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BIG DATA ANALYTICS ADOPTION IN THAILAND'S EEC: LEADERSHIP, TECHNOLOGICAL READINESS, AND SYSTEM ALIGNMENT

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Abstract

Big Data Analytics (BDA) has become a critical driver of competitive advantage, yet its adoption among small and medium-sized enterprises (SMEs) in emerging economies like Thailand remains largely underexplored. This current study investigates the determinants of BDA adoption within Thailand's Eastern Economic Corridor (EEC) by integrating the Technology-Organization-Environment (TOE) framework with the Technology Acceptance Model (TAM). Surveying a diverse sample of 340 SME entrepreneurs, the research employs confirmatory factor analysis (CFA) and Structural Equation Modeling (SEM) to evaluate relationships among complex constructs. The findings demonstrate that leadership capability is the most influential organizational determinant for adoption. At the same time, technological readiness, specifically data security and system compatibility, significantly enhances perceived usefulness and ease of use. Furthermore, perceived usefulness strongly predicts actual BDA application, emphasizing that tangible operational benefits heavily drive adoption intentions. The structural model confirms an excellent fit, effectively validating the integrated theoretical approach. Ultimately, this research provides vital practical implications, highlighting that policymakers and industry stakeholders must prioritize transformational leadership development, foster an innovation-oriented culture, and establish targeted training programs to accelerate sustainable digital transformation, competitive advantage, and data-driven decision-making in SMEs.

Keywords: Big Data Analytics, Technology Acceptance Model, TOE Framework, Digital Transformation, SME Competitiveness

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Introduction

Big data refers to the collection, storage, and processing of large and continuously expanding volumes of information from diverse sources. Traditional management methods are increasingly inadequate for handling such data, as they cannot cope effectively with the four Vs of big data: volume, velocity, variety, and veracity (Department of Local Administration, 2021). Conventional approaches often lead to delayed insights, incomplete information, and errors, undermining timely decision-making. These limitations underscore the critical need for specialized analytical technologies, such as Big Data Analytics (BDA), to support strategic, evidence-based decision-making in organizations.

This study integrates the Technology-Organization-Environment (TOE) framework with the Technology Acceptance Model (TAM) to examine BDA adoption among SMEs. TOE provides a lens for understanding contextual conditions, including technological complexity, organizational culture, and external pressures, while TAM explains individual-level acceptance by focusing on perceived usefulness (PU) and perceived ease of use (PEU) (Nguyen et al., 2022; Asiri et al., 2024; Aldraiweesh & Alturki, 2025). Senior executive support is particularly important, as it reduces uncertainty, fosters innovation, and enhances employees' attitudes toward technology. When employees perceive tangible benefits from BDA, their engagement, efficiency, and willingness to adopt new systems are strengthened, contributing to overall organizational performance.

The economic importance of big data is evident globally and in Thailand. However, SMEs face persistent challenges, including skill gaps, limited access to external real-time data, data integrity concerns, and potential workforce displacement (Economic Intelligence Center, 2017). Thai SMEs play a substantial role in GDP and employment. The Thailand 4.0 initiative actively promotes technology adoption to enhance SME efficiency and competitiveness (SME Thailand Club, 2019). However, resource constraints, lack of expertise, and concerns over data quality remain significant barriers, particularly in the Eastern Economic Corridor (EEC), where SMEs are dense and operate in a highly competitive and dynamic environment (Office of Small and Medium Enterprises Promotion, 2024). The EEC's focus on industrial clusters, digital infrastructure, and government support for innovation makes it an ideal context for studying the adoption of BDA technologies.

Integrating BDA can generate tangible benefits for SMEs, including data-driven decision-making, improved resource allocation, anticipation of market trends, and enhanced innovation capacity (Mahabub et al., 2025). These advantages are particularly relevant in the EEC, where firms must remain agile and responsive to technological and market changes. While prior studies have emphasized technological readiness, they often overlook the role of leadership capability and organizational factors as key drivers of BDA adoption. Leadership competence, encompassing vision, technological understanding, and the ability to coordinate resources, is critical for guiding strategy, motivating teams, and fostering an innovation-oriented culture, particularly in Thai SMEs with hierarchical or family-owned structures. Effective leadership and organizational support enhance perceived usefulness (PU) and perceived ease of use (PEU), which in turn increase the likelihood of actual BDA adoption.

