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Re`assessing ICT Adoption Among Malaysian SMEs: A Post-COVID-19 Thematic Literature Review Using TOE Framework

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ABSTRACT

This study presents a thematic literature review examining Information and Communication Technology (ICT) adoption among Malaysian small and medium-sized enterprises (SMEs) using the Technology-Organization-Environment (TOE) framework. It synthesizes findings from recent empirical studies (2016–2024) and evaluates how technological, organizational, and environmental factors influence ICT adoption and SME performance, particularly during the COVID-19 pandemic. Key insights highlight that perceived relative advantage, top management support, and competitive pressure are consistent enablers, while factors such as complexity and regulatory support yield mixed results depending on context. The pandemic accelerated digital transformation, reshaping organizational behavior and external environments. This review argues that although the TOE framework remains relevant, it must be adapted to account for temporal shifts and crisis responsiveness. The findings offer practical guidance for SME leaders and policymakers and call for structural support to promote long-term digital resilience. Limitations include reliance on existing studies and lack of longitudinal data. Future research should empirically validate extended TOE models and explore sector-specific and cross-regional adoption patterns.

Keywords: COVID-19; ICT Adoption; Malaysia; Manufacturing SMEs; Performance; Technology; TOE Framework

INTRODUCTION

Small and medium-sized enterprises (SMEs) are integral to national economies worldwide, contributing to employment generation, innovation, and inclusive growth. In Malaysia, SMEs comprise 98.5% of all business establishments, yet their contribution to the national Gross Domestic Product (GDP) remains relatively modest at 38.3%, lagging behind counterparts in more advanced economies such as Singapore (Khoo & Chan, 2017; SME Corporation Malaysia, 2021). This discrepancy suggests structural inefficiencies and underutilization of digital tools that could enhance operational performance and competitiveness.

The rise of digital platforms and Information and Communication Technology (ICT) offers transformative opportunities for SMEs to streamline operations, engage broader markets, and adapt to rapidly changing business environments. However, despite growing awareness and government support, ICT adoption among Malaysian SMEs remains limited. As of 2020, nearly 71% of SMEs in Malaysia had not integrated basic digital tools into their operations (Gong & Tong, 2020). Barriers such as technological complexity, limited digital skills, resource constraints, and inconsistent regulatory support continue to hinder widespread adoption (Nor-Aishah et al., 2020).

The urgency of digital transformation intensified during the COVID-19 pandemic (Amran et al., 2023). The crisis exposed the vulnerabilities of analog business models and highlighted ICT as essential for resilience and survival. Government-imposed lockdowns disrupted physical operations, forcing SMEs to rapidly digitize processes, adopt e-commerce platforms, and embrace remote work tools (Papadopoulos et al., 2020). Yet, the extent to which SMEs in Malaysia adapted and how this transformation altered the factors influencing ICT adoption remains unclear.

Although previous research has explored ICT adoption through various models, the Technology-Organization-Environment (TOE) framework offers a comprehensive and integrative lens for understanding how internal and external factors shape technology uptake. However, most existing studies apply the TOE model in stable environments, often ignoring how crises, such as COVID-19, reshape firm behaviour, priorities, and digital capabilities. Moreover, studies focusing specifically on Malaysian manufacturing SMEs remain fragmented, with mixed findings on the role of organizational culture, management support, and regulatory context (Albar & Hoque, 2019a; Wong et al., 2020). This review addresses these gaps by critically synthesizing the literature on ICT adoption among Malaysian SMEs using the TOE framework, while integrating insights from the pandemic period. The objective is to identify consistent and divergent patterns across TOE dimensions, assess how COVID-19 moderated adoption behaviour, and evaluate the TOE framework's suitability for crisis contexts. The paper contributes to both theoretical and practical discussions on digital transformation by offering recommendations for policymakers and SME leaders.

LITERATURE REVIEW

The adoption of ICT by SMEs has garnered increasing scholarly interest due to its potential to transform operational capacities, enhance competitiveness, and support economic resilience. The TOE framework developed by Tornatzky and Fleischer (1990) offers a comprehensive lens to explore these dynamics. This section critically synthesizes the literature across the three TOE dimensions and integrates the impact of the COVID-19 pandemic in reshaping ICT adoption.

