Driving Digital Adoption: A Conceptual Framework for Artificial Intelligence (AI) Integration in Small and Medium Enterprises (SMEs)

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ABSTRACT

Artificial Intelligence (AI) technology has transitioned from an advanced corporate application into an accessible operational utility for contemporary business management. For Small and Medium Enterprises (SMEs), integrating AI capabilities offers substantial potential to optimize internal workflows, enhance decision-making precision, and strengthen market positioning. However, actual AI adoption among smaller enterprises in developing economies remains fragmented due to resource limitations and technical risks. Moving beyond a conventional application of the Technology-Organization-Environment (TOE) framework, this paper proposes an extended theoretical framework that integrates AI-specific trustworthiness and organizational digital maturity as contingency mechanisms. The conceptual model evaluates primary drivers across technological (relative advantage, complexity), organizational (top management support, financial readiness), and environmental contexts (competitive pressure, regulatory support), while incorporating Perceived AI Trustworthiness as a mediating mechanism and Organizational Digital Maturity as a moderating condition. The paper formulates eight testable propositions and details a quantitative methodology based on Partial Least Squares Structural Equation Modeling (PLS-SEM) for a target sample of $N = 300$ SMEs. This framework advances theoretical understandings of technology adoption in emerging economies and offers actionable directives for policymakers and business managers seeking to accelerate digital maturity.

Keywords: *Artificial Intelligence, AI Adoption, Technology-Organization-Environment (TOE), SMEs, Small Business, Malaysia*

INTRODUCTION

The global commercial landscape is undergoing rapid technological restructuring driven by advanced digital applications, with Artificial Intelligence (AI) serving as a primary mechanism for organizational capability enhancement. AI technologies comprising machine learning algorithms, natural language processing, predictive analytics, and automated decision systems that enable firms to process complex data streams, automate routine tasks, and refine customer engagement models (Hansen&Bogh, 2021). For Small and Medium Enterprises (SMEs), which represent the structural foundation of industrial output and employment generation globally, adopting AI applications offers a strategic pathway to increase operational productivity and compete against larger market incumbents.

In Malaysia, SMEs constitute the core of the national economic architecture. According to data from the Department of Statistics Malaysia (DOSM, 2023) and SME Corp. Malaysia (2023), SMEs represent 97.4% of total business establishments, contributing 38.4% to the national Gross Domestic Product (GDP) and employing approximately 48.2% of the total workforce. Recognizing the strategic importance of this sector, the Malaysian government has established policy initiatives, including the National Entrepreneurship Policy (NEP) 2030, the MyDIGITAL Blueprint, and the National AI Roadmap 2021 - 2025 (Ministry of Entrepreneur Development and

Cooperatives [MEDAC], 2019; Economic Planning Unit [EPU], 2021). These frameworks aim to accelerate digital transformation across micro, small, and medium enterprises to support long term economic sustainability.

Despite state level policy support, a significant disparity exists between basic digital technology usage and advanced AI integration among Malaysian SMEs. Industry surveys indicate that while over 70% of Malaysian SMEs have adopted basic digital tools such as social media marketing platforms, electronic point-of-sale systems, and e-wallets fewer than 15% have integrated advanced technologies including AI, Big Data Analytics, or Internet of Things (IoT) solutions into their primary operational processes (SME Corp. Malaysia, 2023; World Bank, 2022). Most small enterprises remain concentrated at lower levels of digital maturity, using digital tools primarily for customer facing communication rather than core operational automation or data driven strategic planning.

To address this gap, prior research frequently relies on classical models such as the Technology-Organization-Environment (TOE) framework (Tornatzky & Fleischer, 1990). However, presenting TOE merely as a contextual template offers limited theoretical novelty. Advanced AI technologies introduce unique attributes—such as algorithmic opacity, autonomous decision-making, and continuous data dependency—that distinguish them from traditional static software applications (Dwivedi et al., 2021; Ullah et al., 2023). Consequently, classic TOE constructs alone are insufficient to capture the psychological and organizational boundary conditions governing AI adoption.