To address the identified research gap, this study empirically tests how technological readiness, system alignment, and organizational factors—particularly leadership capability—jointly influence BDA adoption among SMEs in the EEC through an integrated TOE and TAM framework. Specifically, the primary objectives of this research are twofold: first, to examine the fundamental components of technological readiness, organizational leadership, and system alignment that drive BDA adoption in this region; and second, to analyze the structural relationships between these TOE factors, the TAM constructs (perceived usefulness and perceived ease of use), and actual BDA application. By exploring these contextual drivers and the mediating roles of user perceptions in driving practical application, the findings from this

study will provide vital guidance for policymakers and industry stakeholders to design targeted training, foster innovation-oriented cultures, and promote leadership development. Ultimately, linking these theoretical frameworks with empirical evidence in a strategically important region contributes to sustainable economic development, highlighting that leadership, technological infrastructure, and user perceptions are critical for accelerating digital transformation and SME competitiveness.

Literature Review

This study builds on prior works (Asiri et al., 2024; Alalawneh & Alkhatib, 2021; Song et al., 2022; Lutfi, 2022) to evaluate the core drivers of digital transformation. The model identifies five latent variables: technological factors (representing technological readiness and system alignment), organizational factors (highlighting leadership capability), perceived usefulness, perceived ease of use, and BDA adoption. The integration of the Technology-Organization-Environment (TOE) framework and the Technology Acceptance Model (TAM) provides a comprehensive theoretical foundation. TOE explains external and internal determinants, such as technology readiness and organizational leadership, while TAM focuses on individual-level perceptions that influence technology acceptance. Together, these frameworks complement each other by linking contextual readiness and system alignment (from TOE) with user perceptions (from TAM), enhancing the predictive power for BDA adoption. This integration clarifies how organizational leadership and technological conditions influence perceived usefulness and ease of use, ultimately shaping adoption behavior within SMEs in the EEC.

Relationship between Technological Readiness and Perceived Usefulness

The technological latent variable emphasizes system compatibility, IT infrastructure, and robust data security (Maroufkhani et al., 2023), which closely aligns with the TOE framework's concepts of technological readiness and system alignment. While BDA applications such as IoT and AI are highly relevant in the EEC, SMEs often face challenges, including limited digital literacy and infrastructure constraints. The Resource-Based View suggests that SMEs equipped with stronger technological readiness and well-aligned systems perceive significantly greater value in BDA, a finding supported by experiences in Malaysia and Vietnam. A robust digital culture and secure system alignment enhance trust and confidence in technology, substantially increasing perceived usefulness (Siangchokyoo et al., 2025). Consequently, the hypothesis is articulated as follows:

H1: Technological readiness and system alignment are positively related to perceived usefulness among small and medium-sized enterprises (SMEs) in the Eastern Economic Corridor (EEC).

Relationship between Technological Readiness and Perceived Ease of Use

The relationship between technological readiness, system alignment, and perceived ease of use has been well established in recent literature. Asiri et al. (2024) found that robust technological knowledge and seamless system integration significantly enhance perceived ease of use. This aligns with findings from Pimpaporn et al. (2025), who studied digital transformation in Thailand's public health sector and observed that when workers were provided with adequate IT support, secure infrastructure, and intuitive digital interfaces, their perceived ease of use and system acceptance increased markedly. Moreover, regional comparisons indicate that SMEs in similar Asian economies achieve higher ease-of-use perceptions when supported by aligned technological platforms and clear training. This can be formulated as the following hypothesis:

H2: Technological readiness and system alignment are positively related to perceived ease of use among small and medium-sized enterprises (SMEs) in the Eastern Economic Corridor (EEC).

