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Optimization of Digital Business to Support MSMEs Growth in the Industry 4.0 Transformation

Aswadi Jaya[1], Farhan Saputra[2], Derlina[3], Dwi Nur Ramadhan[4], Thomas Green[5*]
[1]Department of English Education, PGRI University Palembang, Indonesia
[2]Faculty of Economics and Business, Universitas Bhayangkara Jakarta Raya
[3]Faculty of Mathematic and Natural Science, Universitas Negeri Medan, Indonesia
[4]Faculty of Economics and Business, University of Raharja, Indonesia
[5]Department of Digital Business, Eesp Incorporation, British Indian Ocean
[1]aswadijaya@univpgri-palembang.ac.id, [2]farhansaputra121@gmail.com, [3]derlina@unimed.ac.id, [4]dwi.nur@raharja.info, [5]thom.green@eesp.io
***Corresponding Author**

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ABSTRACT

Digital transformation has become essential for Micro, Small, and Medium-Sized Enterprises (MSMEs) in the Industry 4.0 age in order to improve resilience and competitiveness in spite of restricted resources. The influence of digital optimization techniques on MSME growth is investigated in **this study**. These tactics include DMA, EPU, and DFMT. Data from 100 MSMEs was gathered **quantitatively using structured questionnaires**, and the correlations between the variables were examined using SmartPLS 3. EPU has the biggest impact, followed by DFMT and DMA, according to the results, which show that all digital strategies have a favorable impact on MSME growth. According to the model's R Square value of 0.694 for MSME Growth, the examined strategies account for around 69.4% of the growth variation. **These results** demonstrate how crucial it is for MSMEs to embrace digital technology in order to increase their market reach, boost operational effectiveness, and fortify financial management. **Future research** is urged to examine other factors impacting digital adoption and to apply these findings in a variety of sector scenarios. **The study concludes** that MSMEs must invest in digital skills in order to achieve sustainable development in a competitive digital world.

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1. INTRODUCTION

Micro, Small, and Medium-Sized Enterprises (MSMEs) have been significantly impacted by digital technology in the era of Industry 4.0. MSMEs can compete globally, boost operational efficiency, and broaden their market access thanks to digitalization [1]. This change is essential as MSMEs often face infrastructure and resource limitations compared to larger businesses. By adopting technologies like e-commerce platforms, digital marketing tools, and technology-based management systems, MSMEs can enhance their competitiveness and long-term viability [2, 3]. These digital strategies are not only essential for adapting to rapidly changing market trends but also for driving innovation and business transformation. However, many MSMEs in Indonesia face challenges in fully embracing digital adoption due to factors like limited digital infrastructure, cost, and lack of technical knowledge. In the context of Industry 4.0, MSMEs must adopt not just digital tools but also advanced technological mechanisms, such as scalable system architectures, robust digital frameworks, and

data-driven algorithms, to maximize the impact of their digital initiatives. These technological mechanisms enable MSMEs to improve operational processes, enhance customer engagement, and gain insights for better decision-making. Thus, it is crucial for MSMEs to understand and leverage the technological mechanisms behind digital transformation, which will ultimately improve their competitiveness and long-term growth in the Industry 4.0 era [4, 5].

Despite the fact that digitization has become essential, many MSMEs in Indonesia continue to encounter major challenges when it comes to using digital technology to its full potential. One of the biggest obstacles is a lack of funding, which limits them access to cutting-edge equipment and essential digital tools. Furthermore, a large number of MSME owners lack digital skills and technological understanding, which leads to less than ideal digitization initiatives. MSMEs' access to digital services is made more difficult by uneven digital infrastructure in some places, particularly in rural areas. This circumstance suggests that in order to help MSMEs overcome these obstacles and fully utilize digitalization, appropriate solutions are required [6].

The goal of this research is to create and enhance digital business plans that can help MSMEs expand in the Age of Industry 4.0. It is anticipated that this study would provide practical methods for boosting MSMEs' adoption of digital technology and promoting its efficient use to boost competitiveness and long-term viability [7]. In order to help MSMEs overcome the problems of digitization and maximize their potential in the age of digital transformation, this research also attempts to offer useful suggestions that they may use.

