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# AI Adoption Barriers in SMEs Analyzing Through the Technology Organization Environment TOE Framework

Syahidun[1], Eko Susetyono[2], Alfri Adiwijaya[3], Muchlisina Madani[4], Yasir Mustafa Kareem[5*]
[1]Faculty of Economics and Business, Mercu Buana University, Indonesia
[2]Department of Business Management, IPB University, Indonesia
[3]Department of Digital Business, University of Raharja, Indonesia
[4]Faculty of Computer Science, REY Incorporation, Indonesia
[5]Department of Business Management, Eesp Incorporation, Samudra Hindia Britania
[1]67122010003@student.mercubuana.ac.id, [2]ekosusetyono@apps.sb.ipb.ac.id, [3]alfri.adiwijaya@raharja.info, [4]muchlisina@raharja.info, [5]mustafa.kar33m@eesp.io
***Corresponding Author**

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**ABSTRACT**

**Artificial Intelligence (AI) has** become a key driver of innovation, improving efficiency, decision-making, and competitiveness in businesses worldwide. However, the adoption of AI tools among Small and Medium Enterprises (SMEs), especially in developing countries like Indonesia, remains limited. **This study aims** to explore the barriers hindering AI adoption in SMEs in Indonesia using the Technology Organization Environment (TOE) framework. **A survey was conducted** among Indonesian SMEs across various sectors to capture their perceptions regarding AI implementation. The survey focused on technological, organizational, and environmental factors that influence AI adoption. **The findings** reveal that technological barriers, such as high implementation costs and system complexity, are significant challenges for SMEs. Organizational barriers, including limited digital literacy, a lack of skilled workforce, and resistance to change, also hinder AI adoption. Furthermore, environmental barriers like insufficient government support, regulatory uncertainty, and low market pressure constrain SMEs' adoption readiness. **This study extends** the TOE framework to the context of AI adoption in SMEs in developing economies. Addressing the identified barriers is essential for accelerating digital transformation and enabling SMEs to leverage AI for sustainable growth in the digital economy.



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## 1. INTRODUCTION

AI has become a pivotal driver of innovation in modern business environments, enabling organizations to improve efficiency, enhance decision-making, and foster competitiveness in rapidly changing markets. Across industries, AI-powered tools are increasingly applied in areas such as customer service, digital marketing, supply chain optimization, and product development. While large corporations have been at the forefront of adopting AI solutions, SMEs face considerable challenges in integrating these technologies into their operations [1]. This situation is particularly evident in developing economies such as Indonesia, where SMEs represent more than 99% of businesses and contribute significantly to national economic growth. Despite their vital role, the adoption of AI among SMEs remains relatively low compared to larger enterprises [2].

The limited adoption of AI in SMEs has been attributed to a variety of challenges ranging from technical constraints to organizational readiness and external environmental factors [3]. Previous studies have largely focused on the potential benefits of AI implementation, such as cost reduction, process automation, and market expansion [4]. However, fewer studies have systematically explored the barriers that prevent SMEs from adopting AI-powered tools, especially in the context of emerging markets [5]. Understanding these barriers is essential because SMEs play a crucial role in fostering inclusive growth, creating jobs, and driving innovation at the grassroots level [6]. Without adequate adoption of advanced technologies, SMEs risk falling behind in the digital transformation era, potentially widening the gap between large corporations and smaller businesses [7].

This research is aligned with several Sustainable Development Goals (SDGs), particularly:

1. SDG 8 on Decent Work and Economic Growth emphasizes that by enhancing the adoption of AI in SMEs, this study contributes to economic growth, fosters job creation, and enhances productivity [8].
2. SDG 9 on Industry, Innovation, and Infrastructure highlights that the integration of AI into SMEs is a key driver of innovation, enabling the development of new technologies and the enhancement of industrial infrastructure [9].
3. SDG 12 on Responsible Consumption and Production indicates that by promoting AI adoption, SMEs can optimize resource use and improve operational efficiency, leading to more sustainable production practices [10].