Technological Context

The technological dimension addresses how characteristics of ICT, such as relative advantage, complexity, and compatibility, affect SME adoption decisions. Numerous studies report that perceived relative advantage is a consistent and strong motivator for adoption (Albar & Hoque, 2019b; Chege et al., 2020). SMEs are more likely to embrace ICT when they perceive it to reduce costs, increase efficiency, and improve customer responsiveness. Cataldo et al. (2020) confirmed this through a large-sample study in Chile, where ICT adoption enhanced revenue and operational productivity.

However, the role of complexity and compatibility yields mixed findings. While some research, including Yunis et al. (2017), found that complexity negatively affects ICT adoption, Wong et al. (2020) observed that complexity was not always a barrier, particularly in blockchain adoption contexts in Malaysia. This suggests that complexity's influence may depend on the nature of the technology and the digital literacy of the SME workforce. Compatibility was frequently cited as a facilitator (Chege et al., 2020), yet Albar and Hoque (2019a) reported its negligible effect in rural Saudi contexts, indicating that contextual infrastructure and existing practices moderate its role.

The COVID-19 pandemic acted as a powerful technological accelerant. SMEs that previously perceived digital tools as optional suddenly recognized their necessity for continuity. Technologies previously deemed “too complex” became normalized through urgent use. Papadopoulos et al. (2020) documented how even low-digital SMEs adopted mobile applications, cloud systems, and social media under pandemic pressure, effectively lowering perceived complexity through forced learning curves.

Organizational Context

Organizational readiness includes top management support, organizational culture, and internal resources. The literature robustly links top management support to ICT success. Albar and Hoque (2019b) emphasize that leadership endorsement not only allocates resources but also fosters innovation climates. Conversely, Wong et al. (2020) found top management support to be statistically insignificant in blockchain-related ICT adoption, suggesting that emerging technologies may bypass traditional hierarchical influence and spread more bottom-up.

Organizational culture also mediates ICT adoption. In rigidly hierarchical or family-run SMEs, change resistance may delay or dilute technology implementation (Albar & Hoque, 2019b). In contrast, agile or learning-oriented cultures facilitate rapid assimilation of innovations (Chege et al., 2020). However, empirical inconsistencies persist. Some studies, like Albar and Hoque (2019a), found no significant correlation between culture and cloud ERP adoption, indicating that cultural impact may be technology-specific or contingent on industry norms.

COVID-19 reshaped internal organizational dynamics. It catalyzed managerial risk-taking and accelerated digital experimentation. With traditional channels disrupted, even conservative leaders endorsed ICT initiatives to stay afloat. Remote work mandates also fostered an unintentional cultural shift toward digital collaboration and reduced resistance to change, as seen in multiple pandemic case studies (Cheah et al., 2023; Lu et al., 2020; Ratnasingam et al., 2020).

Environmental Context

The environmental context involves external pressures such as regulatory frameworks and market competition. Competitive pressure has long been viewed as a motivator for ICT adoption (Chege et al., 2020; Wong et al., 2020). SMEs in saturated or rapidly evolving markets are more likely to adopt ICT to maintain strategic parity or

differentiation. Yet Albar and Hoque (2019b) noted that in rural Saudi Arabia, competitive pressure had minimal influence, highlighting the moderating role of market maturity and digital ecosystem development.

Regulatory environments show inconsistent impacts. While some scholars identify government incentives and ICT policies as crucial enablers (Arslan et al., 2019), others like Wong et al. (2020) argue that in certain cases, regulatory approval does not significantly shape SME decision-making. This disparity may stem from policy clarity, enforcement strength, and perceived relevance by SME actors.

COVID-19 transformed the environmental context in two key ways. First, governmental lockdowns forced businesses to shift online, thus directly influencing the external environment and imposing digital adaptation as a survival requirement. Second, digital policies were swiftly introduced or enhanced—e.g., Malaysia's PENJANA digitalization grants, which served as new institutional stimuli. However, disparities in access and awareness meant benefits were unevenly distributed, particularly across micro-enterprises and rural firms (Gong & Tong, 2020).

Synthesis and Critical Appraisal

Across all three TOE dimensions, findings demonstrate both convergence and divergence. While technological benefits and top management support are widely affirmed, the influence of cultural, competitive, and regulatory contexts remains inconsistent and appears highly contingent on geographic, sectoral, and technological specifics.