This study contributes to the achievement of several Sustainable Development Goals (SDGs), particularly SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation, and Infrastructure). The digitalization adopted by MSMEs through e-commerce platforms, digital marketing, and Digital Financial Management Tools (DFMT) not only enhances operational efficiency but also expands market access, thereby fostering inclusive and sustainable economic growth [8, 9]. The application of these technologies plays a crucial role in boosting MSME competitiveness, driving innovation, and building accessible digital infrastructure, which strengthens MSMEs' ability to thrive in the face of Industry 4.0 challenges. By providing policy recommendations that encourage the broader use of digital technologies, this research also contributes to achieving a more modern and sustainable industrial development, in line with the global SDGs agenda [10].

2. LITERATURE REVIEW

2.1. Concept of Industry 4.0

The integration of cutting-edge technology like automation, artificial intelligence, and the Internet of Things (IoT) characterizes Industry 4.0, a shift in the industrial and commercial environment. The idea, which has its roots in Germany, focuses on digitizing production procedures to build "smart factories" interconnected equipment, systems, and people [11, 12]. This idea affects many industries, including MSMEs, and goes beyond manufacturing. MSMEs have the chance to use technology to increase production efficiency, access a wider audience, and produce higher-quality goods thanks to Industry 4.0. Given the normal resource and scale limitations faced by MSMEs, Industry 4.0 is relevant because it has the ability to increase a company's agility, competitiveness, and resilience in a quickly changing economic environment [13].

2.2. Digitalization of MSMEs

Digitalization in MSMEs is a critical driver for enhancing operational efficiency, customer engagement, and business sustainability in the Industry 4.0 era. Industry 4.0 integrates technologies like automation, Artificial Intelligence (AI), IoT, and blockchain, which significantly improve MSMEs' production efficiency, data utilization, and decision-making processes [14]. Advanced digital tools, such as e-commerce platforms, AI-driven digital marketing, and blockchain-based financial management systems, are transforming how MSMEs engage with customers, optimize their operations, and manage their resources. Digitalization not only enhances MSMEs' ability to meet consumer demands but also empowers them to engage in real-time, data-driven decision-making, aligning their business models with the dynamic digital economy [15]. However, MSMEs in emerging markets face challenges in adopting these technologies due to cost constraints, limited digital literacy, and inadequate digital infrastructure, which restrict their ability to fully capitalize on Industry 4.0's potential for sustainable growth and innovation [16, 17].

2.3. Digital Optimization Strategies

In the era of Industry 4.0, MSMEs must strategically optimize their digital operations to succeed. Using a variety of digital tools and platforms to improve business performance is known as digital optimization.

For example, MSMEs may access a wider audience through e-commerce platforms, which lessens their reliance on physical locations and boosts their potential for sales [18, 19]. Digital marketing strategies, such as search engine optimization and social media marketing, give MSMEs affordable means of reaching specific audiences and increasing brand recognition. Enterprise Resource Planning (ERP) software and Customer Relationship Management (CRM) systems are two examples of technology-based company management solutions that may increase productivity, streamline processes, and promote customer interaction. Strategic planning is necessary before using these technologies to guarantee that MSMEs can fully utilize digital technology to increase growth and resilience in cutthroat marketplaces [20].

3. METHODOLOGY

3.1. Research Design

This study adopts the Structural Equation Modeling (SEM) technique using SmartPLS 3 to analyze the complex relationships between digital optimization strategies and MSME growth. SEM-PLS is particularly suitable for this research as it allows for modeling latent variables, such as DMA, EPU, and digital financial management tools, while accounting for measurement error [21, 22]. This method is highly effective for exploring both direct and indirect relationships between variables and provides robust insights into the factors that drive MSME growth in the context of Industry 4.0. Additionally, SEM-PLS is well-suited for predictive modeling and hypothesis testing, making it ideal for understanding the impact of multiple, interconnected digital strategies on MSME performance. The use of this method enhances the model's explanatory power, providing a solid foundation for evaluating how digital optimization techniques contribute to MSME growth [23].