To address the barriers limiting AI adoption in SMEs, TOE framework provides a comprehensive lens through which the determinants of technology adoption can be examined [11]. The framework considers three dimensions: (1) technological factors, such as cost, compatibility, and complexity; (2) organizational factors, such as resource availability, digital literacy, and leadership support; and (3) environmental factors, such as regulatory frameworks, government policies, and market pressures. By applying the TOE framework, this study seeks to provide a holistic understanding of the adoption barriers that hinder SMEs from leveraging AI [12].

This study aims to answer the following research questions:

1. RQ1 explores the technological barriers that limit the adoption of AI-powered tools in SMEs.
2. RQ2 examines the organizational factors that constrain SMEs' readiness to adopt AI.
3. RQ3 investigates how environmental conditions affect AI adoption in SMEs.

The contributions of this research are twofold [13]. First, it extends the application of the TOE framework to the field of AI adoption, offering theoretical insights into the factors influencing SMEs in developing economies [14]. Second, it provides practical implications for policymakers, industry leaders, and SME managers by identifying the critical barriers to AI adoption and suggesting strategies to overcome them [15]. By addressing these barriers, this study aims to support the acceleration of digital transformation in SMEs and ensure that these enterprises can sustain competitiveness in the digital economy [16].

## 2. LITERATURE REVIEW

### 2.1. Artificial Intelligence in Business Context

AI has been widely recognized as a transformative force in contemporary business environments, enabling organizations to improve efficiency, enhance decision-making, and foster competitiveness in rapidly evolving markets [17]. AI technologies are increasingly utilized in areas such as customer analytics, predictive modeling, supply chain optimization, and automated content generation [18]. Scholars argue that AI adoption provides firms with significant competitive advantages by enabling data-driven decisions, enhancing customer engagement, and fostering the development of new business models [19]. In developed economies, AI has become a mainstream tool for driving digital transformation, whereas in developing countries, adoption remains uneven [20]. This gap emphasizes the need to not only explore the benefits of AI but also identify the barriers that hinder its widespread implementation, especially in resource-constrained contexts such as SMEs in developing economies [21].

### 2.2. AI Adoption in Small and Medium Enterprises (SMEs)

SMEs play a critical role in the economic development of many nations, particularly in developing countries like Indonesia [22]. They represent the majority of businesses, contributing significantly to job creation and national GDP [23]. Despite their importance, SMEs often face significant challenges in adopting advanced technologies due to factors such as limited financial resources, lack of expertise, and insufficient digital infrastructure. Research indicates that AI can help SMEs optimize operations, enhance productivity, and expand into new markets [24]. However, barriers such as high initial costs, limited skilled workforce, and resistance to change especially in organizational culture prevent its widespread adoption [25]. Comparative studies conducted in regions such as Europe, Asia, and Africa show that SMEs generally lag behind large enterprises in AI adoption, increasing their risk of falling behind in the digital economy [26].

### 2.3. Technology Organization Environment (TOE) Framework

TOE framework is widely used to examine the factors influencing organizational adoption of new technologies [27, 28]. The framework categorizes these factors into three dimensions:

1. The technological context includes the perceived benefits, costs, compatibility, and complexity of the technology being adopted [29].

2. The organizational context involves firm size, resource availability, leadership support, and digital capabilities [30].

3. The environmental context refers to industry characteristics, regulatory pressures, government policies, and market competition [31, 32].

The TOE framework has been successfully applied across various domains, including the adoption of e-commerce, Enterprise Resource Planning (ERP), cloud computing, and fintech solutions [33]. Its holistic perspective makes it particularly suitable for studying AI adoption in SMEs, as it accounts for both internal organizational factors and external environmental influences that impact decision-making [34, 35].