Methodologically, many studies relied on cross-sectional surveys, limiting causal inference. There is a relative scarcity of longitudinal designs that capture how ICT adoption evolves under crises like COVID-19. Moreover, few studies address the digital maturity levels of SMEs in depth, which may be a critical moderator for interpreting the influence of TOE variables. The pandemic has provided a natural quasi-experiment, yet its full implications remain underexplored.

Problem Statement

SMEs are universally acknowledged as the backbone of Malaysia's economy, comprising 98.5% of the nation's business establishments. However, their contribution to the GDP remains disproportionately low—only 38.3%—when compared to their counterparts in developed economies such as Singapore, where SMEs contribute 48% to the GDP (Khoo & Chan, 2017; SME Corporation Malaysia, 2021). This performance discrepancy highlights structural inefficiencies and underutilized capacity in Malaysian SMEs, particularly within the manufacturing sector.

Amid growing pressure from globalization, digital transformation has emerged as a pivotal solution. Despite the availability of various digital tools, approximately 71% of Malaysian SMEs have limited ICT adoption (Cheah, 2018; Gong & Tong, 2020), revealing a significant digital gap. These limitations, including inefficient resource management and outdated technologies, hinder SMEs from optimizing productivity and achieving global competitiveness (Nor-Aishah et al., 2020).

The COVID-19 pandemic further amplified these vulnerabilities. With the enforcement of the Movement Control Order (MCO), over 70% of SMEs reported losing half of their revenue (Annuar, 2020; Cheah et al., 2024; Tan & Cheah, 2025). The crisis also exposed the fragility of analog business models and underscored the urgency of digital integration. However, there remains a lack of empirical clarity on how the pandemic reshaped the dynamics of technology adoption among SMEs.

While the TOE framework offers a holistic model for understanding ICT adoption, its application in crisis contexts, particularly within developing economies, remains under-explored. Prior studies have delivered mixed and sometimes contradictory results, especially concerning the influence of organizational culture and regulatory environments (Albar & Hoque, 2019a; Wong et al., 2020). Thus, there is a pressing need to contextualize and update the TOE framework to reflect the altered landscape of ICT adoption in the wake of COVID-19.

Significance of Study

This study is significant in both theoretical and practical terms. It offers a contextualized understanding of how Malaysian manufacturing SMEs navigate ICT adoption through the lens of the TOE framework, particularly under the extraordinary pressures imposed by the COVID-19 pandemic.

Theoretical Contribution

Theoretically, this study expands on the TOE framework by investigating how pandemic-induced disruptions act as moderators across the technological, organizational, and environmental dimensions of ICT adoption. While past studies have examined individual TOE elements in isolation, this research integrates all three contexts in a cohesive model and systematically compares their relative influence on SME performance. It contributes to existing literature by clarifying previously contradictory findings, particularly in relation to complex or ambiguous variables such as top management support, regulatory constraints, and technological compatibility (Albar & Hoque, 2019a; Rajah et al., 2023; Wong et al., 2020).

Furthermore, the study introduces a crisis-sensitive layer to the TOE framework, showing how external shocks, like COVID-19, may alter or accelerate decision-making processes and innovation adoption cycles. In doing so, it enhances the applicability of the TOE model beyond normal operating environments and suggests modifications to better suit future research during periods of uncertainty.

Practical Contributions

From a practical standpoint, the findings offer concrete implications for SME owners, policymakers, and support institutions. For SME owners, the study identifies the most critical technological attributes (e.g., relative advantage, complexity), organizational enablers (e.g., leadership support, adaptive culture), and external pressures (e.g., regulatory clarity, competitive pressure) that influence successful ICT integration. This can inform strategic planning and resource allocation, especially for digitally lagging enterprises.

For policymakers, the research highlights the regulatory and infrastructural bottlenecks that impede digital transformation and recommends actionable strategies, such as digital subsidies, upskilling programs, and simplified compliance frameworks, to address them. By understanding how COVID-19 catalyzed or hindered ICT adoption across TOE dimensions, government and development agencies can better design targeted interventions to bolster SME resilience in future crises.

