service-based business models. However, the perceived complexity and required investment in these technologies may pose significant challenges for resource-constrained MSMEs. Studies have shown that the successful integration of digital technologies is pivotal for firms aiming to transition towards digital servitization, as it facilitates the creation of value-added services and improves customer engagement.

*3.2. Organizational Context*

The organizational dimension encompasses the internal characteristics of a firm, including its size, structure, resources, and culture. For MSMEs, factors such as limited financial resources, insufficient digital literacy, and a lack of skilled personnel can hinder the adoption of digital servitization. Conversely, a supportive organizational culture that fosters innovation and a proactive leadership team can facilitate this transition. Research indicates that organizations with a clear strategic vision and a commitment to continuous learning are better positioned to leverage digital technologies for servitization.

*3.3. Environmental Context*

The environmental context refers to the external factors that influence an organization's operations, including market dynamics, competitive pressure, regulatory environment, and the broader ecosystem. Philippine MSMEs operate within a rapidly evolving market where customer expectations are increasingly shaped by digital experiences. Government initiatives aimed at promoting digital transformation, such as the MSME Development Plan 2023-2028, play a crucial role in creating an enabling environment for digital servitization. Additionally, collaboration with external partners, such as knowledge-intensive business service firms, can provide MSMEs with the necessary expertise and resources to navigate the complexities of digital transformation.

By applying the TOE framework, this study aims to identify and analyze the critical factors within these three contexts that influence the adoption of digital servitization among Philippine manufacturing MSMEs. Understanding these factors will inform the development of a Business Model Innovation (BMI) framework tailored to the unique challenges and opportunities faced by these enterprises in the Industry 4.0 era.

*3.4. Research Questions*

1. What is the status of servitization and digitalization in Philippine manufacturing MSMEs?
2. How do MSMEs currently use or intend to use digital technologies (e.g., IoT, cloud computing, analytics) to offer value-added services?
3. What are the internal and external challenges MSMEs face in achieving digital servitization?
4. What configurations of servitization and digitization (as defined by Frank et al.) are most viable for Philippine MSMEs?
5. How can MSMEs design and implement sustainable business model innovations for digital servitization?

## 4. Research Methodology

This study employs a mixed-methods, exploratory sequential research design to investigate the current state of digital servitization among Philippine manufacturing micro, small, and medium enterprises (MSMEs) and to develop a context-specific Business Model Innovation (BMI) framework. The research unfolds in four distinct phases: Desk Research and Policy Analysis, Quantitative

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Assessment, Qualitative Case Studies, and Framework Development and Validation. This exploratory sequential design is particularly suited for emerging research areas where theory-building and context-specific understanding are paramount [12]. The study commences with a broad exploration of existing practices through quantitative assessment and policy review, progresses to in-depth qualitative inquiry to elucidate and deepen insights, and culminates in the development and expert validation of the proposed framework.

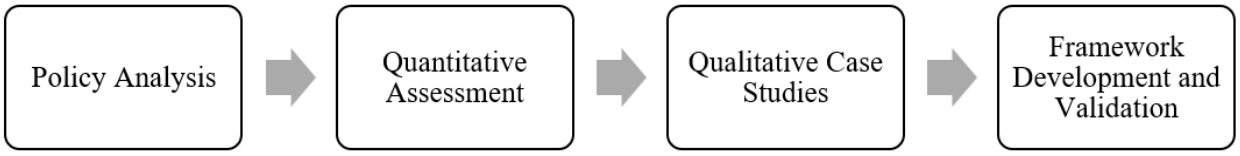


**Figure 2.**
Data Gathering Procedure.

*4.1. Phase 1: Policy Analysis*

In the initial phase, a comprehensive review of national innovation policies, industry reports, and academic literature is conducted. Key policy documents examined include the Philippine Innovation Act (RA 11293), the Inclusive Innovation Industrial Strategy (i3S), the Department of Science and Technology's (DOST) Science, Technology, and Innovation Roadmap, and the Department of Trade and Industry's (DTI) MSME Development Plan. The objective of this phase is to align the study with national development goals and to identify gaps in MSME support mechanisms for digital transformation and servitization.