### 2.4. Previous Studies on Technology Adoption Using TOE

Numerous studies have employed the TOE framework to analyze the barriers and enablers of technology adoption [36]. For example, research on e-commerce adoption in SMEs highlighted cost, technical complexity, and lack of trust as major obstacles [37]. Similarly, cloud computing adoption studies identified organizational readiness and external environmental pressures, such as market competition, as key determinants [38, 39]. Recent studies on fintech and blockchain adoption have pointed out regulatory uncertainty and insufficient government support as critical barriers [40]. While these studies provide valuable insights, few have explicitly focused on AI adoption in SMEs, particularly within developing country contexts [41].

Moreover, studies that address AI adoption tend to emphasize its potential benefits, such as driving innovation and competitiveness [42, 43]. However, empirical studies reveal that SMEs face structural barriers that hinder effective implementation of AI. These barriers span all three dimensions of the TOE framework, underlining the appropriateness of this model for understanding AI adoption in SMEs [44].

### 2.5. Research Gap

Although the transformative potential of AI in enhancing business operations is well acknowledged, there is a limited body of research examining the barriers to AI adoption in SMEs, especially within emerging economies like Indonesia [45]. Existing literature largely concentrates on large enterprises or developed country contexts, leaving a gap in understanding the unique challenges faced by resource-constrained SMEs. Furthermore, while the TOE framework has been widely applied in various technology adoption contexts, its application to AI adoption remains underexplored [46].

This study seeks to fill this gap by applying the TOE framework to investigate the barriers hindering AI adoption in Indonesian SMEs [47]. By identifying technological, organizational, and environmental factors, the study contributes both theoretically by extending the TOE framework into the field of AI adoption and practically by offering insights for SME managers and policymakers [48]. This approach not only advances scholarly understanding but also provides actionable strategies to accelerate AI-driven digital transformation within SMEs, facilitating their competitiveness in the digital economy [49].

## 3. RESEARCH METHODOLOGY

### 3.1. Research Design

This study adopts a quantitative research design with a survey-based approach to examine the barriers hindering the adoption of AI tools among SMEs in Indonesia [50]. TOE framework serves as the theoretical foundation, enabling a structured assessment of technological, organizational, and environmental factors that influence AI adoption [51].

The quantitative approach is selected to ensure the generalizability of the findings across a large sample of SMEs [51]. Descriptive and inferential analyses are employed to evaluate the impact of these barriers on AI adoption readiness [52]. The hypothesis model used in this study is based on the relationships between these three dimensions (technological, organizational, and environmental) and AI adoption readiness, as depicted in Figure 2.

### 3.2. Population and Sample

The target population for this study consists of Indonesian SMEs operating in diverse sectors, including retail, manufacturing, services, and creative industries [53, 54]. SMEs are chosen as the unit of analysis due to their significant role in the Indonesian economy and their vulnerability to challenges in adopting advanced technologies. A purposive sampling technique is employed to select SMEs that are aware of AI technologies, even if they have not yet fully adopted them [55].

In this study, the sample size is set to 150 SMEs, which is deemed sufficient to ensure statistical reliability for regression and Structural Equation Modeling (SEM) analysis. This sample size is considered adequate to capture variation across different industries and firm sizes, providing a comprehensive understanding of the barriers SMEs face in adopting AI.

### 3.3. Data Collection Method

Primary data is collected through a structured questionnaire distributed electronically via email, professional networks, and SME associations. The questionnaire is designed based on validated constructs from prior TOE-based studies on technology adoption. It is divided into four sections to capture data across the three dimensions of the TOE framework:

1. Demographics include industry type, firm size, and years in operation.
2. Technological factors cover perceived cost, compatibility, and complexity of AI implementation.
3. Organizational factors involve leadership support, digital literacy, resource availability, and resistance to change.
4. Environmental factors encompass government support, regulatory environment, and market competition.

Responses are measured using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), to quantify perceptions of the barriers hindering AI adoption.

