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TECHNOLOGICAL INNOVATION: ADOPTION OF ARTIFICIAL INTELLIGENCE IN MICRO, SMALL, AND MEDIUM ENTERPRISES (MSMES)

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Abstract. This study examines the factors influencing Artificial Intelligence (AI) adoption among Micro, Small, and Medium Enterprises (MSMEs) in Indonesia. By integrating the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT), it explores how perceived usefulness, ease of use, and social influence shape MSME attitudes and behavioral intentions toward AI adoption. A quantitative approach using path analysis and structural equation modeling (SEM) is employed, with data analyzed using Smart PLS 4.0 for accuracy and reliability. The findings reveal that perceived usefulness and effectiveness positively influence attitudes toward AI, while ease of use and effort expectancy enhance perceptions of AI's benefits. Behavioral intention is driven by perceived benefits, ease of use, and social influence, moderated by gender, age, and experience. Attitudes toward AI significantly affect behavioral intention, leading to actual usage.

Abstrak. Abstrak. Penelitian ini mengkaji faktor-faktor yang memengaruhi adopsi Kecerdasan Buatan (AI) di kalangan Usaha Mikro, Kecil, dan Menengah (UMKM) di Indonesia. Dengan mengintegrasikan Technology Acceptance Model (TAM) dan Unified Theory of Acceptance and Use of Technology (UTAUT), penelitian ini mengeksplorasi bagaimana persepsi kegunaan, kemudahan penggunaan, dan pengaruh sosial membentuk sikap dan niat perilaku UMKM terhadap adopsi AI. Pendekatan kuantitatif menggunakan analisis jalur dan pemodelan persamaan struktural (SEM) digunakan, dengan data dianalisis menggunakan Smart PLS 4.0 untuk akurasi dan keandalan. Temuan penelitian mengungkapkan bahwa persepsi kegunaan dan efektivitas secara positif memengaruhi sikap terhadap AI, sementara kemudahan penggunaan dan ekspektasi upaya meningkatkan persepsi manfaat AI. Niat perilaku didorong oleh persepsi manfaat, kemudahan penggunaan, dan pengaruh sosial, yang dimoderasi oleh jenis kelamin, usia, dan pengalaman. Sikap terhadap AI secara signifikan memengaruhi niat perilaku, yang mengarah pada penggunaan aktual.

INTRODUCTION

Micro, small, and medium enterprises (MSMEs) play a vital role in the global economy. MSMEs significantly contribute to economic growth, job creation, and poverty alleviation (Ayandibu & Houghton, 2017). Despite their potential, many MSMEs still face challenges such as limited resources, skills, competitiveness against larger corporations, market access, and technology adoption. In the era of digital transformation, AI technology emerges as a transformational force that can help MSMEs become more efficient and competitive (Chatterjee et al., 2022; Schwäke et al., 2024).

AI, a rapidly advancing field of technology, offers innovative solutions to enhance business models and improve MSME performance. The integration of AI into MSME activities can impact various areas, such as business process automation, advanced data analytics, data-driven marketing, and the development of smarter products and services. No business can afford to remain idle and ignore the potential of Artificial Intelligence (AI) (Floridi, 2021), without risking competitiveness (Athira Prakash et al., 2023).

Based on research conducted by PwC, AI is expected to drive greater product variety, enhance personalization, increase appeal, and improve affordability over time. While AI technology offers MSMEs opportunities for growth, it also raises concerns among business operators. A survey conducted by Pancake on MSMEs in Indonesia revealed that most MSME operators in the country have heard of or are familiar with artificial intelligence (AI) technology. However, only a small proportion of MSMEs have adopted AI in their business processes. This is primarily due to several factors, including concerns about lacking the technical knowledge to operate AI technology, uncertainty about how to implement AI in their business, and worries about the potential costs associated with adopting AI technology.

The integration of AI can have a positive impact. In this context, MSMEs can adopt new business models that utilize AI as an emerging technology to create value (Foss & Saebi, 2017; Sena & Nocker, 2021; Teece, 2018; Zott & Amit, 2013). However, MSMEs cannot hastily approach AI adoption through trial and error. AI implementation must be smooth, affordable, scalable, and capable of avoiding potential issues that could hinder company performance. AI can become a hindrance when companies use it to create new, innovative business models (Boitnott, 2019; Gladysz et al., 2023; Lee et al., 2019; Pessot et al., 2021; Sena & Nocker, 2021).