3.2. Data Collection

The study employed a mixed-method approach, incorporating both quantitative surveys and qualitative structured interviews to provide a comprehensive view of digital adoption in MSMEs. The survey data collected quantitative insights into the extent of digital adoption, the challenges faced, and the perceived benefits of digital strategies. In addition to the quantitative analysis, structured interviews with MSME owners were conducted to gather qualitative insights, which were used to contextualize the survey findings [24]. These qualitative insights, while not directly analyzed in the SEM-PLS model, were critical in providing a deeper understanding of the barriers to digital adoption, such as digital literacy and access to infrastructure, and the practical challenges MSMEs face in implementing digital strategies. The qualitative data helped enrich the interpretation of the SEM-PLS results and provided actionable recommendations for MSMEs in overcoming these barriers [25].

3.3. Population and Sample

MSMEs that work in the retail and service industries in a certain city (like Jakarta or Surabaya) make up the study population. Because they have access to superior digital infrastructure, these businesses are more likely to embrace digital capabilities. MSMEs with at least three years of experience who are either actively implementing digital strategies or in the early phases of digital adoption are the goal of the sample, which is chosen using a purposive sampling approach. With 100 MSMEs as the ultimate sample size, solid data analysis and trustworthy generalizations are possible [26–28].

3.4. Data Analysis Techniques

Descriptive and inferential statistical techniques are used to analyze data and assess how well digital optimization tactics are working. An overview of the data's features, including adoption rates and typical difficulties, is given by the descriptive analysis. Regression analysis is used in inferential analysis to ascertain the connection between particular digital tactics and metrics of business success (e.g., revenue rise, client base expansion). To guarantee accuracy and dependability, statistical software like SPSS or SmartPLS is used for the data analysis [29].

3.5. Research Variables

In this study, several latent variables are identified and measured through observable indicators:

- Digital Marketing Adoption (DMA)

  Indicators use of social media, frequency of online advertising, engagement with digital marketing channels.

- E-commerce Platform Usage (EPU)

  Indicators frequency of platform usage, variety of products offered online, customer feedback on e-commerce platforms.

- Digital Financial Management Tools (DFMT)

  Indicators use of digital payment systems, financial planning software, integration of online accounting.

- MSME Growth (MG)

  Indicators revenue growth, customer base expansion, operational efficiency.

3.6. Hypotheses Development

- H1: Digital Marketing Adoption has a positive effect on MSME Growth.
- H2: E-commerce Platform Usage has a positive effect on MSME Growth.
- H3: Digital Financial Management Tools have a positive effect on MSME Growth.

3.7. Research Model

The research model delves into the intricate relationships between several key variables, aiming to provide a deeper understanding of how digital optimization influences the growth of MSMEs [30–32]. At the core of the study are the independent variables, which include DMA, EPU, and DFMT, all of which are expected to have significant effects on MSME performance. Each of these variables plays a critical role in modernizing MSME operations and is hypothesized to contribute to the overall growth of these enterprises in the digital age. DMA reflects the integration of online marketing strategies to reach wider audiences, while EPU highlights the importance of adopting e-commerce platforms to enhance market accessibility and expand customer bases. DFMT represents the growing reliance on digital financial tools to streamline financial management processes, enhance decision-making, and improve overall efficiency [33]. The dependent variable, MG, serves as the ultimate measure of success, encompassing various aspects such as revenue growth, market expansion, and operational efficiency. The research model employs a path analysis to visualize how these variables interconnect, shedding light on the expected impacts of digital strategies on the trajectory of MSME development and sustainability. By exploring these relationships, the study aims to offer valuable insights into how MSMEs can harness digital tools to navigate the challenges of a rapidly evolving business landscape and secure long-term growth [34].