RESEARCH METHOD

This study employed a narrative literature review approach, guided by the conceptual lens of the TOE framework. While not systematic in the traditional sense, this method

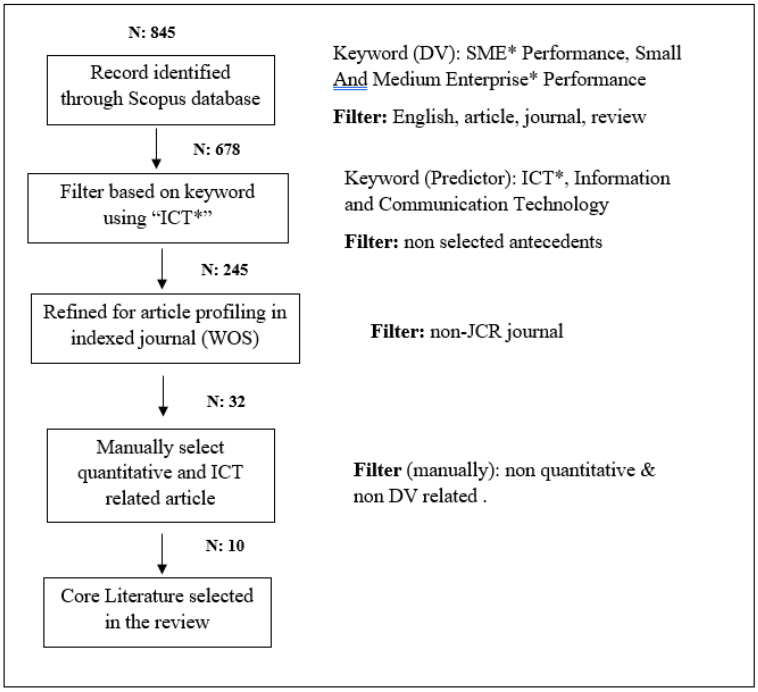
enabled a comprehensive and interpretative synthesis of diverse studies concerning ICT adoption in SMEs, with particular attention to Malaysian manufacturing SMEs during and after the COVID-19 pandemic.

Literature Selection and Inclusion Criteria

This review aimed to include both empirical studies and conceptual papers (Quyen et al., 2024) that directly addressed ICT adoption by small and medium-sized enterprises (SMEs), specifically in relation to one or more dimensions of the Technology-Organization-Environment (TOE) framework. To ensure relevance and focus, the following inclusion criteria were applied: (1) the article must explore ICT adoption or digital transformation within SMEs; (2) the study must incorporate at least one TOE dimension, either explicitly or conceptually; (3) priority was given to studies conducted in developing countries, particularly in Southeast Asia and Malaysia, due to their underrepresentation in existing literature; (4) articles must have been published in peer-reviewed journals between 2016 and 2024, capturing the evolving digital landscape, especially during and after the COVID-19 pandemic; and (5) only English-language publications were considered to maintain consistency and accessibility in analysis.

Exclusion criteria were also clearly defined. Studies were omitted if they focused exclusively on large enterprises or public sector organizations, lacked empirical or theoretical engagement with ICT adoption in SME contexts, or were published as editorials, commentaries, or other non-peer-reviewed formats. To strengthen the comprehensiveness of the review, backward citation tracking was employed to identify foundational works that, despite being published prior to 2016, continue to exert significant influence in the field, such as Albar & Hoque (2019b) and Tornatzky & Fleischer (1990). The full article selection process is illustrated in Figure 1, which outlines the flow from initial identification to final inclusion.

Figure 1. Flow of Key Article Selection



To enhance transparency, Table 1 provides a summary of the core articles reviewed, including author(s), sample characteristics, geographic focus, and key findings.

Table 1. Summary of Prior Empirical Findings Aligned to TOE Dimensions

No.	Author(s) (Year)	Country / Sample	TOE Dimension(s)	Key Findings	COVID-19 Context
1	Terziovski (2010)	600 Australian SMEs	Technology	Technological capabilities had an insignificant negative correlation with SME performance.	No
2	Cataldo et al. (2020)	5,519 Chilean MSMEs	Technology	ICT adoption improved performance—revenue, profitability, and cost reduction.	No
3	Chege et al. (2020)	240 Kenyan SMEs	Technology, Organization, Environment	Technological context and innovation positively impacted performance; organizational structure and environment had limited influence.	Indirect relevance
4	Yunis et al. (2017)	150 Lebanese SMEs	Technology, Organization	ICT adoption correlated positively with organizational performance.	No
5	Albar & Hoque (2019b)	137 SMEs in rural Saudi Arabia	All TOE Dimensions	Relative advantage, organizational support, and regulatory environment positively influenced ICT adoption. Compatibility and competitive environment had no significant impact.	No
6	Wong et al. (2020)	194 Malaysian SMEs	All TOE Dimensions	Complexity and competition positively affected	Indirect relevance