AI has become a key driver of business model innovation across various industries (Lee et al., 2019; Wang et al., 2023), enabling companies to gain or maintain competitive advantages while exploring new businesses and ventures (Lee et al., 2019). AI can influence and benefit MSMEs in two main ways: first, by transforming the business environment; and second, by enabling them to change their business models and practices. Ultimately, this can enhance their productivity, reach, and scalability (Ahmad et al., 2021; Julyanthry et al., 2022; Sharma & Rai, 2023).

Artificial Intelligence (AI) is the simulation of human intelligence in machines, enabling them to perform tasks that typically require human cognitive abilities (Fahle et al., 2020; Soori et al., 2023). The real business value of artificial intelligence is its ability to augment human capabilities and improve business operations (Mikalef & Gupta, 2021; Perifanis & Kitsios, 2023). To understand the factors influencing AI adoption in MSMEs, a robust theoretical framework is essential.

The Technology Acceptance Model (TAM) (Aljarrah et al., 2016; Bahador & Ibrahim, 2021) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Taiwo & Downe, 2013; Venkatesh et al., 2016) are two theoretical frameworks widely employed in previous studies to elucidate the adoption of new technologies. TAM emphasizes perceived usefulness and perceived ease of use as primary determinants influencing technology usage intentions (Bahador & Ibrahim, 2021; Bryan & Zuva, 2021; Scherer et al., 2019). Conversely, UTAUT expands this perspective by incorporating social factors, such as social influence, facilitating conditions, and performance and effort expectations (Shachak et al., 2019; Venkatesh et al., 2016).

TAM thus offers a strong lens through which to understand how individual perceptions of technology impact their intention and behavior toward adoption. UTAUT emphasizes that technology adoption is also influenced by performance expectations, the perceived effort required, social influence from the surrounding environment, and the presence of supportive conditions that facilitate technology adoption. By combining elements from both models, this study aims to gain a deeper understanding of the factors that shape AI adoption by SMEs from both technical and social perspectives.

Moreover, this study considers the role of AI in enhancing the competitiveness of SMEs in the era of globalization. AI offers practical solutions that can improve operational efficiency and business innovation, such as process automation, advanced data analytics, and market trend prediction (Badghish & Soomro, 2024). For instance, AI-powered demand forecasting can help SMEs manage inventory and resources more effectively, reducing operational costs. However, to fully realize this potential, SMEs must overcome barriers to AI adoption, which involve better understanding the technology's benefits and developing the skills and infrastructure necessary to support it.

In the context of Indonesia, the government has begun to encourage the digitalization of SMEs through various initiatives and funding programs. However, despite these efforts, the adoption rate of AI among SMEs remains low compared to larger enterprises. This suggests a pressing need to develop more effective strategies to support AI adoption in this sector. One proposed solution is to provide tailored training and guidance to meet the specific needs of SMEs, as well as to create an environment conducive to technological innovation. The Indonesian government has launched various initiatives to promote the digitalization of Micro, Small, and Medium Enterprises (MSMEs). One of the key programs is the Digital Technology Adoption 4.0 Program, introduced by the Ministry of Communication and Informatics (Kominfo) in May 2022.

This program aims to enhance MSME productivity through digitalization, particularly for businesses that still operate offline. In 2021, Kominfo facilitated mentoring for 26,000 MSMEs to engage in digital commerce across 10 Priority Tourism Areas. By 2022, the program was expanded to include 30,000 MSMEs, focusing on the adoption of Industry 4.0 digital technologies in 13 priority areas (aptika.kominfo.go.id).

Furthermore, the government, through a collaboration between the Coordinating Ministry for Economic Affairs, the Ministry of Cooperatives and SMEs, the Halal Product Assurance Agency of the Ministry of Religious Affairs, and six Integrated Business Service Centers (PLUT KUMKM), implemented the Integrated Business Service Center Educational Center (PLUTEC) Program. This initiative, conducted from June 13 to June 30, 2022, provided training in digital marketing and halal product management for MSMEs and entrepreneurs at six PLUT KUMKM locations (ekon.go.id). Despite these efforts, the adoption rate of Artificial Intelligence (AI) among MSMEs remains relatively low compared to larger enterprises. This indicates an urgent need for the development of more effective strategies to support AI adoption in this sector. One proposed solution is to provide training and guidance tailored to the specific needs of MSMEs while fostering an environment conducive to technological innovation. Targeted training programs can assist MSMEs in understanding the benefits and practical applications of AI in their business operations, whereas a supportive innovation ecosystem can facilitate collaboration among MSMEs, technology providers, and educational institutions. By implementing this approach, it is expected that AI adoption among MSMEs will increase, thereby enhancing their competitiveness in the global market.