*4.2. Phase 2: Quantitative Assessment*

This phase involves the development and administration of a structured questionnaire, informed by Frank, et al. [4] conceptual framework. The questionnaire measures various dimensions, including the level of digitization (ranging from manual operations to digital and Industry 4.0-related technologies), types of services offered (smoothing, adapting, substituting), awareness and adoption of Industry 4.0 technologies (such as IoT, cloud computing, and analytics), and organizational readiness for servitization (assessing aspects like culture, skills, and infrastructure).

A purposive stratified sampling technique is employed to select 150 MSMEs, with 50 enterprises from each of the CALABARZON, Central Luzon, and National Capital Region (NCR) regions. The sample encompasses micro, small, and medium-sized enterprises within the manufacturing sector. Firms are identified through collaborations with DTI regional offices, chambers of commerce, and local industry associations. Data collection is conducted via both online and in-person surveys. Descriptive statistics are utilized to summarize adoption levels, while cluster analysis is applied to categorize firms into configurations (e.g., digital smoothing services, factory-integrated substituting services) as proposed by Frank, et al. [4]. The results from this phase inform the selection of cases for the subsequent qualitative phase.

*4.3. Phase 3: Qualitative Case Studies*

Building upon the quantitative findings, this phase involves conducting in-depth case studies with 6–8 MSMEs that represent varied levels of digital servitization maturity, ranging from high-tech adopters to firms with predominantly manual service operations. Data collection methods include semi-structured interviews with business owners, managers, and technical staff; analysis of relevant documents such as business plans, service portfolios, and digital strategies; and field observations where applicable. A thematic analysis approach is employed to identify strategic drivers and barriers to servitization and digital transformation, internal capabilities (technological, organizational, human capital), and external support systems (including government initiatives, industry partnerships, and

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digital ecosystems). Cross-case synthesis is conducted to discern patterns and configurations in digital servitization adoption, which subsequently inform the development of the BMI framework.

*4.4. Phase 4: Framework Development and Validation*

In the final phase, insights gleaned from both the quantitative and qualitative research are integrated to construct a Business Model Innovation (BMI) framework. This framework maps MSMEs into servitization-digitization configurations, recommends strategic pathways for progression, identifies requisite digital technologies and business capabilities, and aligns with Philippine policy priorities for innovation. The framework undergoes validation through Focus Group Discussions (FGDs) with selected MSMEs and government stakeholders, including representatives from DTI and DOST. Additionally, an Expert Panel Review is conducted, involving innovation scholars, industry consultants, and policymakers. Feedback from these validation exercises is incorporated using the Delphi method to refine the framework, ensuring its usability and policy relevance.

By systematically progressing through these phases, the study aims to provide a robust, contextually grounded understanding of digital servitization among Philippine manufacturing MSMEs and to offer a practical framework to guide their transition in the Industry 4.0 era.

## 5. Results and Discussion

This section presents a comprehensive analysis of the study's findings on the integration of digital servitization among Philippine manufacturing micro, small, and medium enterprises (MSMEs). The discussion is structured to address the research objectives, encompassing the current state of digital servitization, enablers and barriers to Industry 4.0 adoption, and the development of a Business Model Innovation (BMI) framework.

*5.1. Current State of Digital Servitization among Philippine Manufacturing MSMEs*

The quantitative assessment conducted across 150 MSMEs in CALABARZON, Central Luzon, and the National Capital Region (NCR) revealed a varied landscape in terms of digitization and servitization levels. A significant portion of these enterprises still rely predominantly on manual operations, with 45% indicating minimal use of digital tools. Approximately 35% have incorporated basic digital technologies, such as email communication and spreadsheet-based record-keeping, into their operations. Notably, only 20% have advanced towards integrating Industry 4.0 technologies, including the Internet of Things (IoT), cloud computing, and data analytics.

In terms of servitization, 50% of MSMEs offer smoothing services aimed at facilitating product purchases, such as financing options and basic customer support. Adapting services, which involve tailoring products to meet specific customer needs, are provided by 30% of the enterprises. Meanwhile, substituting services, where services replace the need for product ownership (e.g., leasing or pay-per-use models), are offered by 20% of the surveyed MSMEs.