### 3.4. Variables and Constructs

The technological context covers factors such as implementation costs, system complexity, and compatibility with existing infrastructure. The organizational context includes digital literacy, resource availability, leadership support, and resistance to change. Meanwhile, the environmental context involves regulatory clarity, government incentives, and market competition that influence AI adoption readiness.

### 3.5. Data Analysis

The collected data will be analyzed in two stages:

1. Descriptive analysis is used to summarize demographic characteristics and general perceptions of barriers among SMEs.
2. Inferential analysis uses regression analysis and structural equation modeling (SEM) to evaluate the relationships between TOE factors and AI adoption readiness. SEM is chosen for its ability to test complex relationships among multiple variables simultaneously.

The analysis will be conducted using statistical software such as SPSS or SmartPLS. The reliability and validity of constructs will be tested using Cronbach's Alpha and factor analysis. Hypotheses will be evaluated to determine which TOE factors significantly influence AI adoption barriers in SMEs.

### 3.6. Ethical Considerations

Ethical standards are strictly adhered to throughout the research process. Participation in the study is voluntary, and the confidentiality of respondents is ensured by anonymizing organizational identifiers. Informed consent is obtained from all participants prior to data collection. Ethical guidelines for research involving human participants will be followed to maintain the integrity and credibility of the study.

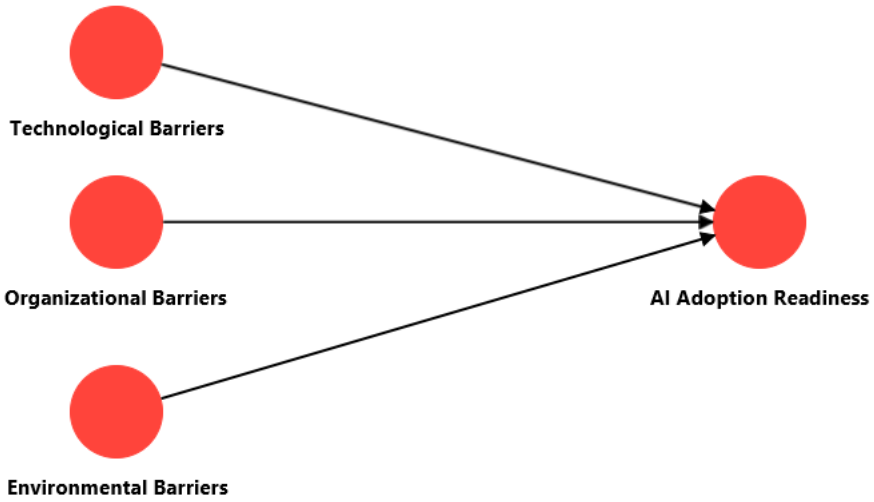


Figure 1. Hypothesis Model: Factors Affecting AI Adoption Readiness in SMEs

Figure 1 shows the hypothesis model illustrating the relationships between the technological, organizational, and environmental barriers to AI adoption readiness in SMEs. The model suggests that these three factors technological, organizational, and environmental have a significant impact on SMEs' ability to adopt AI technologies. The arrows indicate the hypothesized negative influence each of these barriers has on AI adoption readiness. This model serves as the basis for the study's hypothesis testing, which aims to explore how these barriers interact and affect AI adoption in Indonesian SMEs.

## 4. RESULT AND DISCUSSION

A total of 162 SMEs participated in this study, representing various sectors and firm sizes. The demographic breakdown is presented in Table 1.