Relationship between Organizational Leadership and Perceived Usefulness

Organizational factors, particularly transformational leadership capability and strategic management support, positively influence perceived usefulness (Al-shanableh et al., 2024; Pinyokul & Chaiprasit, 2019). The resource-based view (RBV) emphasizes that SMEs that leverage visionary leadership and managerial resources can more effectively translate complex data insights into sustainable competitive advantages. Regional studies in Malaysia and Vietnam similarly highlight that leadership-driven, innovation-oriented organizational cultures significantly enhance the perceived strategic value of BDA. Al-Shanableh et al. (2024) and Pinyokul & Chaiprasit (2019) reported a positive association between organizational readiness and perceived usefulness, highlighting the indispensable role of leadership competence in guiding decision-making and maximizing the benefits of big data. Accordingly, the hypothesis can be stated as follows:

H3: Organizational leadership is positively related to perceived usefulness among small and medium-sized enterprises (SMEs) in the Eastern Economic Corridor (EEC).

Relationship between Organizational Leadership and Perceived Ease of Use

Nasongkhla & Shieh (2023) and Pimpaporn et al. (2025) found that organizational leadership and structural support are positively associated with perceived ease of use, thereby supporting the research hypothesis. The study highlights that the integration of technology, driven by strong leadership within organizational settings, contributes to ease of use, enhances the work environment, and facilitates the seamless adoption of technology across all areas of operation. Additionally, proactive leadership promotes continuous learning and skill development across all age groups. Support from management and colleagues further helps make technology easier to navigate, reinforcing the organization's overall capacity to adopt and use new systems effectively. In line with this argument, the hypothesis is stated as follows:

H4: Organizational leadership is positively related to perceived ease of use among small and medium-sized enterprises (SMEs) in the Eastern Economic Corridor (EEC).

Relationship between Perceived Usefulness and Big Data Adoption

Perceived usefulness and ease of use, core constructs of TAM, are key determinants of adoption. Perceived usefulness enhances efficiency, productivity, and competitiveness (Putro & Takahashi, 2024; Sarioguz & Miser, 2024), while ease of use reflects effortlessness in adoption (Liu et al., 2025; Maroufkhani et al., 2023). Prior studies confirm that perceived usefulness directly drives big data adoption and supports SMEs in applying knowledge for business growth (Al-shanableh et al., 2024; Asiri et al., 2024). Aziz et al. (2023) found that firms in Vietnam and Malaysia that perceive BDA as highly useful tend to implement it more effectively, especially when internal capabilities are aligned with the technology. Thus, the hypothesis is proposed as follows:

H5: Perceived usefulness is positively related to the adoption of big data analytics among SMEs in the Eastern Economic Corridor (EEC)

Relationship between Perceived Ease of Use and Big Data Adoption

Perceived ease of use has a significant impact on big data adoption, as simplicity fosters user acceptance and enhances both individual effectiveness and organizational capabilities (Bakı et al., 2018). This contributes to profitability, cost reduction, risk management, and better decision-making. Since ease of use may vary across individuals and contexts, successful adoption requires that systems remain simple and convenient, especially in both the public and private sectors (Pimpaporn et al., 2025). Accordingly, the hypothesis is proposed as follows:

H6: Perceived ease of use is positively related to the adoption of big data analytics among small and medium-sized enterprises (SMEs) in the Eastern Economic Corridor (EEC)

Big Data Analytics Application and Conceptual Framework

The application of Big Data Analytics (BDA) reflects actual implementation, including data-driven decision-making and operational improvements (Shabbir & Gardezi, 2020). As

conceptualized in this study, technological readiness, system alignment, and organizational leadership jointly influence adoption through the TAM construct's mediating variables. SMEs with strong internal resources (RBV) and adaptive capabilities (Dynamic Capabilities View) are more successful in implementing BDA. Lessons from Malaysia and Vietnam highlight common challenges such as infrastructure limitations, skill gaps, and costs, while demonstrating that strong leadership support, robust data security, and aligned technological systems act as critical enablers. Integrating these insights provides a highly context-specific understanding of BDA adoption among Thai SMEs. Treating BDA application as the dependent variable, the relationships between these technological, organizational, and perceptual factors are illustrated in the conceptual framework shown in Figure 1.

