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Evaluating the TOE Framework for Technology Adoption: A Systematic Review of Its Strengths and Limitations

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Abstract— The adoption and decision-making of information technology (IT) remains the cornerstone of organizational innovation and market competitiveness. Various frameworks, such as the Technology Acceptance Model (TAM), the diffusion of innovations (DoI), and the Technology-Organization-Environment (TOE) framework, have been utilized to explain IT adoption decision-making. Among these, the TOE framework stands out for its holistic approach. The TOE framework has demonstrated adaptability across industries and technologies and has been used to examine technological capabilities, organizational readiness, and environmental influences on technology adoption. However, there remains a persistent debate about the TOE framework's theoretical rigor and contextual applicability to address decision-making about technology adoption. This systematic review critically analyzes the strengths and limitations of the TOE framework while comparing and contrasting it with the DoI and TAM frameworks for technology adoption. This paper identified the gaps, such as the limited consideration of dynamic adoption processes and post-adoption outcomes in the TOE framework. This research synthesizes existing knowledge and critiques the current utility of the framework. It also offers a foundation for its evolution, addressing a significant scholarly need for critical evaluation and innovation in technology adoption studies.

Keywords-TOE framework, Technology adoption, Organizational technology adoption, Systematic review, Technology-Organization-Environment framework, IT adoption decision-making, innovation in technology adoption, Strengths and limitations of TOE framework

I. INTRODUCTION

The adoption of information technology (IT) is widely recognized as a key driver of organizational innovation, efficiency, and long-term competitiveness. However, understanding the factors influencing IT adoption decisions remains challenging for researchers and practitioners. While several theoretical frameworks have been developed to address this issue, the Technology-Organization-Environment (TOE) framework, introduced by Tornatzky and Fleischer (1990), has emerged as one of the prominent due to its holistic stance. The TOE framework has been extensively applied across industries and technologies, demonstrating its versatility. For instance, in cloud computing adoption, researchers have used TOE to analyze key drivers such as data security, organizational readiness, and regulatory compliance [1], [2], [3], [4]. Similarly, it has been utilized to study the implementation of enterprise resource planning (ERP) systems, where internal IT capabilities and market competition were found to play significant roles [5]. Beyond these, its application extends to emerging technologies such as IoT, blockchain, and big data analytics, where the interplay of internal and external factors has been emphasized [6], [7], [8].

The TOE framework provides three interrelated contexts: technological capabilities, organizational characteristics, and external environmental factors, offering a structured approach to understanding the determinants of technology adoption [9]. Despite its widespread application, there remains an ongoing debate regarding its theoretical robustness, adaptability, and limitations in addressing evolving technological landscapes and organizational needs. Prior studies have highlighted the framework's adaptability and explored gaps, such as limited attention to individual decision-making, task-specific factors, and post-adoption outcomes, raising questions about its comprehensiveness in addressing contemporary challenges.

This study identifies a key research gap: while the TOE framework provides valuable insights into the factors influencing IT adoption, its theoretical limitations and contextual applicability remain underexplored. Specifically, there is a lack of systematic synthesis of its strengths and weaknesses across diverse empirical studies, leaving room for ambiguity regarding its suitability for modern and emerging technologies. The objective of this research is to conduct a

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systematic review to evaluate the TOE framework, critically assessing its strengths and limitations in explaining IT adoption decisions. By synthesizing existing empirical evidence, this study aims to deepen understanding of the TOE framework's theoretical and practical contributions, offering guidance for its refinement. Furthermore, the research provides actionable insights for future researchers seeking to evaluate or extend the framework to address evolving organizational and technological complexities.

II. LITERATURE REVIEW

The primary focus of this study is to examine the TOE framework and how it helps understand technology adoption through three core elements influencing innovation in organizations. The TOE framework emphasizes the impact of organizational and environmental context on technological adoption and is widely used in management and organizational studies. The framework examines the organizational context, technological factors, and internal and external environmental factors. All three aspects are vital in understanding IT adoption decision-making through various constructs. A substantial body of research has demonstrated the applicability of the TOE framework and uses it to explain the innovation phenomenon [10], [11]. This literature review will examine the tenets of the TOE framework and highlight its strengths and limitations while exploring potential avenues for further development and application.

A. TOE Framework

The Technology-Organization-Environment (TOE) framework, initially proposed by Tornatzky and Fleischer (1990) [9], [12], [13], [14], stands as a prominent theoretical lens for understanding technology adoption at the organizational level. The TOE framework considers various relevant factors holistically, recognizing that technological choices do not happen in isolation. A complex interplay of technological, organizational, and environmental forces shapes the technology choices and decisions. The TOE framework posits that three core contexts influence an organization's decision to adopt a particular technology [9], [12], [13], [14].

