

Prevalence and predictors of influencing digital transformation among small and medium-sized enterprises in the central highlands of Vietnam



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Abstract Digital transformation (DT) has become a critical factor in the growth and competitiveness of small and medium-sized enterprises (SMEs), yet its adoption remains uneven across different regions. This study examines the prevalence and predictors of DT among SMEs in the Central Highlands of Vietnam. A cross-sectional survey was conducted among 380 randomly selected SMEs across five provinces, utilizing structured questionnaires to assess technological, organizational, and environmental influences. The results from analyses identified key predictors of digital transformation. While eight factors were initially associated with digital adoption, the multivariable analysis revealed that technology (OR = 2.476, $p = 0.003$), organization (OR = 3.514, $p < 0.001$), and environment (OR = 4.461, $p < 0.001$) were significant predictors. Additionally, SMEs with only one sales channel (OR = 1.947, $p = 0.019$) and those employing a single marketing strategy (OR = 2.197, $p = 0.006$) were significantly associated with DT. These findings underscore the importance of fostering a supportive digital ecosystem for SMEs through targeted policies, financial incentives, and infrastructure development. Policymakers and leaders should focus on reducing barriers, enhancing technological capabilities, and improving organizational readiness to drive DT.

Keywords: digital transformation, small and medium enterprises, prevalence, predictor, central highlands

1. Introduction

Digital transformation (DT) has become a crucial factor in the growth and sustainability of businesses in each region and worldwide (Kraft et al., 2022). Small and medium-sized enterprises (SMEs) formed the backbone of many economies are increasingly adopting digital technologies to enhance efficiency, competitiveness, and innovation (Bilal et al., 2024). In Vietnam, SMEs have a major role in economic development and contribute to employment and GDP (Bui et al., 2021; Hanh, 2020; Huong & others, 2024). However, their ability to embrace DT varies due to different internal and external factors (Ha et al., 2024).

Existing literature highlights several challenges that hinder DT adoption among SMEs in developing economies. These include limited financial resources, shortages of skilled personnel, technological constraints, and regulatory barriers (Nguyen et al., 2023; Truc et al., 2024a; Truc et al., 2024b). Without targeted interventions, these obstacles can restrict SMEs from leveraging digital technologies effectively, thereby impeding long-term growth and competitiveness.

Globally, research has examined DT adoption in SMEs, underscoring its transformative role in business resilience and innovation (Bilal et al., 2024; Gyamerah et al., 2025; Kipkirui, 2024; Kraft et al., 2022; Pelletier et al., 2025; Tajudeen et al., 2025; Valdez-Juárez et al., 2024). In Vietnam, some studies have explored SMEs' digital readiness and challenges (Bui et al., 2021; Do Thi et al., 2024; Ha et al., 2024; Huong & others, 2024; Van et al., 2023). However, these studies largely focus on broader national or sectoral contexts, with limited attention to region-specific dynamics. The Central Highlands of Vietnam, comprising Dak Lak, Dak Nong, Gia Lai, Kon Tum, and Lam Dong, remains underexplored despite its economic significance and distinct challenges.

Addressing this gap, the present study investigates the prevalence of DT among SMEs in the Central Highlands and identifies key predictors influencing its adoption. By analyzing technological, organizational, and environmental factors, the research provides evidence-based insights for policymakers and business leaders. The findings aim to guide strategies that promote sustainable digital adoption and strengthen SMEs' contribution to regional and national economic development.

2. Materials and Methods

2.1. Study design, study areas and participants

In our research, the survey was a cross-sectional study based on community conducted in five provinces in the Central Highlands of Vietnam. The study focused on SMEs that were registered and actively operating in the region.

2.2. Study measures

Following the guidelines provided by well-trained research assistants, participants completed a structured questionnaire consisting of two sections. The first section gathered enterprise information, including the type of enterprise and business sector. The second section contained 30 items assessing satisfaction. Responses are rated on a 5-point Likert scale, from 1 ("strongly disagree") to 5 ("strongly agree").

The 30 items were classified into eight factors: government support (GS), industry development (ID), customer demand (CD), leadership characteristics (LC), enterprise capability (EnC), employee characteristics (EmpC), business model innovation (BMI), and DT. These were further grouped into three main dimensions: 1) Technology with EnC and BMI; 2) Organization with LC and EmpC; and 3) Environment with GS, ID, and CD. To ensure reliability and validity, the questionnaire was reviewed by a panel of experts in DT and SME management. A pilot test was conducted with 30 SMEs outside the study area, and minor wording adjustments were made for clarity. Internal consistency of the final instrument was assessed using Cronbach's alpha, which demonstrated good reliability across all dimensions: Technology (0.830), Organization (0.868), Environment (0.825), and Digital Transformation (0.821).