Given this background, this research seeks to explore the key factors influencing AI adoption by SMEs in Indonesia, focusing on the application of the TAM and UTAUT models as an analytical framework. This study is expected to contribute significantly to both theoretical and practical knowledge, offering valuable insights for policymakers and business practitioners in supporting the digital transformation of SMEs through AI adoption. They are often seen as the backbone of the economy, especially in developing countries. This study will also address the following research questions: (1) How do perceived usefulness and ease of use influence MSMEs' attitudes and behavioral intentions toward AI? (2) How do social influence and facilitating conditions affect AI adoption? (3) What moderating factors play a role in these relationships?.

Micro, Small and Medium Enterprises (MSMEs)

According to the World Bank, MSMEs are defined based on the number of employees and annual sales revenue. Typically, micro enterprises employ fewer than 10 people, small enterprises employ between 10 and 50 people, and medium enterprises employ between 51 and 250 people. MSMEs play a crucial role in economic development by providing jobs, fostering innovation, and contributing to national income.

Adoption of Artificial Intelligence

Recent studies have explored the adoption of Artificial Intelligence (AI) in various contexts. In organizations, factors such as cost-effectiveness, relative advantage, top management support, and competitive pressure positively influence AI adoption for talent acquisition (Rajasshrie Pillai & Brijesh Sivathanu, 2020). Critical success factors across different adoption stages include performance expectancy, technical competencies, and organizational compatibility (Solaimani & Swaak, 2022). For consumer adoption, the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT) are commonly used theoretical frameworks, with perceived usefulness, ease of use, and trust being key antecedents (Bawack & Desveaud, 2022). At the organizational level, change capability, leadership, AI readiness, and adoption by trading partners positively impact AI adoption (Kurup & Gupta, 2022). These studies provide valuable insights for managers, marketers, and researchers in understanding and promoting AI adoption across different domains (Kopka & Fornahl, 2024)

The Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is a widely used framework for understanding user acceptance of information technology (Silva, 2015). It explains how various factors influence users' decisions to adopt new technologies (Silva, 2015). TAM has been extensively applied in Library and Information Science and Education domains, with researchers incorporating modifications to suit specific contexts (Weerasinghe & Hindagolla, 2017). The model's validity has been empirically proven through factor analysis, confirming that its key dimensions - perceived usefulness, perceived ease of use, and behavioral intention to use - remain relevant in today's rapidly evolving technological landscape (Napitupulu et al., 2017). TAM's flexibility allows for extensions and modifications to account for additional factors such as age, gender, and prior experience (Alomary & Woollard, 2015). This adaptability makes TAM a robust and powerful framework for examining technology acceptance across diverse user groups and organizations (Alomary & Woollard, 2015).

The Unified Theory of Acceptance and Use of Technology (UTAUT)

The Unified Theory of Acceptance and Use of Technology (UTAUT) is a widely used model for predicting technology acceptance and use (Venkatesh et al., 2003). It proposes that performance expectancy, effort expectancy, and social influence predict behavioral intention, while facilitating conditions and behavioral intention predict use behavior (Taiwo & Downe, 2013). A meta-analysis found that only the relationship between performance expectancy and

behavioral intention is strong, with other relationships being weak (Taiwo & Downe, 2013). UTAUT has been extensively applied in various fields, particularly in educational technology contexts (Or & Chapman, 2021). Researchers have proposed extensions to the model, such as adding constructs like usability, learnability, and attitude (Or & Chapman, 2021). Despite its widespread use, some limitations have been identified, leading to suggestions for a multi-level framework to guide future research and enable cross-context theorizing (Venkatesh et al., 2016).

METHOD

A quantitative approach is used to measure variables based on the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT). The variables in the TAM model are Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Attitude Toward Using (ATU), Behavioral Intention to Use (BI), and Actual Use (AU).

Meanwhile, the variables in the UTAUT model are Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), Facilitating Conditions (FC), Behavioral Intention (BI), and Use Behavior (UB). In this study, the TAM and UTAUT models will be combined. In this combined model, PU and PE will be merged as both focus on perceptions of technology performance. PEOU and EE will also be combined because both emphasize ease of use. ATU, BI, and AU from TAM will be retained, along with SI and FC from UTAUT. The moderating variables are gender, age, experience, and voluntariness of use.