Table 1. Respondent Profile (N = 162)

| Characteristics | Category | Frequency (%) |
|---|---|---|
| **Industry Sector** | Retail | 46 (28.4%) |
| | Manufacturing | 32 (19.8%) |
| | Services | 54 (33.3%) |
| | Creative Industry | 30 (18.5%) |
| **Firm Size** | Micro (< 10) | 58 (35.8%) |
| | Small (10 – 49) | 71 (43.8%) |
| | Medium (50 – 249) | 33 (20.4%) |
| **Awareness of AI** | Low | 42 (25.9%) |
| | Medium | 87 (53.7%) |
| | High | 33 (20.4%) |

Table 1 shows the demographic breakdown of the 162 SMEs that participated in the study. It includes the distribution of SMEs across different industry sectors, firm sizes, and levels of AI awareness. The largest proportion of SMEs falls within the service sector (33.3%), followed by retail (28.4%). In terms of firm size,

the majority are classified as small enterprises (43.8%), and most SMEs reported medium awareness of AI technologies (53.7%).

### 4.1. Descriptive Statistics of TOE Barriers

The mean scores (using a 1–5 Likert scale) indicate the perceived strength of each barrier faced by SMEs in adopting AI technologies. Table 2 provides a summary of the descriptive statistics for the TOE variables.

Table 2. Descriptive Statistics of TOE Variables

| Variable | Mean | Std. Dev | Interpretation |
|---|---|---|---|
| Cost of AI Implementation | 4.21 | 0.78 | High barrier |
| Complexity of AI Systems | 3.94 | 0.81 | Moderate – High |
| Compatibility with Existing Systems | 3.61 | 0.72 | Moderate |
| Lack of Skilled Workforce | 4.08 | 0.85 | High barrier |
| Limited Financial Resources | 4.15 | 0.74 | High barrier |
| Resistance to Change | 3.77 | 0.69 | Moderate |
| Lack of Leadership Support | 3.52 | 0.73 | Moderate |
| Insufficient Government Support | 4.26 | 0.83 | Very high barrier |
| Regulatory Uncertainty | 4.18 | 0.79 | High barrier |
| Weak Market Pressure | 3.68 | 0.71 | Moderate |

Table 2 shows the descriptive statistics for the TOE variables, including the mean and standard deviation for each perceived barrier. The data reveals that the most significant barriers to AI adoption are technological, particularly the high costs of implementation (mean = 4.21) and the complexity of AI systems (mean = 3.94). Organizational factors such as a lack of skilled workforce and limited financial resources also present high barriers (mean = 4.08 and 4.15, respectively). Environmental factors, including insufficient government support (mean = 4.26) and regulatory uncertainty (mean = 4.18), were identified as very high barriers.

### 4.2. Reliability and Validity

To ensure the reliability and validity of the constructs in this study, both Cronbach's Alpha and Average Variance Extracted (AVE) were employed. Cronbach's Alpha is a measure of internal consistency, and values above 0.70 are considered acceptable. For this study, all constructs had Cronbach's Alpha values exceeding 0.70, indicating high reliability. Specifically, the Cronbach's Alpha for technological, organizational, and environmental constructs were 0.85, 0.83, and 0.88, respectively. Convergent validity was assessed using AVE, with values above 0.50 confirming that the constructs explain more than half of the variance in their indicators. The AVE values for technological, organizational, and environmental contexts were 0.75, 0.72, and 0.77, respectively, indicating good convergent validity.

In addition to convergent validity, discriminant validity was tested using the Fornell-Larcker criterion, which suggests that the square root of the AVE for each construct should be greater than the correlations between constructs. The results confirmed discriminant validity, as the square roots of the AVE values exceeded the inter-construct correlations. Furthermore, all factor loadings exceeded 0.70, supporting the convergent validity of the constructs. Composite reliability (CR) values for all constructs also surpassed the recommended threshold of 0.70, indicating internal consistency among the measurement items. Likewise, the Cronbach's alpha coefficients were above 0.70, reinforcing the reliability of the constructs.

Overall, the reliability and validity assessments confirm that the constructs used to measure the TOE barriers to AI adoption in SMEs are both reliable and valid. These findings provide confidence in the robustness of the measurement model, ensuring the credibility of the data and the subsequent analysis. Consequently, the measurement model demonstrates strong psychometric properties, which form a solid foundation for evaluating the structural model. This ensures that any observed relationships among the constructs in the TOE framework accurately reflect the underlying theoretical assumptions rather than measurement errors, thus strengthening the empirical rigor and generalizability of the study's results.