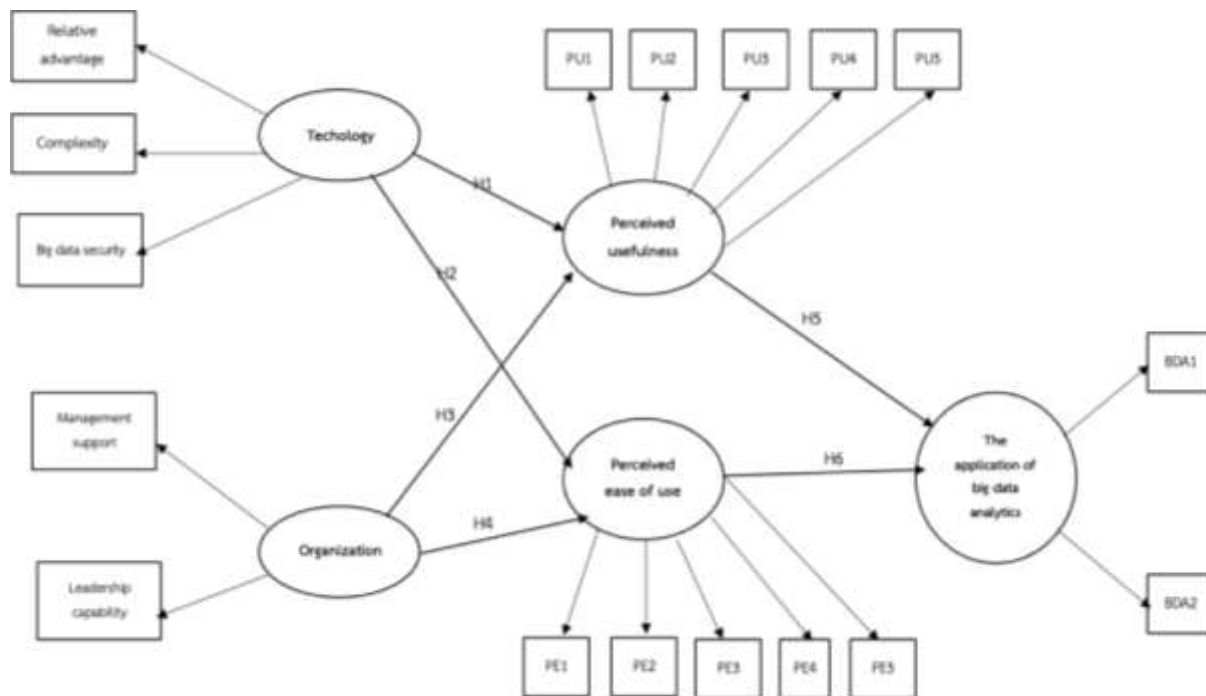


Figure 1 Conceptual Framework

Research Methodology

The target population comprises SME entrepreneurs in the Eastern Economic Corridor (EEC), including Chonburi, Rayong, and Chachoengsao provinces, with a total of 186,317 SMEs (Office of Small and Medium Enterprises Promotion, 2024). A sample of 340 respondents was determined following Hair et al.'s (1998) guideline of 5-20 times the number of observed variables, though power analysis could further ensure adequacy given the model's complexity. Data collection involved one respondent per firm, which, while efficient, introduces potential common method bias. To address this, future studies may incorporate multiple data sources or apply statistical remedies such as Harman's single-factor test or the marker variable technique. Purposive sampling was used to select respondents with sufficient knowledge to provide accurate responses, thereby enhancing data reliability. However, this non-random approach may limit the representativeness and generalizability of results to the wider SME population in the EEC.