A quantitative method using path analysis and structural equation modeling (SEM) is employed to test the relationships between independent variables (AI adoption) and dependent variables (MSME performance), with data analysis conducted using Smart PLS 4.0 software.
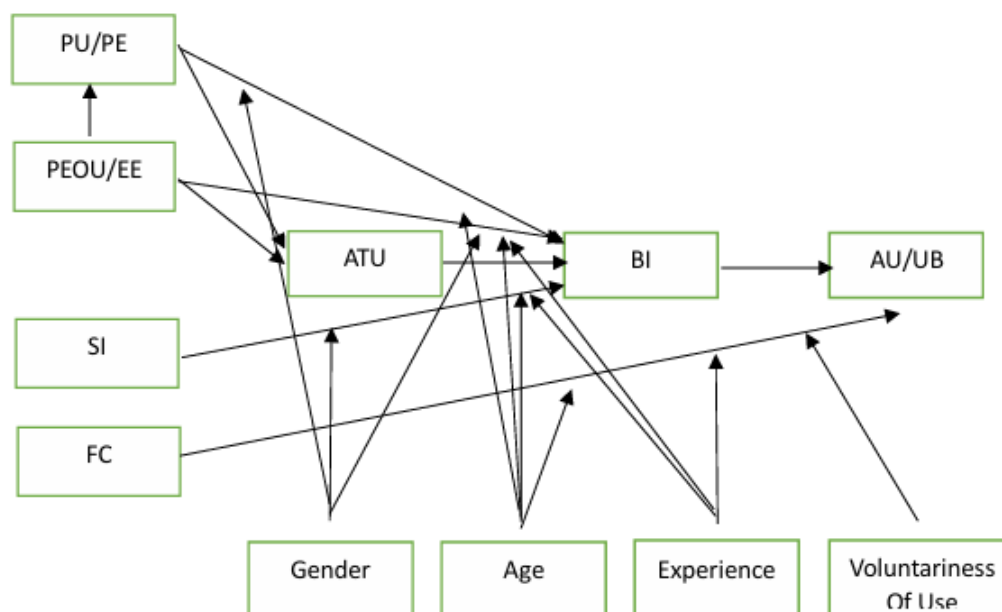

Figure 1. *Conceptual frame work*

RESULT AND DISCUSSION

Respondents were selected using purposive sampling techniques, totaling 50 MSMEs that met the relevance criteria for the topic of AI adoption.

Table 1. *Respondent Characteristics*

Category	Count	Percentage
Industrial Sectors		
- Culinary	22	45%
- Retail	15	30%
- Trade	8	15%
- Services	5	10%
Educational Background		
- Bachelor's Degree	35	70%
- Diploma	8	15%
- Master's Degree	5	10%
- Primary/Secondary Education	2	5%
Adoption of Digital Technologies		
- Financial Applications	38	75%

The respondents varied in business size (from small to medium) and industrial sectors, including retail, culinary, trade, and services. The majority were from the culinary sector (45%), followed by retail (30%), trade (15%), and services (10%), with an average of 10-50 employees per MSME. Most MSME owners held at least a bachelor's degree (70%), with 15% having a diploma, 10% holding a master's degree, and 5% possessing only primary or secondary education. The majority of MSMEs had already adopted simple digital technologies, such as financial applications (75%), before considering the use of AI.

Table 2. *SEM Results: Direct and Indirect Effects*

Relationship Between Variables	Direct Effect (β)	t-Statistic	p-Value	Indirect Effect	Total Effect	Description
PU/PE $\rightarrow$ ATU	0.45	6.8	< 0.001	-	0.45	Perceived usefulness and effectiveness enhance attitudes toward AI.
PEOU/EE $\rightarrow$ ATU	0.38	5.2	< 0.001	-	0.38	Ease of use positively influences attitudes toward AI.

PEOU/EE → PU/PE	0.42	6.1	< 0.001	-	0.42	Ease of use strengthens perceived usefulness and effectiveness.
PU/PE → BI	0.39	5.9	< 0.001	0.22	0.61	Perceived usefulness influences behavioral intention through attitudes toward AI.
PEOU/EE → BI	0.36	4.8	< 0.001	0.27	0.63	Ease of use impacts behavioral intention both directly and indirectly.
SI → BI	0.34	4.1	< 0.001	-	0.34	Social influence enhances the intention to use AI.
ATU → BI	0.48	7.5	< 0.001	-	0.48	Positive attitudes drive the intention to adopt AI.
BI → AU/UB	0.44	6	< 0.001	-	0.44	Behavioral intention is closely linked to actual usage behavior.
FC → AU/UB	0.41	4.5	< 0.001	0.18	0.59	Facilitating conditions strengthen usage behavior, especially indirectly.