				blockchain adoption. Top management support and regulatory approval were not significant.	
7	Albar & Hoque (2019a)	200 Saudi firms	All TOE Dimensions	Relative advantage and regulatory factors supported cloud ERP adoption; complexity had negative impact. Culture and compatibility were insignificant.	No
8	Bala & Feng (2019)	4,300 Myanmar SMEs	Technology, Organization	Web presence, internet usage, and firm age/size linked to higher performance.	No
9	Arslan et al. (2019)	Turkish, Mexican, and Guatemalan firms (2,591 total)	Organization, Environment	Organizational support and regulatory conditions influenced ICT adoption across emerging markets.	No
10	Soto-Acosta et al. (2016)	175 Spanish SMEs	Technology	E-business systems adoption improved performance in cost, quality, and flexibility.	No
11	Papadopoulos et al. (2020)	Not sample-based (conceptual)	All TOE Dimensions	Highlighted the catalytic role of COVID-19 in pushing SMEs to adopt digital tools (IoT, mobile, collaboration tech).	Yes

12	Kee et al. (2024)	Malaysian SMEs	Technology	Tech adoption improved sales and productivity among adopters during COVID-19.	Yes

RESULTS

The literature review reveals several interrelated patterns regarding the adoption of ICT by SMEs. Through the lens of the TOE framework, three key thematic clusters emerge: (1) technological enablers and barriers, (2) organizational readiness and culture, and (3) environmental pressures and support systems. These themes are examined below with a focus on their impact on SME performance and contextual variations across regions and industries.

Technological Factors: Performance Enablers and Cognitive Barriers

The most frequently cited technological factors influencing ICT adoption among SMEs are relative advantage, complexity, and compatibility, each playing a distinct yet interrelated role. Relative advantage is consistently found to be a strong driver of adoption, with SMEs more inclined to embrace ICT when they perceive clear benefits such as cost savings, operational efficiency, or enhanced customer responsiveness. This trend holds true across both developing and developed countries (Bala & Feng, 2019; Cataldo et al., 2020; Chege et al., 2020). In contrast, complexity often acts as a significant barrier, particularly in environments with limited resources or low digital literacy, where the perceived difficulty of ICT implementation can deter adoption (Albar & Hoque, 2019a). Interestingly, the COVID-19 pandemic disrupted this pattern in some cases, as the urgency of the crisis spurred rapid upskilling and improvisational ICT use despite initial constraints (Papadopoulos et al., 2020). Meanwhile, compatibility has yielded mixed results. While some studies confirm its importance—emphasizing the need for ICT solutions to align with existing workflows and values (Chege et al., 2020)—others report it as less influential, particularly in rural or traditionally structured SMEs where innovation adoption may be resisted regardless of fit (Albar & Hoque, 2019b). These findings highlight the nuanced and context-dependent nature of technological factors in shaping SME digital adoption.

In terms of performance outcomes, studies consistently associate ICT adoption with improvements in sales growth, profitability, market expansion, and operational efficiency. The relationship is particularly strong where SMEs integrate multiple ICT tools (Soto-Acosta et al., 2016; 2018) or leverage digital platforms during crisis periods (Kee, Lee, et al., 2023; Kee, Sin, et al., 2023).

Organizational Factors: Culture, Leadership, and Resource Readiness

Organizational readiness—particularly in terms of top management support and organizational culture—emerged as a critical determinant of ICT implementation success among SMEs. Top management support has been consistently identified as a decisive factor in numerous studies, especially when leaders actively champion digital initiatives and commit the necessary financial and human resources (Albar & Hoque, 2019b; Yunis et al., 2017). However, this influence is not uniform across all technological contexts; for example, Wong et al. (2020) found no significant managerial effect in the adoption of blockchain, suggesting that the impact of leadership may diminish with more novel or unfamiliar technologies. Organizational culture also plays a pivotal, yet context-sensitive,

role. Firms with agile and innovation-driven cultures are more likely to embrace digital transformation swiftly, while those with hierarchical or risk-averse mindsets often struggle to adapt. This cultural resistance is particularly pronounced in SMEs with traditional business models, where digital initiatives may clash with entrenched practices (Albar & Hoque, 2019a). These findings underscore the need to consider internal dynamics when assessing organizational readiness for ICT adoption.