This study extends current theoretical understanding by integrating two critical contingency constructs into the TOE framework: Perceived AI Trustworthiness (an AI-specific belief mechanism) and Organizational Digital Maturity (an organizational boundary condition). By doing so, this paper clarifies *how* traditional TOE drivers translate into adoption intent through trust, and *under what conditions* (levels of digital maturity) these relationships are strengthened within Malaysian SMEs.

Specifically, this study addresses the following research questions:

RQ1: How do technological, organizational, and environmental factors influence the intention to adopt AI among Malaysian SMEs?

RQ2: Does Perceived AI Trustworthiness mediate the relationship between TOE factors and AI adoption intention?

RQ3: Does Organizational Digital Maturity moderate the influence of TOE factors on AI adoption intention?

THEORETICAL UNDERPINNINGS AND EXTENDED CONCEPTUAL FRAMEWORK

Theoretical Foundations: Extending the TOE Framework

The Technology-Organization-Environment (TOE) framework (Tornatzky & Fleischer, 1990) provides a robust firm-level analytical structure categorizing adoption determinants into technological, organizational, and environmental contexts. While validated across various IT domains such as cloud computing (Gangwar et al., 2015) and e-commerce (Qalati et al., 2021) traditional TOE models assume a direct deterministic pathway from antecedent factors to technology adoption.

To enhance the explanatory power of TOE within the AI domain, this study incorporates insights from Structural Contingency Theory (Donaldson, 2001) and Trust-Centric Technology Adoption Models (Dwivedi et al., 2021). Structural Contingency Theory asserts that no single organizational structure is universally optimal; instead, organizational effectiveness depends on the alignment between internal capabilities (e.g., digital maturity) and external technological demands. Furthermore, because AI algorithms operate with varying degrees of autonomy and perceived risk, Perceived AI Trustworthiness serves as a vital cognitive bridge mediating the impact of external drivers on managerial decisions (Ullah et al., 2023)

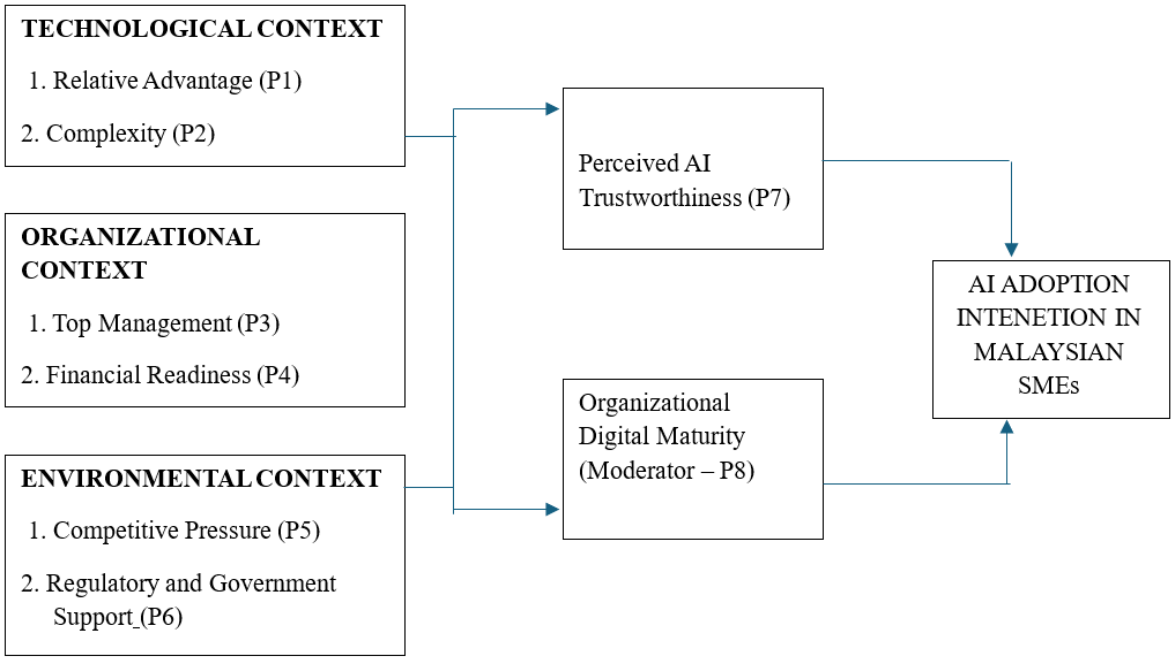

Figure 1: Extended Conceptual Framework for AI Adoption in Malaysian SMEs

Source: Developed by authors based on Tornatzky & Fleischer (1990), Dwivedi et al. (2021), and Al-Sharif & Al-Ansi (2024)