The research instrument was a six-section questionnaire. Section 1 included open-ended questions to capture qualitative insights, suitable for thematic or content analysis. Sections 2-6 employed a five-point Likert scale to measure perceptual variables, with items adapted from prior studies (Bin-Nashwan et al., 2025; Cao et al., 2025; Al-Shanableh et al., 2024; Asiri et al., 2024) to enhance theoretical grounding and construct validity. Content validity was

assessed by five experts, yielding an Item-Objective Congruence (IOC) index of 0.874, indicating clear and comprehensive coverage. Reliability was high (Cronbach's $\alpha = 0.936$), demonstrating strong internal consistency. Convergent and discriminant validity were also examined to ensure construct soundness for structural equation modeling (SEM). The study received ethical approval No.2568/118 (17).

Data analysis employed confirmatory factor analysis (CFA) to verify the factor structure and SEM to test complex relationships among constructs. Model fit was assessed using multiple indices, including the Comparative Fit Index ($CFI \geq 0.90$), Goodness-of-Fit Index ($GFI \geq 0.90$), Root Mean Square Error of Approximation ($RMSEA \leq 0.08$), and Standardized Root Mean Square Residual ($SRMR \leq 0.08$), ensuring rigorous evaluation of model adequacy (Brown, 2015; Hancock & Mueller, 2001; Schumacker & Lomax, 2016). The dataset collected for this study is available upon reasonable request from the corresponding author, thereby providing transparency and facilitating potential replication.

Discriminant Validity

Table 1 presents the correlation matrix of the latent variables along with the coefficient of determination (R^2) for each construct. The diagonal elements represent the square roots of the Average Variance Extracted (AVE), and the off-diagonal elements show correlations between constructs. According to the Fornell-Larcker criterion (Fornell & Larcker, 1981), discriminant validity is established when the square root of the AVE of each construct is greater than its correlations with other constructs. The table shows that all constructs—Technology, Organizational Factors, Perceived Usefulness (PU), Perceived Ease of Use (PEU), and Big Data Analytics Application satisfy this criterion, confirming that they are conceptually and empirically distinct.

The R^2 values, presented in the bottom row, indicate the proportion of variance explained for each latent variable. Technology and Organizational Factors have R^2 values of 0.635 and 0.712, respectively. Perceived Usefulness (PU) has an R^2 of 0.826, Perceived Ease of Use (PEU) 0.742, and Big Data Analytics Application 0.879. These results demonstrate strong explanatory power, particularly for Big Data Analytics Application, confirming that the structural model effectively accounts for variance in the endogenous constructs. Overall, the findings support both the discriminant validity and predictive capability of the proposed model.

Table 1 Discriminant Validity

Latent Variable	Technology	Organizational Factors	Perceived Usefulness (PU)	Perceived ease of use (PEU)	Big Data Analytics Application
Technology	0.811				
Organizational Factors	0.548	0.858			
Perceived Usefulness (PU)	0.622	0.627	0.860		
Perceived ease of use (PEU)	0.593	0.611	0.703	0.881	
Big Data Analytics Application	0.584	0.655	0.678	0.645	0.873
R^2	0.635	0.712	0.826	0.742	0.879

Confirmatory Factor Analysis

As presented in Table 2, the confirmatory factor analysis (CFA) reveals the prominence of specific observed variables within each construct. Within the Technological construct, Big Data Security exhibits the highest factor loading (0.646), indicating that, for SMEs in the EEC,