### 4.3. Regression Analysis Results

Multiple regression was conducted to test the relationship between TOE barriers and AI adoption readiness. Table 3 presents the regression results, showing the standardized beta coefficients ($\beta$), t-values, and

p-values for each barrier.

Table 3. Regression Results

| Independent Variable | $\beta$ Coefficient | t-value | p-value |
|---|---|---|---|
| Technological Barriers | -0.38 | 5.47 | $< 0.001$ |
| Organizational Barriers | -0.34 | 4.95 | $< 0.001$ |
| Environmental Barriers | -0.42 | 6.12 | $< 0.001$ |
| $R^2 = 0.56$ | | | |

Table 3 shows the results of the multiple regression analysis. All three TOE dimensions technological, organizational, and environmental barriers significantly and negatively affect AI adoption readiness in SMEs. Environmental barriers ($\beta$ = -0.42) have the strongest negative impact on AI adoption readiness, followed by technological barriers ($\beta$ = -0.38) and organizational barriers ($\beta$ = -0.34). The model explains 56% of the variance in AI adoption readiness ($R^2 = 0.56$).

### 4.4. Structural Model (SEM)

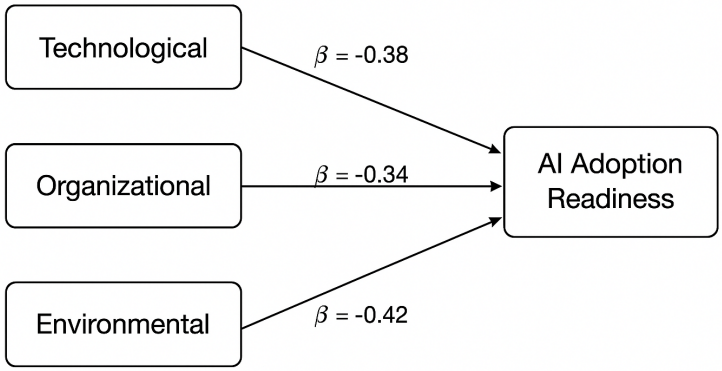


Figure 2. Structural Model of TOE Barriers to AI Adoption

The Structural Equation Modeling (SEM) analysis confirms the regression results by providing a comprehensive understanding of the relationships between the TOE barriers and AI adoption readiness in SMEs. SEM allows for the simultaneous testing of complex relationships among multiple variables, capturing both direct and indirect effects, which helps quantify the impact of technological, organizational, and environmental barriers on AI adoption. Figure 2 shows the structural model of these barriers, offering a visual representation of the hypothesized relationships. The model illustrates how technological barriers (e.g., high implementation costs, system complexity) interact with organizational factors (e.g., leadership support, digital literacy) and environmental conditions (e.g., regulatory uncertainty, government support), with arrows indicating the direction and strength of these relationships. The SEM analysis further confirms the significant negative effects of these barriers on AI adoption readiness, offering valuable insights into the specific challenges SMEs face in the process of digital transformation.

### 4.5. Discussion

The quantitative results highlight that environmental barriers, such as lack of government support and regulatory uncertainty, are the most critical constraints for AI adoption in SMEs. This finding reflects the institutional challenges faced by developing economies, where supportive policies and digital infrastructure are often underdeveloped.

Technological barriers, particularly high costs and system complexity, also significantly reduce SMEs' readiness to adopt AI. Many SMEs lack sufficient budgets to invest in advanced technologies and struggle to integrate AI with their existing processes. Organizational factors, including limited digital skills and employee resistance, further hinder adoption.

These findings align with previous studies applying the TOE framework in technology adoption, but this study extends the framework to AI adoption in SMEs in Indonesia. The results suggest that effective

interventions must address not only internal organizational capacity but also the broader policy and market environment. Policymakers should focus on creating a conducive environment for AI adoption, while SME leaders should invest in building digital capabilities and reducing resistance to change.