1. **The Influence of PU/PE on ATU**

   The analysis results show that perceived usefulness (PU) and perceived effectiveness (PE) have a significant effect on attitude toward the use of AI (ATU). SMEs that consider AI to be beneficial and effective tend to have a more positive attitude toward its use (5). The regression coefficient indicates a strong positive influence ($\beta = 0.45$, $p < 0.01$).

2. **The Influence of PEOU/EE on ATU**

   The influence of perceived ease of use (PEOU) and effort expectancy (EE) on attitude toward the use of AI (ATU) is also significant. The easier AI is to understand and use, the more positive the attitude toward its usage ($\beta = 0.38$, $p < 0.05$), supporting H2.

3. **The Influence of PEOU/EE on PU/PE**

   PEOU/EE has a direct influence on perceived usefulness and effectiveness (PU/PE) of AI technology. Users who find AI easy to learn and apply tend to perceive it as more useful and effective in operational activities. This influence is proven to be significant ($\beta = 0.42$, $p < 0.01$).

4. **The Influence of ATU on BI**

   Attitude toward the use of AI (ATU) is shown to have a highly significant influence on BI ($\beta = 0.48$, $p < 0.01$), supporting H7. SMEs with a positive attitude toward AI are more likely to have the intention to adopt AI.

5. The Influence of BI on AU/UB (H8)

The influence of BI on Actual Use (AU) and Use Behavior (UB) is significant ($\beta = 0.44$, $p < 0.01$). A strong intention to use AI is shown to be closely related to actual usage behavior.

Table 2. SEM Result with Moderating Variables

Relationship	Direct Effect (β)	t-Statistic	p-Value	Moderating Variable	Moderation Effect	Description
PU/PE → BI	0.39	5.9	< 0.001	Gender, Age	Stronger in younger males	Perceived usefulness influences behavioral intention more in younger male respondents.
PEOU/EE → BI	0.36	4.8	< 0.001	Gender, Age, Experience	Stronger in experienced users	Ease of use impacts behavioral intention more for respondents with higher technology experience.
SI → BI	0.34	4.1	< 0.001	Gender, Age, Experience	Stronger in older users	Social influence has a stronger effect on behavioral intention for older and less tech-savvy users.
FC → AU/UB	0.41	4.5	< 0.001	Age, Experience, Voluntariness	Stronger for experienced users	Facilitating conditions affect actual usage more in users with experience and voluntary adoption.

1. The Influence of PU/PE on BI Moderated by Gender and Age

The influence of PU/PE on the intention to use AI (Behavioral Intention, BI) is significantly proven, with a positive coefficient ($\beta = 0.39$, $p < 0.01$). However, the moderation by gender and age yields varying results. In SMEs led by younger men, the influence of PU/PE on BI is stronger compared to female respondents or older individuals.

2. **The Influence of PEOU/EE on BI Moderated by Gender, Age, and Experience**

   The influence of PEOU/EE on BI is also significant ($\beta = 0.36$, $p < 0.05$). Experience with technology plays an important role in moderation, where respondents with higher technology experience show stronger intentions to use AI. Moderation by gender and age also shows similar results, with male respondents and younger individuals having stronger intentions.

3. **The Influence of SI on BI Moderated by Gender, Age, and Experience**

   Social Influence (SI), which is the influence from the social environment such as colleagues and industry players, also has a positive effect on BI ($\beta = 0.34$, $p < 0.05$). Moderation by gender, age, and experience indicates that respondents with low technology experience are more influenced by SI. Older respondents also show a stronger correlation between SI and BI.

4. **The Influence of FC on AU/UB Moderated by Age, Experience, and Voluntariness of Use (H9)**

   Facilitating Conditions (FC), such as technology infrastructure and support from organizations, significantly influence AU/UB ($\beta = 0.41$, $p < 0.05$). This influence is stronger among respondents with more experience and older age. Voluntariness of use also plays an important role, where users who are not mandated but choose to adopt AI show more active usage.