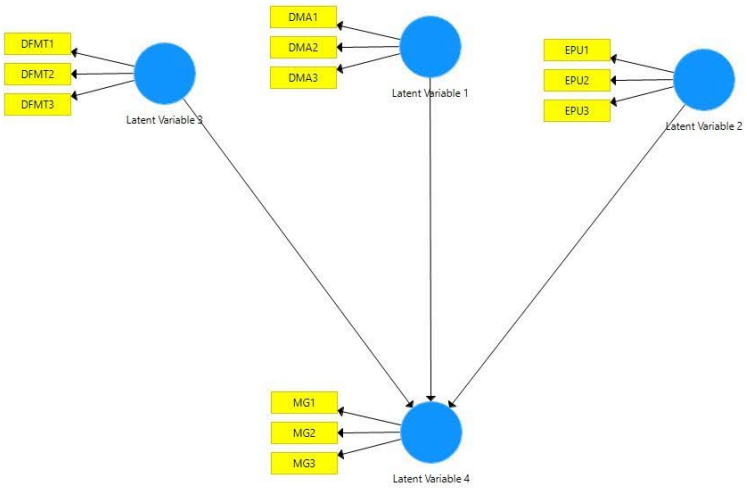

Figure 1. Hypothesis Framework

The hypothesis framework models the connections between MG and digital optimization techniques, such as DMA, EPU, and DFMT, as shown in Figure 1. Increased use of digital marketing, e-commerce platforms, and digital financial tools is anticipated to have a major positive impact on MSME growth by increasing

customer reach, improving operational efficiency, and strengthening financial management [35–37]. Each arrow represents a hypothesized positive impact. The research is guided by this framework, which seeks to determine which digital tactics, in the context of Industry 4.0, best propel MSME growth [38].

4. RESULTS AND DISCUSSION

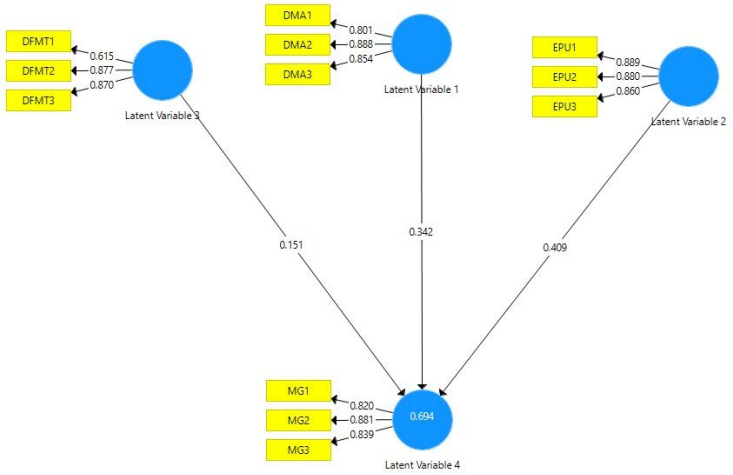

Figure 2. SmartPLS-SEM

As shown in Figure 2, the SmartPLS-SEM model illustrates the relationships between latent variables related to digital optimization strategies and MSME growth. Latent Variable 1, representing DMA, Latent Variable 2, representing EPU, and Latent Variable 3, representing DFMT, each demonstrate their respective factor loadings for observed indicators. These latent variables are connected to Latent Variable 4, which represents MG, with path coefficients indicating the strength of the relationships: 0.342 for DMA, 0.409 for EPU, and 0.151 for DFMT. This model highlights the hypothesized positive influence of each digital strategy on MSME growth, allowing for an in-depth analysis of the contributing factors in the context of digital transformation [39, 40].