COVID-19 appears to have temporarily reconfigured organizational dynamics**,** compelling even conservative managers to embrace digital solutions under duress. Remote work, online sales, and virtual collaboration normalized digital practices that were previously resisted. Across studies, organizational readiness consistently correlates with SME resilience, productivity, and adaptability, particularly under volatile conditions like the pandemic.

Environmental Factors: Regulation, Competition, and Crisis Impacts
The external environment—particularly regulatory support and competitive pressure—plays a complex and often contradictory role in influencing ICT adoption among SMEs. Competitive pressure has emerged as a significant motivator, especially in dynamic or saturated industries, where SMEs adopt digital technologies to maintain relevance and avoid losing market share (Chege et al., 2020; Wong et al., 2020). However, this influence tends to diminish in less competitive markets or rural areas, where such pressures are weaker and the urgency for adoption is lower (Albar & Hoque, 2019b). Similarly, the regulatory environment presents mixed effects. In certain contexts, supportive government policies—such as digitalization grants and investments in ICT infrastructure—have facilitated adoption by lowering barriers and providing incentives (Arslan et al., 2019). Conversely, in environments marked by regulatory ambiguity or burdensome compliance requirements, these policies have become obstacles rather than enablers (Wong et al., 2020). These variations highlight the need for context-specific analysis when evaluating the impact of external environmental factors on SME digital adoption.

During the COVID-19 pandemic, the environmental context shifted dramatically**.** SMEs were pressured to digitize by external necessity (e.g., lockdowns, customer behavior shifts), and many governments introduced temporary digital incentives**,** altering the risk-reward calculus of adoption (Papadopoulos et al., 2020).

Overall, SMEs operating in digitally supported, highly competitive environments reported the highest gains from ICT adoption, both in terms of business continuity and long-term performance gains.

Visual Summary: TOE Factors and Their Relationship to SME Performance
Figure 2 below is a conceptual figure summarizing the key TOE factors influencing ICT adoption and how they impact SME performance across geographic and crisis contexts:

Figure 2. TOE Factors Influencing ICT Adoption and Their Impact on SME Performance

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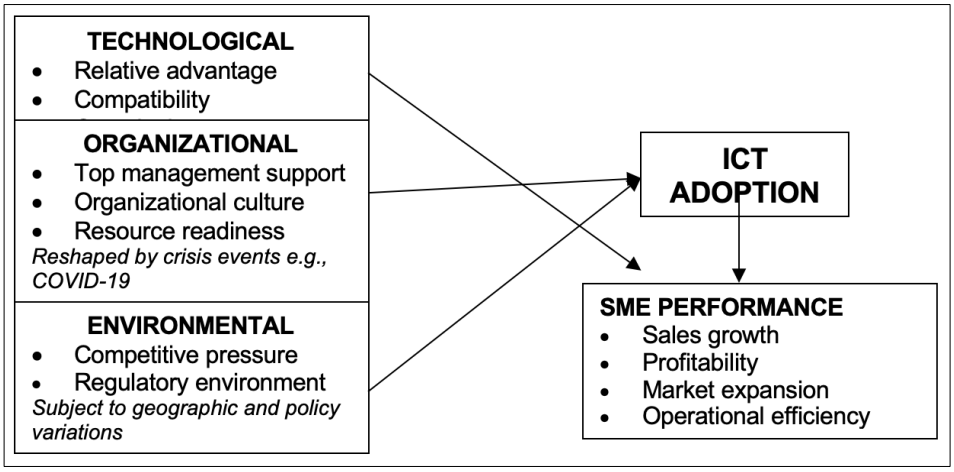

DISCUSSION

This literature review highlights how the TOE framework remains a valuable analytical tool for understanding ICT adoption among SMEs, especially in developing countries like Malaysia. However, critical engagement with the reviewed literature reveals that while the TOE framework provides a structured lens, it requires contextual adaptation to fully account for the dynamic and disruptive nature of crises such as the COVID-19 pandemic.