The results of this study provide important insights into the factors influencing the adoption of AI technology among MSMEs (Micro, Small, and Medium Enterprises). The findings indicate that perceived usefulness and effectiveness of the technology have a significant impact on user attitudes. MSMEs that view AI as a beneficial and effective tool tend to have a positive attitude, which in turn encourages their intention to use the technology. This highlights the importance of communication strategies that emphasize the benefits and practical applications of AI in business operations.

Additionally, the ease of use of the technology has proven to be a crucial factor in shaping positive attitudes toward AI. When users feel that AI is easy to understand and apply, they are more likely to adopt it. This underscores the need for adequate training and support to assist users in understanding how AI works, so they feel more confident in utilizing it.

The influence of PEOU (Perceived Ease of Use) and EE (Effort Expectancy) on the perceived usefulness and effectiveness of AI also indicates that ease of use can enhance users' confidence in the value offered by AI. Therefore, it is essential for technology providers to design user-friendly AI systems and offer tutorials or technical support.

The study also revealed that gender and age moderate the relationship between perceived usefulness and the intention to use AI. Male respondents who are younger showed a stronger intention to adopt AI, while females and older respondents may require different approaches in marketing and training. This suggests that technology adoption strategies should consider demographic differences, tailoring content and delivery methods to appeal to various user segments.

Furthermore, social influence from the surrounding environment, such as colleagues and industry players, contributes to the intention to use AI. This indicates the importance of building communities or networks within MSMEs that can support and motivate each other to adopt new technologies. In this context, testimonials and positive experiences from peers in the industry can be effective tools in encouraging AI adoption.

A positive attitude toward AI use has proven to be a strong predictor of users' intentions to adopt the technology. Therefore, creating a supportive and positive environment regarding the use of AI can enhance the willingness of MSMEs to integrate this technology into their operations.

Finally, the study highlights that facilitating conditions, such as organizational support and technological infrastructure, are vital in supporting AI usage. Users who have access to adequate resources and support from their organizations tend to be more active in utilizing the technology. This emphasizes the importance of policies and initiatives that promote the development of technological infrastructure and human resources among MSMEs.

The findings of this study align with several previous studies that indicate limitations in human resources, costs, and knowledge about technology are the main barriers to adopting new technologies among MSMEs. However, the positive perceptions regarding the benefits of AI, particularly in terms of efficiency and improved customer service, serve as major drivers for MSMEs that have begun to adopt this technology.

More intensive support from the government, technology providers, and educational institutions is needed to enhance awareness and skills among MSME actors regarding AI technology. Collaboration among these parties is also expected to help reduce implementation costs through subsidies and training programs.

CONCLUSION

In conclusion, this study provides valuable insights into the factors that influence AI adoption among MSMEs. The research highlights the significant role of perceived usefulness and ease of use in shaping positive attitudes toward AI, which in turn increases the likelihood of adoption. Effective communication strategies that emphasize the practical benefits of AI and its ease of use, combined with adequate training and support, are essential to boost MSME confidence in the technology.

Additionally, demographic factors, such as gender and age, play a moderating role in adoption intentions, suggesting that marketing and training approaches need to be tailored to different user groups. The importance of social influence, particularly from peers and industry networks, underscores the value of building supportive communities that can motivate AI adoption.

Facilitating conditions, such as organizational support and infrastructure, are crucial for successful implementation, and this study reaffirms that challenges such as human resource limitations, costs, and lack of knowledge remain barriers to widespread AI adoption. Collaborative efforts from government, technology providers, and educational institutions are necessary to address these barriers by providing financial and technical support, which can enhance awareness and reduce the costs associated with AI implementation for MSMEs.

Ultimately, positive perceptions regarding AI's efficiency and ability to improve customer service will continue to drive adoption, but greater external support is needed to help MSMEs fully leverage AI technology. This study has several limitations. First, the research sample only includes MSMEs from certain sectors, which may not fully represent the entire population of MSMEs in Indonesia. Second, this study primarily focuses on quantitative factors and has not explored qualitative aspects in depth, which could provide a deeper understanding of the challenges in AI implementation. Third, the study uses cross-sectional data, making it unable to observe changes in MSMEs' attitudes and behaviors toward AI over a longer period. A longitudinal study could offer better insights into the dynamics of AI adoption as technology evolves and market conditions change. For future research, it is recommended to adopt a mixed-method approach by combining quantitative analysis with qualitative insights to obtain a more comprehensive understanding.

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