The technological aspect refers to the characteristics inherent to the technology itself. The technological aspect includes the latest technology's relative advantage over existing solutions, compatibility with current infrastructure and processes, complexity, security features, and perceived benefits. Previous studies across various innovations, such as e-business [14], cloud computing [15], blockchain technology (BCT) [11], [16], and enterprise mobility [17], have demonstrated the importance of technological factors in shaping technology adoption decisions. The organizational context focuses on the organization's internal characteristics, including its size, scope, resources, managerial structure, culture, and leadership style [11], [12]. Factors like top management support, organizational innovativeness, and learning capabilities are consistently linked to successful technology adoption. The environmental aspect plays a critical role and allows researchers to examine the external environment in which the organization operates. The environmental aspect includes influencing factors such as competitive pressure, industry trends, government regulations, and the readiness of partners to adopt and utilize the technology [3], [11], [12].

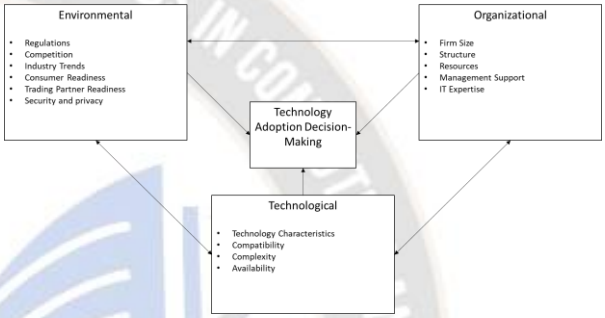

Figure 1 The TOE Framework Adopted from Baker [12], Gangwar et al. [18], and Oliveira et al. [2].

While the specific factors within each context can vary depending on the technology and industry, the TOE framework provides a flexible structure that can accommodate a wide range of contextual variables [12]. The flexible and adaptable nature of the TOE framework contributes to its widespread application across various research domains.

B. Comparative Analysis of TOE with Other Adoption Framework

This section offers a comparative view of the adoption models, such as the Technology Acceptance Model (TAM), Diffusion of Innovations (DOI), and TOE Framework. The comparison in Table 1 provides the key insights. Though the individual frameworks have a strong theoretical basis for examining the IT adoption factors, integrating concepts from TAM and DOI into the TOE framework remains possible to create a more holistic understanding of technology adoption. The integration could create a more robust model to understand technology adoption decision-making better. Several studies have proposed an integrated framework to provide a holistic understanding of technology adoption [9], [19].

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TABLE 1 COMPARATIVE ANALYSIS OF TOE WITH TAM AND DOI

Frame work	Level of Analysis	Factors Considered	Theoretical Scope	Key Insights	References
TOE	Organizational	• Technological – Technology Characteristics, Compatibility, Complexity, Availability • Organizational – Firm Size, Structure, Resources, Management Support, IT expertise • Environmental – Competition, regulations, industry trends, consumer readiness, trading partner readiness	Explains technology adoption decisions within a specific organizational context by considering the interplay of technological, organizational, and environmental factors.	TOE framework provides a comprehensive, macro-level view of technology adoption within organizations	[9], [12], [14], [15], [19]
TAM	Individual	• Perceived Usefulness - Beliefs about the positive impact of using the technology • Perceived Ease of Use - Beliefs about the effortlessness of using the technology	Predicts individual user acceptance of a specific technology based on their perceptions of its usefulness and ease of use.	TAM offers a micro-level perspective focused on individual user acceptance	[12], [19]
DOI	Individual, Societal, Organizational	• Relative Advantage - The degree to which the innovation is perceived as better than the existing alternative. • Compatibility - The degree to which the innovation is perceived as consistent with existing values, experiences, and needs. • Complexity - The degree to which the innovation is perceived as challenging to understand and use. • Trialability - The degree to which the innovation can be experimented with on a limited basis. • Observability - The degree to which the results of using the innovation are visible to others.	Explains the process of innovation diffusion across a population over time, focusing on the characteristics of the innovation and their influence on adoption rates and patterns.	DOI theory bridges these levels by examining innovation diffusion across populations, focusing on the innovation's inherent characteristics	[9], [12], [15], [20]

III. RESEARCH QUESTIONS

This study conducts a systematic review of the TOE Framework, examining its strengths and limitations in the context of technology adoption decision-making. By critically assessing the use of the TOE framework, this research addresses existing gaps in the literature and provides insights for future researchers. The researchers have identified the following research question based on the literature review.

RQ: What are the key strengths and limitations of the Technology-Organization-Environment (TOE) framework in exploring the technology adoption decisions?