These findings align with previous studies indicating that while some Philippine MSMEs have begun adopting digital technologies, the overall level of digital transformation remains limited. For instance, a study by Mia, et al. [13] found that many MSMEs started adopting social media and e-commerce platforms during the COVID-19 pandemic to continue servicing clients' needs. However, the depth and breadth of digital adoption varied significantly among enterprises.

Qualitative case studies provided deeper insights into these trends. For instance, a small-scale electronics manufacturer implemented IoT-enabled predictive maintenance services, resulting in a 30% reduction in downtime and the creation of a new revenue stream through maintenance contracts. A medium-sized furniture producer adopted an online customization platform, enabling customers to design products to their specifications, which led to a 25% increase in sales and enhanced customer satisfaction. Additionally, a micro-scale textile enterprise introduced a subscription-based model for fashion rentals, appealing to eco-conscious consumers and expanding their market reach.

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*5.2. Enablers and Barriers to Adoption of Industry 4.0 Technologies for Service-Based Value Creation*

The study identified several enablers and barriers influencing the adoption of Industry 4.0 technologies among Philippine MSMEs.

Enablers include intrinsic motivations such as entrepreneurs' desires for personal and professional growth, which drive the pursuit of innovative digital solutions to enhance business operations. Extrinsic factors, particularly the COVID-19 pandemic, have accelerated digital transformation as enterprises adapted to mobility restrictions and shifts in market demand. The pandemic acted as a catalyst, compelling many MSMEs to explore and integrate digital tools to survive and remain competitive. This observation is consistent with findings from Cueto, et al. [14] who noted that economic disruptions reinforced entrepreneurial innovations, prompting businesses to shift to digital platforms.

Conversely, barriers to adoption are significant. Limited digital literacy among entrepreneurs and employees hamppers the effective implementation of advanced digital tools. Financial constraints pose another major challenge, as the high costs associated with adopting Industry 4.0 technologies are often prohibitive for resource-limited MSMEs. Infrastructure issues, including unreliable internet connectivity and inadequate technological infrastructure, further impede seamless digital integration. These challenges underscore the need for targeted interventions to support MSMEs in their digital transformation journey. Mia, et al. [13] highlighted similar barriers, noting that MSMEs faced diverse challenges during the pandemic, including limited resources and technical know-how.

*5.3. Business Model Innovation (BMI) Framework Development*

Synthesizing the findings, a BMI framework was developed to guide MSMEs in integrating digital servitization into their operations. The framework comprises four phases:

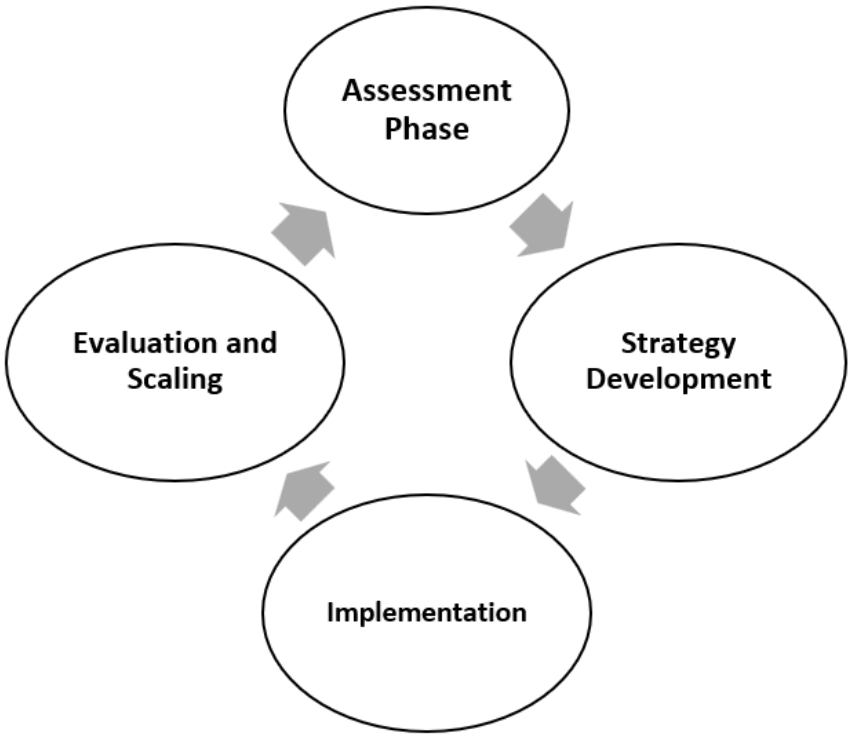


**Figure 3.**
Business Model Innovation (BMI) Framework.

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1. Evaluate the current digital maturity and service offerings of the enterprise to establish a baseline understanding.
2. Identify the target servitization level and corresponding digital tools that align with the enterprise's goals and capabilities.
3. Deploy the selected technologies and develop service-based value propositions, ensuring alignment with customer needs and market trends.
4. Monitor performance, gather feedback, and scale successful initiatives, fostering continuous improvement and adaptation.

This framework provides a structured approach for MSMEs to navigate the complexities of digital servitization, enabling them to enhance competitiveness and service delivery in the Industry 4.0 era.

*5.4. Discussion*

The study's findings align with existing literature emphasizing the critical role of digital transformation in enhancing MSME resilience and competitiveness. The observed enablers and barriers resonate with challenges identified in prior research, highlighting the necessity for targeted interventions to support MSMEs in their digital servitization journey. For instance, Cueto, et al. [14] emphasized that while the COVID-19 pandemic accelerated digital adoption among MSMEs, challenges such as limited digital literacy, financial constraints, and infrastructure issues persist, hindering effective implementation.

Addressing these barriers requires a collaborative effort involving policymakers, industry associations, and the MSMEs themselves. Initiatives aimed at improving digital literacy, providing financial support, and enhancing technological infrastructure are essential to facilitate the successful integration of Industry 4.0 technologies. By leveraging the proposed BMI framework and addressing the identified challenges, Philippine manufacturing MSMEs can strategically navigate the digital servitization landscape, unlocking new opportunities for growth and innovation.

## 6. Conclusion

The study has provided a comprehensive analysis of the current landscape, challenges, and opportunities associated with the adoption of digital servitization among Philippine manufacturing micro, small, and medium enterprises (MSMEs). The findings underscore the critical role of digital transformation in enhancing the resilience and competitiveness of MSMEs, particularly in the context of the rapidly evolving Industry 4.0 environment.

The research revealed that while a significant portion of Philippine manufacturing MSMEs have begun integrating basic digital tools into their operations, the adoption of advanced Industry 4.0 technologies remains limited. This partial digital integration highlights a substantial opportunity for MSMEs to further leverage digital technologies to enhance their service offerings and operational efficiency. The study identified both intrinsic motivations, such as the pursuit of personal and professional growth, and extrinsic factors, notably the COVID-19 pandemic, as key drivers accelerating digital transformation among these enterprises.

However, the transition towards digital servitization is not without challenges. The study identified several barriers impeding the adoption of advanced digital technologies, including limited digital literacy, financial constraints, and infrastructural issues such as unreliable internet connectivity. These challenges underscore the necessity for targeted interventions aimed at supporting MSMEs in their digital transformation journey. Addressing these barriers requires a collaborative effort involving policymakers, industry associations, and the MSMEs themselves to provide comprehensive support mechanisms.

In response to these findings, the study proposed a Business Model Innovation (BMI) framework tailored to guide MSMEs in integrating digital servitization into their operations. This framework offers a structured approach encompassing assessment, strategy development, implementation, and evaluation phases, enabling MSMEs to navigate the complexities of digital transformation effectively. By adopting this framework, MSMEs can systematically enhance their digital capabilities, develop

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innovative service-based value propositions, and position themselves competitively in the Industry 4.0 era.

The integration of digital servitization presents a significant opportunity for Philippine manufacturing MSMEs to enhance their competitiveness and resilience in the Industry 4.0 era. While challenges exist, the adoption of a structured approach, as outlined in the proposed BMI framework, combined with collaborative efforts to address existing barriers, can facilitate a successful digital transformation. This transition is not only vital for the growth and sustainability of individual enterprises but also contributes to the broader economic development of the Philippines.

## Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

## Copyright:



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