Revisiting the TOE Framework in Light of Post-Pandemic Realities

The technological dimension of the TOE framework, consisting of relative advantage, compatibility, and complexity, has long served as a solid foundation for understanding ICT adoption behavior in SMEs. Relative advantage remains a reliable predictor, as SMEs continue to adopt digital technologies that promise efficiency, responsiveness, or competitive edge. Compatibility also retains explanatory value when technology aligns with firms' existing systems, workflows, or cultural norms. However, the construct of complexity warrants renewed attention, particularly in light of findings during the COVID-19 pandemic. Technologies previously regarded as difficult to implement—such as e-commerce platforms, remote work tools, and cloud-based systems—were rapidly adopted, not because they became intrinsically simpler, but due to the urgent need to remain operational under restrictive conditions. This suggests that external shocks can temporarily lower psychological and operational barriers, flatten learning curves, and reframe complexity as a manageable trade-off. As such, crisis-induced urgency fundamentally reshapes the salience of technological constructs, rendering the static assumptions of the traditional TOE model insufficient. Future models should consider temporal sensitivity by introducing moderators like urgency or perceived crisis severity to better capture the dynamic shifts in technological perception.

The organizational context, typically defined by internal characteristics such as leadership commitment and organizational culture, also proved to be more fluid than previously theorized. While top management support has consistently been cited as a key enabler of digital transformation, the pandemic revealed a more reactive dimension of leadership. Leaders who had previously been conservative or resistant to digital change found themselves compelled to adopt ICT solutions, not from strategic foresight but in response to existential threats to their business continuity. This shift underscores the importance of recognizing organizational adaptability or resilience as a key variable in the TOE framework. Furthermore, organizational culture, which has often been treated as a relatively stable background condition, demonstrated surprising malleability under pressure. Firms with traditionally rigid or hierarchical cultures began to experiment with agile workflows and remote operations, revealing that culture can evolve rapidly in response to external stimuli. These findings point to a need for TOE extensions that allow

for intra-organizational transformation over time, particularly in contexts marked by high uncertainty or crisis.

The environmental dimension of the TOE framework exhibited the greatest volatility during the pandemic, challenging the assumption that institutional and market environments evolve incrementally. Governments across the globe implemented a range of emergency measures—from digital adoption incentives to regulatory relaxations—that significantly altered the risk-reward calculus for SMEs. In some cases, these policies accelerated digital transformation; in others, regulatory ambiguity created confusion and hesitation. Additionally, competitive pressures intensified in the digital marketplace, as firms rapidly shifted operations online, collapsing traditional geographic barriers and heightening the urgency to innovate. These rapid and sometimes contradictory shifts highlight the limitations of the TOE framework's relatively static view of the environment. To remain analytically relevant, the framework must be recalibrated to accommodate policy fluidity and temporal variation. The inclusion of constructs such as institutional agility, regulatory responsiveness, and crisis-triggered competition would enhance the TOE's capacity to explain ICT adoption in fast-changing external conditions.

In sum, while the TOE framework remains a valuable foundation for analyzing ICT adoption, its utility is significantly enhanced by recognizing the temporal dynamics and adaptive behaviors that emerge during crises. By expanding the model to include constructs that account for urgency, organizational resilience, and environmental volatility, researchers and practitioners can better capture the realities of digital transformation in uncertain and rapidly evolving contexts.

Extending the TOE Framework: A Post-Crisis Adaptation

To enhance its relevance in a post-pandemic world, the TOE framework could be extended in three key ways. First, temporal sensitivity should be incorporated by introducing time-based moderators that account for how crises accelerate or delay ICT adoption across the TOE dimensions. This adjustment is essential for understanding variation in adoption behavior during the early, peak, and recovery phases of disruptions. Second, a crisis responsiveness layer should be added to integrate constructs such as perceived urgency, digital improvisation capacity, and institutional trust—factors that significantly influenced organizational behavior during the COVID-19 pandemic but are absent from the original TOE framework. Third, sectoral calibration is necessary to reflect differences in adoption patterns across industries, particularly between manufacturing and service-based SMEs. The reviewed studies indicate that sector-specific operational demands mediate the impact of TOE variables, suggesting that a one-size-fits-all approach may limit explanatory power. Together, these enhancements would improve the TOE framework's adaptability and analytical depth in the context of dynamic, crisis-prone environments.