## 5. MANAGERIAL IMPLICATIONS

The findings of this study offer several managerial implications that can guide stakeholders in accelerating the adoption of Artificial Intelligence (AI) within Small and Medium Enterprises (SMEs). These implications are presented across four perspectives: policy development, organizational management, academic collaboration, and industry engagement.

### 5.1. Policy Development

Government agencies should focus on creating an enabling ecosystem for AI adoption through clear regulatory frameworks, financial incentives, and accessible digital infrastructure. Strengthening policies that support SMEs in obtaining AI-related training, funding, and consultancy services will help reduce the technological and financial barriers identified in this study. A national roadmap for AI implementation in SMEs can further promote inclusivity and competitiveness across regions.

### 5.2. Organizational Management

SME leaders should prioritize internal digital transformation by enhancing digital literacy and encouraging a culture of innovation. Investment in employee training and leadership development is essential to overcome resistance to change and skill shortages. Managers should also adopt strategic planning that aligns AI initiatives with business objectives to maximize the long-term benefits of automation, efficiency, and decision-making accuracy.

### 5.3. Academic Collaboration

Higher education institutions and research organizations can play a pivotal role in supporting SMEs through knowledge transfer, applied research, and capacity-building programs. Collaborative initiatives, such as public–private partnerships or industry-based learning platforms, can help bridge the gap between theoretical AI research and practical applications within SMEs. This synergy will foster innovation and strengthen local talent in the digital economy.

### 5.4. Industry Engagement

Private sector actors, including technology providers and large corporations, should facilitate AI diffusion by offering affordable and scalable AI solutions tailored to SME needs. Partnerships between SMEs and larger firms can accelerate technology transfer and encourage cross-sector learning. Such collaborations not only enhance SME competitiveness but also contribute to sustainable digital transformation aligned with SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 12 (Responsible Consumption and Production).

## 6. CONCLUSION

This study provides empirical insights into the barriers hindering AI adoption among SMEs in Indonesia through the lens of the Technology Organization Environment (TOE) framework. The results reveal that environmental barriers, such as limited government support and regulatory uncertainty, exert the strongest negative influence on AI adoption readiness, followed by technological and organizational barriers. High implementation costs, system complexity, and a lack of skilled workforce continue to challenge SMEs in integrating AI into their operations. These findings highlight the urgent need for supportive policies, digital infrastructure development, and initiatives to enhance digital literacy within SMEs to accelerate AI-driven transformation.

Furthermore, this study contributes theoretically by extending the application of the TOE framework into the context of AI adoption in developing economies. Practically, it offers valuable implications for policymakers and business leaders to formulate strategies that address both internal organizational readiness and external institutional factors. Strengthening collaboration between government, academia, and industry will be crucial in overcoming adoption barriers and achieving sustainable digital growth. Ultimately, promoting AI integration within SMEs will foster competitiveness, innovation, and productivity, aligning with Sustainable Development Goals (SDGs) 8, 9, and 12.

## 7. DECLARATIONS

### 7.1. About Authors

Syahidun (SS) https://orcid.org/0009-0003-6691-442X
Eko Susetyono (ES) https://orcid.org/0009-0000-1483-1866
Alfri Adiwijaya (AW)https://orcid.org/0009-0008-4049-5286
Muchlisina Madani (MM) https://orcid.org/0009-0001-8858-9547
Yasir Mustafa Kareem (YM) https://orcid.org/0009-0008-5096-2300

### 7.2. Author Contributions

Conceptualization: SS; Methodology: ES; Software: SS; Validation: SS and ES; Formal Analysis: SS; Investigation: SS; Resources: SS; Data Curation: ES; Writing Original Draft Preparation: SS; Writing Review and Editing: SS and ES; Visualization: ES; All authors, SS, ES, AW, MM, and YM, 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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