IV. METHODOLOGY

This systematic review study has utilized the methodology presented by Tranfield et al. [21]. Authors Tranfield et al. [21] have recommended maintaining transparency and objectivity while reporting recent progress in the literature review on the TOE framework's usage in technology adoption and decision-making. This systematic review aims to identify the strengths and limitations of the TOE framework. This study follows the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). PRISMA model allows for a comprehensive and transparent approach to systematic reviews and inclusion of relevant studies. Figure 2 describes the PRISMA approach taken for system literature review selection, and Table 2 highlights the inclusion and exclusion criteria for the paper selection.

A. Search Strategy

This paper followed a methodical search strategy to answer the identified research questions and to identify the relevant studies. The search terms utilized included "Strength of Technology-Organization-Environment framework" or "Limitations of Technology-Organization-Environment framework" to search for better results. The search criteria were applied to IEEE Xplore and Google Scholar to search for relevant articles. The authors selected studies published in the last 10 years to cover the recent theoretical development.

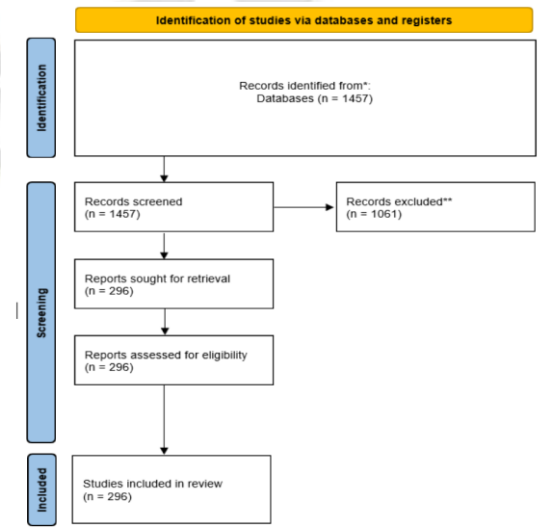

Figure 2 PRISMA Flow Chart. Adoption from Page et al. [22]

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B. Search Strategy

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C. Data Extraction and Analysis

Data extraction utilized an analysis of individual papers to identify the relevancy of research questions. The study considered the research subject as the key criteria and extracted the studies based on relevancy with abstract, title, authors, keywords, and research technique. Key findings and methodological details were also collected. The retrieved data was classified into themes or subjects related to the study questions throughout the data analysis phase.

D. Inclusion and Exclusion Criteria

Table 2 defines the inclusion and exclusion criteria utilized during the study for research and filtering out the selected papers. Inclusion and exclusion criteria are extremely helpful in narrowing down the relevancy of suitable papers for the study.

TABLE 2 LITERATURE INCLUSION AND EXCLUSION CRITERIA

Inclusion Criteria	Exclusion Criteria
Papers published in the last 10 years	Papers unrelated to the research question.
Peer-reviewed papers published in journals or presented in conference papers.	Paper written in languages other than English.

V. RESULTS AND DISCUSSIONS

TOE framework brings comprehensiveness, adaptability, and empirical support, making it a robust framework for researchers and practitioners. The results and discussions section provides an in-depth exploration of the findings to answer the research question posed in the study. This section is organized into two distinct parts: a) the strength of the TOE framework and b) the limitations of the TOE framework.

A. Strengths of the TOE Framework

The Technology-Organization-Environment (TOE) framework is a comprehensive and widely recognized model that seeks to explain and predict how organizations adopt new technologies. This framework encompasses three critical dimensions—Technology, Organization, and Environment—that interact to influence an organization's technology adoption process. The following points elaborate on the key strengths of the TOE framework:

- A Comprehensive and Holistic Framework: The TOE framework examines the interplay of three key contexts - technological, organizational, and environmental, that influence technology adoption. Accounting for these diverse factors offers a comprehensive understanding of the complex adoption process compared to other frameworks that focus solely on individual or technological aspects [9], [15], [19].
- A Strong Theoretical Foundation: The framework is grounded in established theories such as the Diffusion of Innovations (DOI) theory and Fred Fiedler's contingency theory. This theoretical foundation provides a strong basis for understanding the relationships between the three contexts and technology adoption [9], [12], [15].
- Broad Applicability and Adaptability: The TOE framework has been successfully applied to explain the adoption of a wide range of technologies across diverse industries, national/cultural contexts, and organizational sizes [9], [12], [13], [15], [20]. Researchers can tailor the specific factors and measures within each context to suit the specific technology and context being studied [9], [12], [14], [15], [16], [19], [23].
- Empirical Support: Numerous empirical studies have validated the TOE framework's predictive power, demonstrating the significant influence of technological, organizational, and environmental factors on technology adoption decisions [9], [12], [13], [14], [15].
- Integration with Other Theories: While the TOE framework is strong foundationally, its adaptability allows integration with other theoretical models to enhance its explanatory and predictive power. This includes incorporating frameworks like the Task-Technology Fit (TTF) and Unified Theory of Acceptance and Use of Technology (UTAUT) to address individual and task-related factors [9], [15], [16], [19].
- Provides Practical Insights: The TOE framework provides valuable and practical insights for practitioners, including vendors, policymakers, and organizational leaders, by identifying the key factors driving or hampering technology adoption. These practical insights can facilitate strategic decision-making and policy development for successful technology implementation [9], [19], [20], [23].