LITERATURE REVIEW

1. Technological Context

Relative Advantage

Relative advantage refers to the degree to which an technological innovation is perceived as offering superior benefits compared to current operational practices (Tornatzky & Fleischer, 1990). In the SME context, relative advantage is evaluated through operational efficiency gains, cost reductions, error minimization, and improved customer response times. AI tools such as automated customer service chatbots, predictive inventory management software, and automated financial reconciliation—allow small firms to handle higher operational volumes without proportional increases in headcount (Hansen & Bogh, 2021). When small business owner-managers perceive clear, tangible financial or operational returns from AI integration, their intent to adopt the technology increases.

Proposition 1 (P_1): *Perceived relative advantage positively influences the intention to adopt AI among Malaysian SMEs.*

Complexity

Complexity represents the degree to which an innovation is perceived as difficult to understand, implement, and operate within an organization (Tornatzky & Fleischer, 1990). Advanced AI applications often require data restructuring, system integration, and staff re-training. For Malaysian SMEs that lack dedicated in-house IT departments, high technical complexity creates a significant entry barrier (Ullah et al., 2023). If AI software requires custom coding or extensive staff training, small business decision-makers are likely to defer implementation. Conversely, the availability of low-code or user-friendly Software-as-a-Service (SaaS) AI tools reduces perceived complexity and encourages adoption.

Proposition 2 (P_2): *Perceived complexity negatively influences the intention to adopt AI among Malaysian SMEs.*

2. Organizational Context

Top Management Support

Top management support reflects the degree to which organizational leadership understands the strategic value of technology and actively allocates resources toward its implementation (Kumar et al., 2023). In Malaysian SMEs, ownership and operational management are typically centralized in a single individual or a small founding team. Consequently, the owner-manager's personal digital literacy, risk tolerance, and strategic orientation directly dictate organizational technology investment decisions (Al-Sharif & Al-Ansi, 2024). When top management actively supports digital initiatives, obstacles related to employee resistance, resource reallocation and operational adjustments are resolved more efficiently.

Proposition 3 (P_3): *Top management support positively influences the intention to adopt AI among Malaysian SMEs.*

Financial Readiness

Financial readiness refers to the availability of capital resources within the firm to fund technology acquisition, software subscription fees, infrastructure upgrades, and initial implementation costs (Qalati et al., 2021). Although modern cloud-based AI tools operate on recurring subscription models that reduce upfront capital requirements, adopting AI still involves hidden costs including data preparation, staff training, and ongoing technical support (Valdeza & Ahmad, 2024). Given that cash flow management remains a primary operational vulnerability for over 60% of Malaysian micro and small enterprises (SME Corp. Malaysia, 2023), adequate financial reserves are a mandatory prerequisite for firm-level AI adoption.

Proposition 4 (P_4): *Financial readiness positively influences the intention to adopt AI among Malaysian SMEs.*

3. Environmental Context

Competitive Pressure

Competitive pressure represents the level of threat experienced by a firm from market rivals operating within the same industry sector (Qalati et al., 2021). As digital technology adoption accelerates across Malaysia's retail, services, and manufacturing sectors, firms that adopt AI tools gain advantages in transaction processing speed, dynamic pricing accuracy, and personalized customer service (Chatterjee et al., 2022). Small enterprises operating in saturated markets face increasing pressure to adopt similar technological capabilities to maintain customer retention rates and preserve market share.

Proposition 5 (P_5): *Competitive pressure positively influences the intention to adopt AI among Malaysian SMEs.*

Regulatory and Government Support

Regulatory and government support encompasses external institutional assistance provided by state agencies to facilitate technology adoption among businesses (Tornatzky & Fleischer, 1990). In Malaysia, agencies such as the Malaysia Digital Economy Corporation (MDEC) and SME Corp. Malaysia offer financial subsidies, including digital matching grants, alongside training frameworks (MDEC, 2023; SME Corp. Malaysia, 2023). Institutional support reduces both financial barriers and technical uncertainty for small enterprises, signaling legitimacy and providing safety nets for technological investments (World Bank, 2022).