Identified Knowledge Gaps

Despite growing interest in the digital transformation of SMEs, several critical research gaps remain underexplored. One major gap is the lack of empirical validation in crisis contexts, as most existing studies rely on cross-sectional data. Longitudinal research is needed to understand how SME perceptions and ICT usage evolve before, during, and after periods of crisis. Additionally, underrepresented regions and sectors—particularly rural areas, informal businesses, and micro-enterprises in Southeast Asia—have received limited attention, despite their significant role in local economies. Another overlooked area is digital maturity and layered adoption; few studies investigate how different levels of digital readiness impact adoption across the dimensions of the TOE framework. Classifying SMEs by their digital maturity could yield more nuanced insights into adoption patterns. Lastly, the institutional context—including factors such as

government trust, public-private partnerships, and infrastructure—warrants deeper investigation, particularly in its role in mediating external pressures and enabling or constraining ICT adoption. Addressing these gaps will enhance the relevance and applicability of future research across diverse SME landscapes.

Implications for Theory and Practice

The TOE framework's structured approach has proved valuable but incomplete. In practice, its application needs to be dynamic and adaptable, especially in uncertain environments. The pandemic has revealed that ICT adoption is not merely a strategic decision, but often a survival mechanism.

For practitioners and policymakers, understanding this shift is critical. Interventions must address not just structural barriers, but also temporary psychological and environmental deterrents during crises. Policies should aim for sustained digital capacity building, not just short-term compliance.

CONCLUSION

This review examined the adoption of ICT by SMEs through the lens of the TOE framework, with particular emphasis on Malaysian manufacturing SMEs and the unique pressures introduced by the COVID-19 pandemic. The synthesis of literature revealed that while the TOE framework remains conceptually robust, it must be contextually adapted to remain effective in times of systemic disruption.

The review's core contribution lies in its thematic integration of research findings across TOE dimensions, revealing the most influential adoption factors—technological relative advantage, top management support, and competitive pressure—as well as inconsistencies in how factors like organizational culture, complexity, and regulatory conditions impact ICT uptake across geographies and industries. Importantly, the pandemic highlighted how these dimensions are not static: urgency, improvisation, and external shocks reshaped ICT decision-making in ways that the original TOE framework does not fully capture.

From a theoretical perspective, this review calls for the extension of the TOE model to include temporal sensitivity, crisis responsiveness, and institutional mediation to reflect the dynamic conditions under which ICT adoption now occurs. Such enhancements would allow the framework to account for rapid behavioral shifts and policy fluctuations experienced during events like COVID-19.

For practitioners, particularly SME owners and digital transformation leaders, the findings emphasize the importance of cultivating agile cultures, proactively engaging with ICT as a strategic asset, and investing in foundational digital capabilities before crises strike. For policymakers, the review underscores the need to move beyond episodic support and implement structural reforms that enhance digital ecosystems, provide inclusive access to ICT infrastructure, and create stable regulatory environments to sustain long-term adoption.

Despite its contributions, this review has several limitations. It relies primarily on published, peer-reviewed studies between 2016 and 2024 and thus may exclude emergent or unpublished empirical data. Additionally, the review's narrative nature, while useful for thematic synthesis, does not allow for quantitative meta-analysis or causal inference. Most studies examined were also cross-sectional, limiting longitudinal understanding of ICT adoption trajectories.

Future research should prioritize several key areas to deepen understanding and enhance the relevance of digital adoption studies. First, longitudinal studies are essential to track the progression and sustainability of digital adoption over time, providing insights into long-term impacts and behavioral patterns. Second, comparative, country-specific analyses across ASEAN and other developing regions are needed to account for contextual differences in policy, infrastructure, and cultural factors influencing adoption. Third, there is a need to explore digital maturity levels among informal SMEs and micro-enterprises, which are often underrepresented but play a critical role in developing economies. Lastly, empirical testing of extended TOE models that incorporate crisis-related constructs, such as resilience and adaptability during disruptions like the COVID-19 pandemic, can offer a more comprehensive understanding of the factors driving digital transformation in uncertain environments.

In conclusion, this review reaffirms the TOE framework's foundational value while advocating for its evolution. It provides an evidence-based roadmap for understanding and enhancing ICT adoption in SMEs, equipping both scholars and practitioners to navigate the digital imperatives of a post-pandemic world.

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DECLARATION OF CONFLICTING INTERESTS
The authors declare that there is no conflict of interest.

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