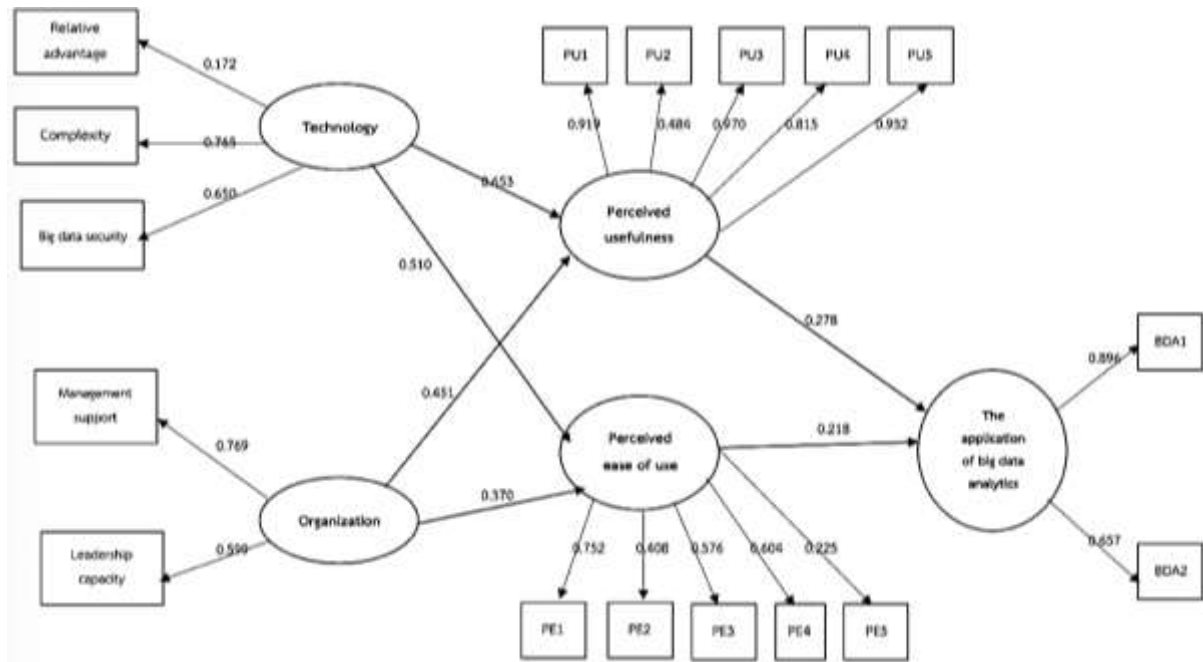
fundamental security and system alignment significantly outweigh perceived complexity (0.392) or relative advantage (0.359) during initial adoption phases. For Organizational Factors, Leadership Capability demonstrates the strongest influence (0.915), reaffirming its pivotal role in driving digital initiatives over general top management support (0.841). Regarding Perceived Usefulness (PU), efficiency improvement (PU3) has the dominant loading (0.995). In contrast, process monitoring support (PU5) has a considerably lower loading (0.232), suggesting that SMEs prioritize immediate operational gains over long-term strategic monitoring. Within the Perceived Ease of Use (PEU) construct, Ease of Understanding (PEU3, 0.863) is the primary driver, underscoring the need for intuitive technological design. Finally, the BDA Adoption construct is heavily defined by actual implementation (BDA2, 0.961). Overall, the measurement model demonstrates an excellent fit, confirming that data security, leadership quality, operational efficiency, and system comprehensibility are the core dimensions validating the integrated theoretical structure.

Table 2 Confirmatory Factor Analysis

Construct	Item	Factor Loading	CR	AVE	χ^2/df	CFI	TLI	RMSEA	SRMR
Technology	RA	0.359	0.761	0.658	1.92	0.95	0.94	0.056	0.045
	COM	0.392							
	BDS	0.646							
Organizational Factors	TMS	0.841	0.847	0.737	1.91	0.96	0.95	0.053	0.042
	LC	0.915							
Perceived Usefulness	PU1	0.838	0.915	0.740	1.94	0.97	0.96	0.052	0.043
	PU2	0.589							
	PU3	0.995							
	PU4	0.853							
	PU5	0.232							
Perceived Ease of Use	PEU1	0.546	0.744	0.776	1.96	0.95	0.94	0.054	0.044
	PEU2	0.767							
	PEU3	0.863							
	PEU4	0.567							
	PEU5	0.464							
BDA Adoption	BDA1	0.808	0.735	0.762	1.93	0.94	0.93	0.055	0.046
	BDA2	0.961							