Proposition 6 (P_6): *Regulatory and government support positively influences the intention to adopt AI among Malaysian SMEs.*

4. The Mediating Role of Perceived AI Trustworthiness

Perceived AI Trustworthiness refers to managerial confidence that AI systems will perform reliably, ethically, and accurately without compromising organizational data privacy (Dwivedi et al., 2021). Unlike static IT tools,

AI systems possess black-box decision logic that can induce perceived risk. Favorable TOE factors (e.g., strong government support, high relative advantage, top management endorsement) reduce perceived risk and enhance trust in AI applications, which subsequently strengthens adoption intention (Ullah et al., 2023).

Proposition 7 (P_7): *Perceived AI Trustworthiness mediates the relationship between TOE antecedent factors and AI adoption intention among Malaysian SMEs.*

5. The Moderating Role of Organizational Digital Maturity

Organizational Digital Maturity reflects the extent to which an enterprise has institutionalized digital infrastructure, digital skills, and data-driven cultural practices (Al-Sharif & Al-Ansi, 2024). In firms with low digital maturity, even strong external drivers may fail to translate into AI adoption due to foundational skill gaps. Conversely, high digital maturity acts as an organizational catalyst, amplifying the positive effects of relative advantage, top management support, and regulatory incentives on AI adoption intention.

Proposition 8 (P_8): *Organizational Digital Maturity positively moderates the relationship between TOE factors and AI adoption intention among Malaysian SMEs, such that the relationships are stronger in firms with higher digital maturity.*

PROPOSED EMPIRICAL METHODOLOGY

To enable future empirical testing of the proposed model, a quantitative, cross-sectional survey design is specified (Creswell & Creswell, 2023).

1. Target Population and Sampling Strategy

The target population comprises registered SMEs across the manufacturing, services, and retail sectors in Malaysia, derived from official directories maintained by SME Corp. Malaysia and the Companies Commission of Malaysia (SSM). A probability-based **stratified random sampling** technique will be deployed across Peninsular Malaysia, Sabah, and Sarawak. To satisfy statistical power requirements for Structural Equation Modeling (PLS-SEM) containing moderation and mediation paths, a target sample size of $N = 300$ completed enterprise responses will be secured (Hair et al., 2022).

2. Respondent Profile and Unit of Analysis

The organizational unit of analysis will be represented by key enterprise decision-makers—specifically Chief Executive Officers (CEOs), Managing Directors, Owner-Managers, or Chief Technology Officers (CTOs)—who possess comprehensive oversight of organizational strategy and technology investments (Kumar et al., 2023).

3. Measurement Instrument

All constructs will be operationalized using multi-item 5-point Likert scales (1 = *Strongly Disagree* to 5 = *Strongly Agree*) adapted from established literature:

- Relative Advantage & Complexity: Adapted from Moore and Benbasat (1991) and Ullah et al. (2023) (4 items each).
- Top Management Support & Financial Readiness: Adapted from Kumar et al. (2023) and Valdeza and Ahmad (2024) (4 items each).
- Competitive Pressure & Regulatory Support: Adapted from Chatterjee et al. (2022) and MDEC (2023) (4 items each).
- Perceived AI Trustworthiness: Adapted from Dwivedi et al. (2021) (4 items measuring accuracy, reliability, and security).

- Organizational Digital Maturity: Adapted from Al-Sharif and Al-Ansi (2024) (4 items measuring digital skills and infrastructure).
- AI Adoption Intention: Adapted from Venkatesh et al. (2003) and Kumar et al. (2023) (4 items).

4. Data Analysis Plan

Data will be evaluated using IBM SPSS (Version 29) for descriptive statistics and SmartPLS 4 for Partial Least Squares Structural Equation Modeling (PLS-SEM). PLS-SEM is chosen due to its suitablity for complex predictive models containing moderating and mediating structures (Hair et al., 2022).

i. **Measurement Model Assessment:** Evaluated via indicator loadings (≥ 0.708), internal consistency (Cronbach's Alpha ≥ 0.70, Composite Reliability ≥ 0.70), convergent validity (Average Variance Extracted, AVE ≥ 0.50), and discriminant validity via the Heterotrait-Monotrait ratio (HTMT < 0.85).
ii. **Structural Model Assessment:** Evaluated using path coefficients (β), 5,000-resample bootstrapping significance tests ($p < 0.05$), coefficient of determination (R^2), effect sizes (f^2), and predictive relevance (Q^2). Moderation effects (P_8) will be tested using the two-stage interaction approach in SmartPLS.