Table 1. Reliability & Validity

	Cronbach's Alpha	**rho_A**	**Composite Reliability**	**Average Variance Extracted (AVE)**
Latent Variable 1	0.806	0.816	0.885	0.720
Latent Variable 2	0.850	0.859	0.909	0.768
Latent Variable 3	0.710	0.772	0.836	0.635
Latent Variable 4	0.802	0.803	0.884	0.717

Each latent variable's reliability and validity metrics reveal good construct validity and internal consistency within the measurement model, as seen in Table 1. All latent variables have Cronbach's Alpha values above the suggested cutoff point of 0.7, demonstrating adequate internal consistency among the questions that measure each construct. The reliability of the constructs is further supported by the fact that each latent variable's Composite Reliability ratings are higher than 0.7. Each latent variable obtains appropriate convergent validity, as indicated by the Average variation Extracted (AVE) values, which are all over 0.5. This means that the latent variables account for more than 50% of the variation in the indicators. These results demonstrate the validity and reliability of the model's constructs, which support the measurement model's overall robustness [41, 42]. These constructs include MSME Growth (Latent Variable 4), DMA (Latent Variable 1), EPU (Latent Variable 2), and DFMT (Latent Variable 3). A solid basis for comprehending the proposed links in the structural model is provided by this validity and reliability [43].

Table 2. Outer Loadings

	Latent Variable 1	Latent Variable 2	Latent Variable 3	Latent Variable 4
DFMT1			0.615	
DFMT2			0.877	
DFMT3			0.870	
DMA1	0.801			
DMA2	0.888			
DMA3	0.854			
EPU1		0.889		
EPU2		0.880		
EPU3		0.860		
MG1				0.820
MG2				0.881
MG3				0.839

The measurement model is validated by the factor loadings for each indicator, illustrating how strongly they are associated with their corresponding latent variables (Table 2). The indicators DMA1, DMA2, and DMA3 for Latent Variable 1 (DMA) show strong factor loadings of 0.801, 0.888, and 0.854, respectively, suggesting a robust association between these items and the DMA construct. Similarly, Latent Variable 2 (EPU) demonstrates strong construct reliability, with factor loadings of 0.889, 0.880, and 0.860 for its indicators EPU1, EPU2, and EPU3. For Latent Variable 3 (DFMT), the indicators DFMT1, DFMT2, and DFMT3 show loadings of 0.615, 0.877, and 0.870. Although DFMT1 has a slightly lower factor loading of 0.615, it still falls within an acceptable range. This suggests that while digital financial tools are an important component of MSME growth, their influence may not be as strong as other factors like digital marketing or EPU [44, 45]. One possible explanation for this lower impact could be the varying levels of digital financial literacy and infrastructure among MSMEs. In many cases, MSMEs may struggle to effectively implement and leverage digital financial tools due to a lack of training, limited access to reliable financial technologies, or concerns about the security of digital financial transactions. As such, while digital financial tools contribute to MSME growth, their adoption may require more time, targeted training, and improved infrastructure to fully realize their potential [46, 47].

Table 3. R-Square

	R Square	R Square Adjust
Latent Variable 4	0.694	0.692

The R Square and R Square Adjusted values for Latent Variable 4 (MSME Growth) are displayed in Table 3, illustrating the model's strong explanatory power. With an R Square value of 0.694, the independent variables DMA, EPU, and DFMT explain approximately 69.4% of the variation in MSME Growth, highlighting the significant role of digital optimization strategies in driving MSME performance [48, 49]. The R Square Adjusted value of 0.692, which accounts for the number of predictors in the model, further supports the model's robustness and indicates that the results remain valid despite the inclusion of multiple predictors. These findings suggest that digital tools like DMA, EPU, and DFMT are crucial for enhancing MSME growth, providing strong evidence for the positive impact of digital optimization techniques. This high level of explanatory power emphasizes the importance of these digital strategies in improving business outcomes and suggests that MSMEs can achieve significant growth by embracing digital technologies, which are essential for staying competitive in the modern business landscape [50].

5. MANAGERIAL IMPLICATIONS

5.1. Prioritize Digital Marketing Investments

MSMEs should focus on enhancing their online presence through digital marketing strategies, such as social media marketing, Search Engine Optimization (SEO), and targeted online advertising, to increase brand visibility and attract a broader audience.