Research Results

The structural model analysis (Figure 2) was conducted among Small and Medium Enterprises (SMEs) in the Eastern Special Development Zone (EEC). The results confirm that the relationships among latent variables align with theoretical assumptions and effectively explain patterns of Big Data adoption and application. Technological readiness (including system alignment) and organizational leadership significantly influence users' perceptions in terms of perceived usefulness (PU) and perceived ease of use (PEU). Technological readiness positively affects PU ($\beta = 0.653$, $p < 0.01$) and PEU ($\beta = 0.510$, $p < 0.01$), indicating that SMEs equipped with secure digital systems, aligned data connectivity, and advanced analytical tools perceive these technologies as beneficial, efficient, and easy to operate, thus supporting Hypotheses 1 and 2. Likewise, organizational leadership exerts positive effects on PU ($\beta = 0.451$, $p < 0.01$) and PEU ($\beta = 0.370$, $p < 0.01$), suggesting that managerial vision, resource allocation, and a learning-oriented culture foster positive attitudes and reduce technological barriers, supporting Hypotheses 3 and 4. Within the internal relationships, PU ($\beta = 0.278$, $p < 0.01$) and PEU ($\beta = 0.218$, $p = 0.010$) both positively influence Big Data application, confirming Hypotheses 5 and 6 and emphasizing that perceived benefits and usability heavily drive actual adoption intentions among SMEs.



$\chi^2/df = 1.96$, P-value = 0.001, GFI = 0.992, RMSEA = 0.032

Figure 2 Finalized Framework

The structural model exhibits a satisfactory fit, as shown in Table 3, and all latent variables are significantly related to their indicators. For technological factors, complexity ($\beta = 0.765$, $p < 0.01$) and data security ($\beta = 0.650$, $p = 0.002$) are the strongest determinants, highlighting their importance in adoption decisions. Organizational factors are mainly driven by top management support ($\beta = 0.769$, $p < 0.01$) and leadership competence ($\beta = 0.599$, $p < 0.01$). PU indicators show high loadings for business efficiency ($\beta = 0.970$) and process monitoring ($\beta = 0.932$), while PEU emphasizes ease of analysis ($\beta = 0.752$) and flexibility ($\beta = 0.604$). Big Data application is reflected in guidance ($\beta = 0.896$) and actual use ($\beta = 0.657$), indicating both awareness and implementation.

Model fit indices confirm excellent goodness-of-fit ($\chi^2/df = 1.96$; GFI = 0.992; AGFI = 0.983; NFI = 0.983; NNFI = 0.983; CFI = 0.957; IFI = 0.960; RFI = 0.972; RMSEA = 0.032; RMR = 0.032; SRMR = 0.032), meeting recommended thresholds (Bentler, 1990; Hair et al., 2019; Steiger, 1990). Overall, the model effectively explains the structural relationships and provides a reliable framework for analyzing Big Data adoption and application among SMEs in the Eastern Special Development Zone.

Table 3 Model Fit Indices

Fit Index	Value	Recommended Threshold	Reference
χ^2/df	1.96	<3.0	Bentler, 1990
GFI	0.992	>0.90	Hair et al., 2019
AGFI	0.983	>0.90	Hair et al., 2019
NFI	0.983	>0.90	Steiger, 1990
NNFI	0.983	>0.90	Steiger, 1990
CFI	0.957	>0.90	Hair et al., 2019
IFI	0.960	>0.90	Hair et al., 2019
RFI	0.972	>0.90	Hair et al., 2019
RMSEA	0.032	<0.08	Steiger, 1990
RMR	0.032	<0.08	Bentler, 1990
SRMR	0.032	<0.08	Bentler, 1990

Conclusion and Discussion

Discussion of Findings

The findings reveal that data security within the technological dimension plays a crucial role in the adoption of Big Data Analytics (BDA) among Small and Medium Enterprises (SMEs), with a high factor loading ($\beta = 0.646$). This finding aligns with Asiri et al. (2024), who emphasized that safeguarding digital assets and ensuring data integrity are essential for maintaining organizational trust. In Thailand, effective data security management requires both advanced technological infrastructure and continuous personnel development. In the organizational dimension, leadership competency showed the strongest influence ($\beta = 0.915$), supporting the work of Müller et al. (2024), who found that leaders with systems thinking, vision, and technological understanding play a key role in BDA adoption. This supports the Resource-Based View (RBV), which posits that leadership competence represents an internal strategic resource that enhances sustainable competitiveness.