DISCUSSION AND THEORETICAL EXPECTATIONS

The proposed framework advances technology adoption literature by addressing critical conceptual gaps. Rather than treating TOE as a static framework, this model introduces **Perceived AI Trustworthiness** and **Organizational Digital Maturity** as vital contingency conditions tailored to the AI context.

Table 1: Summary of Conceptual Framework Dimensions and Hypothesized Paths

Variable Dimension	Specific Variable	Role in Framework	Expected Theoretical Impact	Key Literature
Technological	Relative Advantage	Antecedent (IV)	Positive direct impact on Trust & Adoption Intention (P_1)	Hansen & Bøgh (2021); Chatterjee et al. (2022)
	Complexity	Antecedent (IV)	Negative direct impact on Trust & Adoption Intention (P_2)	Ullah et al. (2023)
Organizational	Top Management Support	Antecedent (IV)	Positive direct impact on Trust & Adoption Intention (P_3)	Kumar et al. (2023); Al-Sharif & Al-Ansi (2024)
	Financial Readiness	Antecedent (IV)	Positive direct impact on Trust & Adoption Intention (P_4)	Qalati et al. (2021); Valdeza & Ahmad (2024)

Variable Dimension	Specific Variable	Role in Framework	Expected Theoretical Impact	Key Literature
Environmental	Competitive Pressure	Antecedent (IV)	Positive direct impact on Trust & Adoption Intention (P_5)	Chatterjee et al. (2022); Qalati et al. (2021)
	Regulatory Support	Antecedent (IV)	Positive direct impact on Trust & Adoption Intention (P_6)	MDEC (2023); World Bank (2022)
AI-Specific Mechanism	Perceived AI Trustworthiness	Mediator	Transmits TOE drivers to Adoption Intention (P_7)	Dwivedi et al. (2021); Ullah et al. (2023)
Organizational Boundary	Digital Maturity	Moderator	Strengthens TOE-Adoption relationships (P_8)	Al-Sharif & Al-Ansi (2024)

Theoretically, these proposed relationships suggest that external government grants or competitive threats alone are insufficient to drive AI adoption unless SMEs possess a baseline level of digital maturity and managerial trust in AI systems.

CONCLUSION AND FUTURE RESEARCH

This study formulates an extended conceptual framework to evaluate the determinants, mediating mechanisms, and moderating conditions governing AI adoption intention among Malaysian SMEs. By combining the TOE framework with trust mechanisms and contingency theory, the paper provides a comprehensive blueprint for empirical validation.

Practical and Managerial Directives

The framework provides strategic guidance for multiple stakeholders within the digital entrepreneurship ecosystem:

1. For SME Owner-Managers: Businesses must focus on building foundational digital skills and data infrastructure (digital maturity) before attempting complex AI implementations.
2. For AI Vendors: Developers must address black-box security concerns by designing transparent, low-code, and highly trustworthy AI applications tailored for small business operations.
3. For Policymakers: Agencies such as MDEC and SME Corp. Malaysia should expand initiatives beyond financial grants to include AI trust certification frameworks and hands-on digital maturity capability building.

Future Research Directions

To move beyond the limitations of cross-sectional survey designs, future empirical studies should incorporate:

- Longitudinal Designs: Tracking SMEs across pre-adoption, implementation, and post-adoption phases to evaluate long-term business performance outcomes.

- Qualitative Case Studies: Conducting in-depth multi-case analyses to explore organizational resistance and cultural nuances during AI integration.
- Mixed-Methods Approaches: Combining survey trends with qualitative interviews to triangulate operational realities.
- ASEAN Comparative Studies: Executing comparative analyses across developing ASEAN economies (e.g., Malaysia, Indonesia, Vietnam) to examine how varying institutional frameworks shape AI adoption trajectories across different levels of market maturity.

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