5.2. Leverage E-commerce Platforms for Expansion

MSMEs must integrate e-commerce platforms into their business models to expand their market reach, improve customer engagement, and streamline sales processes. This will help them overcome geographical limitations and tap into new customer bases.

5.3. Invest in Digital Financial Management Tools

Although digital financial tools showed moderate impact, MSMEs are encouraged to invest in financial management systems to improve budgeting, forecasting, and financial transparency. Providing training to MSME owners on the use of these tools can increase their effectiveness.

5.4. Focus on Building Digital Literacy

MSMEs should implement training programs for their workforce to enhance digital literacy. This will help overcome the barriers of digital adoption and empower employees to use digital tools effectively, thus improving overall business performance.

5.5. Adopt a Phased Approach for Digital Transformation

Given the varying levels of digital readiness among MSMEs, managers should adopt a phased approach to digital transformation. This includes starting with foundational tools like digital marketing and e-commerce platforms before advancing to more complex digital financial tools.

6. CONCLUSION

This study introduces a novel perspective on MSME growth within the context of Industry 4.0, broadening the scope of traditional digital adoption strategies by incorporating advanced technological innovations such as AI-driven marketing tools, blockchain for financial management, and IoT-based operational optimization. The integration of these cutting-edge technologies provides a more comprehensive understanding of how MSMEs can leverage digital strategies to foster growth in the modern economy. By developing a holistic model, this research emphasizes the role of not only conventional digital tools like digital marketing and e-commerce platforms but also the transformative potential of emerging technologies. The findings reveal how the combination of these strategies contributes to MSME growth, with a strong explanatory power reflected in an R Square value of 0.694. This indicates that digital optimization, when applied strategically, significantly enhances MSME performance.

One of the key highlights of this study is the central role of e-commerce platforms in driving MSME growth, particularly in the post-pandemic digital landscape. As the digital economy continues to evolve, e-commerce has emerged as a powerful catalyst for expanding market reach and increasing sales for MSMEs. Unlike previous research, this study emphasizes the importance of leveraging blockchain and AI technologies to innovate financial and marketing practices. Blockchain offers enhanced security and transparency for financial management, while AI-powered marketing tools provide personalized customer experiences, driving customer engagement and retention. Together, these technologies offer new opportunities for MSMEs to differentiate themselves in an increasingly competitive market, ultimately promoting long-term sustainability and growth.

The study also delves into the barriers faced by MSMEs in Indonesia, identifying challenges such as limited digital skills, inadequate infrastructure, and resistance to adopting new technologies. To address these obstacles, the study provides actionable recommendations, including the need for targeted digital skill training programs and tailored infrastructure support. By focusing on these areas, MSMEs can overcome the challenges that hinder their digital transformation and improve their ability to compete in the digital age. This paper contributes a fresh perspective on how MSMEs can thrive in a rapidly changing environment, ensuring their resilience and adaptability in the face of technological disruptions. Future research should continue to explore the dynamic relationship between emerging technologies and MSME performance, particularly focusing on sectors beyond retail and services, to provide a deeper understanding of how different industries can harness the power of Industry 4.0 technologies to drive growth.

7. DECLARATIONS

7.1. About Authors

Aswadi Jaya (AJ) https://orcid.org/0000-0001-5706-0977

Farhan Saputra (FS) https://orcid.org/0000-0002-5642-8685
Derlina (DD) https://orcid.org/0000-0002-8650-129X
Dwi Nur Ramadhan (DR) https://orcid.org/0009-0004-2941-2364
Thomas Green (TG) https://orcid.org/0009-0001-7048-2231

7.2. Author Contributions

Conceptualization: AJ; Methodology: DD; Software: TG; Validation: DR and TG; Formal Analysis: AJ and TG; Investigation: DD; Resources: AA; Data Curation: AJ; Writing Original Draft Preparation: AJ and DR; Writing Review and Editing: DR and DD; Visualization: AJ; All authors, AJ, DD, DR and TG have read and agreed to the published version of the manuscript.

7.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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7.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

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