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B. Limitations of the TOE Framework

The previous section systematically explored the strengths of the TOE framework, highlighting its valuable contributions to our understanding of technology adoption. On one side, the TOE framework offers a broad and insightful perspective, making it an effective tool for analyzing how organizations embrace new technologies. However, it is important to recognize that the TOE framework is not without its limitations. The subsequent points will outline these shortcomings in detail, providing a more nuanced understanding of the framework's applicability and constraints in real-world scenarios.

- Limited Theoretical Development: The TOE framework is viewed as a "generic" theory, primarily focused on enumerating various factors relevant to different adoption contexts [12], [24]. The framework lacks significant theoretical synthesis or critique, and no new constructs have been added since its initial development [12][24]. This limited theoretical development restricts refinement and a deeper understanding of the interplay between the framework's core elements [12], [24].
- Subsumption of Similar Theories: Instead of engaging with competing theories, the TOE framework tends to subsume them, lacking theoretical comparison and refinement [12]. For example, the EDI adoption model was developed independently but is gradually being integrated into TOE research, assuming it supports the TOE framework while having different drivers for the adoption process [12]. This absorption of similar theories hinders the development of alternative perspectives and limits the potential for theoretical debate and advancement.
- Neglect of Individual and Task-Related Factors: The original TOE framework focuses primarily on organizational-level factors, overlooking the influence of individual decision-makers and task-specific requirements [9], [24]. Although individual decision-makers' interests are considered a factor in the organizational context, their influence is not explored as a separate driver or context [9]. Similarly, the framework fails to address the technology fitment and task requirements, significantly impacting adoption decisions [9]. These limitations necessitate integrating frameworks like UTAUT and TTF to account for the impact of individual and task-related factors on technology adoption [9], [19].
- Limited Focus on Performance Outcomes: The TOE framework primarily focuses on the adoption decision itself, with limited emphasis on the impact of technology adoption on organizational performance [12]. While some research attempts to link TOE factors to performance outcomes using additional frameworks like the resource-based view (RBV), the framework itself lacks a direct mechanism for incorporating performance considerations [12]. This limits its ability to comprehensively understand the value and implications of technology adoption for organizations.
- Lack of Specificity in Model Presentation: Critics argue that Tornatzky and Fleischer (1990) did not present a specific model but used the TOE taxonomy to categorize factors into relevant contexts [9]. This lack of a clearly defined model can lead to ambiguity and inconsistencies in research applications.
- Over-Reliance on Customization: Literature suggests that the TOE framework offers adaptability, thus allowing researchers to customize factors for each research context, which can be considered a theoretical limitation [12], [24]. This flexibility can result in a lack of consistency and comparability across studies, making it difficult to generalize findings and build a cohesive body of knowledge.

VI. Conclusion

The TOE framework serves as a fundamental basis for understanding organizational technology adoption decision-making, providing a comprehensive perspective by incorporating technological, organizational, and environmental factors. Its versatility and strong theoretical foundation have made it broadly applicable across various industries and contexts, underscoring its significance in exploring diverse technologies. When combined with complementary frameworks such as UTAUT or TTF, the TOE framework can effectively address the limitations related to individual or task-specific considerations, thereby enhancing its overall utility. However, this study emphasizes the necessity for a greater focus on adoption outcomes, the refinement of theoretical constructs, and the creation of new constructs to broaden the TOE's applicability and tackle existing challenges.

This research has synthesized a substantial body of literature, reaffirmed the strengths of the TOE framework, and pinpointed critical areas for enhancement. The findings emphasized TOE's relevance while highlighting the need for improvements that bridge the gaps between theoretical concepts and empirical applications. This study has practical implications and suggests that the TOE framework can serve as a valuable guide for policymakers and organizational leaders in formulating strategies that optimize technology adoption. Additionally, the framework's adaptability across various industries can aid vendors and developers in customizing

technology solutions to meet specific organizational and environmental needs.

Future research should prioritize the development of constructs that integrate performance outcomes, thereby facilitating a more comprehensive understanding of the long-term effects of technology adoption. Additionally, efforts should be directed toward standardizing the application of the TOE framework to enhance consistency and comparability across studies. Investigating emerging technologies such as artificial intelligence and blockchain offers valuable opportunities to test and expand the framework's applicability, ensuring its relevance within a rapidly changing technological landscape. By addressing these gaps, scholars have contributed to the refinement of the TOE framework, advancing TOE's theoretical rigor and improving its practical utility in comprehending organizational decision-making processes.

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