Regarding perceived usefulness (PU), the variable “enhancing efficiency” exhibited the highest factor loading ($\beta = 0.995$), consistent with Kgakatsi et al. (2024), who argued that Big Data technologies can significantly improve productivity, responsiveness, and innovation. In the Perceived ease of use (PEU) dimension, “ease of understanding” had the highest loading ($\beta = 0.863$), confirming Kling et al.'s (2025) view that accessible, user-friendly systems reduce complexity and resistance to technology. Furthermore, in the BDA application dimension, the variable representing actual implementation ($\beta = 0.961$) was particularly strong, aligning with Chen (2024), who found that employee readiness and digital capability are critical for improving performance and collaboration.

All six hypothesized relationships were supported, demonstrating that technological readiness (including system alignment) and organizational leadership significantly influence both PU and PEU, which in turn drive BDA application. Specifically, technological readiness ($\beta = 0.653$, $p < 0.01$) had a stronger effect on PU than on PEU ($\beta = 0.510$, $p < 0.01$), suggesting that SMEs perceive the availability of secure digital infrastructure and aligned analytical tools as more critical for realizing tangible benefits than for merely simplifying system use. Similarly, organizational leadership had a larger effect on PU ($\beta = 0.451$, $p < 0.01$) than on PEU ($\beta = 0.370$, $p < 0.01$). Regarding the direct effects on BDA application, PU ($\beta = 0.278$, $p < 0.01$) exerted a stronger influence than PEU ($\beta = 0.218$, $p = 0.010$), which is consistent with TAM predictions that perceived utility is the primary determinant of behavioral intention and actual usage.

Conclusion and Practical Recommendations

Overall, the comparative strengths of these path coefficients confirm that leadership capability, technological readiness, and system alignment are the foundational pillars of BDA adoption. While both technological design and organizational support are crucial, the perception of tangible operational benefits drives actual implementation more strongly than usability alone. This underscores the critical need for SMEs in Thailand and across Asia to cultivate transformational leadership and to ensure their digital infrastructure is secure and well-aligned with business objectives.

To achieve this, government agencies and policymakers should prioritize capacity-building and leadership training to enhance data-driven decision-making among SME executives, especially in the Eastern Economic Corridor (EEC). Establishing Big Data training programs through public-private collaboration can strengthen digital literacy and cybersecurity awareness. Policies should also promote data governance frameworks to ensure compliance with the Personal Data Protection Act (PDPA). Additionally, providing financial incentives for technological upgrading and establishing a regional Big Data Innovation Center as a knowledge hub will encourage SMEs to invest in digital transformation.

Limitations and Future Research

Despite the valuable insights generated by this study, several limitations should be acknowledged to guide future investigations. First, the cross-sectional design limits the ability to draw definitive causal inferences about the relationships among technological readiness, leadership, and BDA adoption over time. Future research should consider longitudinal data to capture the dynamic evolution of BDA adoption and organizational learning as SMEs mature digitally. Second, the study focused primarily on SMEs within Thailand's EEC, a highly industrialized region with strong policy support. Consequently, the results may not fully represent SMEs operating in less-developed areas. Future cross-country research across ASEAN could reveal crucial differences in digital maturity and cultural factors.

Finally, while the integrated TOE-TAM model provides robust explanatory power, it did not incorporate other potential influencing variables. Future studies should address this limitation by extending the model to include mediating or moderating factors such as data governance maturity, innovation orientation, firm size, or specific industry types. Furthermore, integrating sustainability and environmental, social, and governance (ESG) frameworks would clarify how BDA adoption supports green growth and long-term competitiveness across diverse SME contexts.

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