2.3. Data Collection

Data collection was conducted between January 2023 and May 2023 by well-trained research assistants who followed standardized guidelines. A total of 480 questionnaires were distributed using random sampling methods, and 380 completed questionnaires were returned and deemed valid for analysis (response rate: 79.2%). Surveys were administered in hard copy, and informed consent was obtained from all participants prior to data collection.

2.4. Data analysis

Technology refers to internal technological capacity and innovation, while the organization reflects leadership and workforce readiness, and the environment encompasses external support and pressures. Understanding these three dimensions is crucial for evaluating the factors that influence digital transformation among SMEs in the Central Highlands of Vietnam.

Our analysis was conducted with meticulous attention to detail to ensure accuracy and reliability. To quantify the impact of these factors, we calculated a standardized score for each factor within the three groups. This score was obtained by summing all relevant items within a given factor and converting the total into a percentage. The scores were then classified as "Yes" if they were $\geq 50\%$ (indicating agreement on the importance of the factor) and "No" if they were $< 50\%$. This classification allowed for a clear assessment of the level of agreement among participants regarding the importance of each factor.

To examine relationships between the factors, we employed Chi-squared tests and Pearson's correlation tests. These statistical techniques helped determine the strength and significance of associations between the Technology, Organization, and Environment groups, providing insights into how different aspects of digital transformation interact with one another.

Furthermore, our study utilized a logistic regression model to identify the key factors associated with overall DT among SMEs. The explanatory variables analyzed included technology-related factors (enterprise capability and business model innovation), environmental factors (government support, industry development, and customer demand), and organizational factors (leadership characteristics and employee characteristics). A two-step process was followed to refine the model. First, univariable models were applied to all explanatory variables, and those with a p -value < 0.20 were selected for further analysis. Next, the final multivariable model included only those variables with a p -value < 0.05 , identifying the most significant factors influencing DT among SMEs. In addition, interactions between all pairs of explanatory variables were examined to detect potential confounding effects, ensuring the robustness of the findings (Truc et al., 2024). All statistical analyses were conducted using R statistical software. The "stats" package was used to develop logistic regression models, while the "ggplot2" package was employed for data visualization (R Core Team, 2022).

3. Results

3.1. Participants' characteristics

There were 380 participants in this study. Most respondents were from limited liability companies (81.58%), followed by joint-stock companies (13.16%), and other types of enterprises (5.26%). The majority of enterprises had 10–50 employees (76.05%), while smaller proportions had fewer than 10 employees (15.00%) or more than 50 employees (8.95%). Regarding the business sector in terms of digital technology adoption, 46.05% of enterprises operated in moderately adoptive sectors such as construction and service, while 40.26% were in high-adoption sectors like transportation and multiple industries. Only 13.68% of enterprises belonged to low-adoption sectors, such as agriculture and industry. In terms of awareness of digital

technology adoption, over half of the participants (55.53%) identified their enterprises as emerging adopters, while 28.16% were classified as potential adopters. A smaller group (15.00%) actively adopted digital technology, and only 1.32% were unaware of digital adoption. Most enterprises (89.74%) had one internal management system, while 6.31% had more than one, and 3.95% had none. Electronic payment was the dominant procurement method, used by 83.95% of enterprises, whereas 16.05% employed Electronic Data Interchange (EDI). Similarly, 76.05% of enterprises used at least one logistics method, while 23.95% reported using none. In manufacturing, 58.16% of enterprises utilized Enterprise Resource Planning (ERP) systems, while 15.26% employed IoT devices, and 3.42% used Manufacturing Execution Systems (MES). However, 23.16% did not implement any manufacturing technology. Regarding marketing strategies, 60.00% of enterprises relied on one strategy, while 25.00% employed multiple strategies, and 15.00% had none. Similarly, 69.21% of enterprises used one sales channel, while 23.42% had multiple channels, and 7.37% had none. Participants' expectations for DT varied, with most reporting moderate expectations (65.26%), followed by low expectations (27.89%) and high expectations (6.85%). Moreover, barriers were also one of the factors impacting the DT of enterprises, with respective low, moderate, and high levels of barriers 21.05%, 47.37%, and 31.58% (Table 1).

Table 1 Study participants with characteristics.

Characteristics of Participants (n=380)	Frequency (n)	Percentage (%)
Types of enterprises		
Joint-stock company	50	13.16
Limited liability company	310	81.58
Others	20	5.26
Business sector in terms of adoptive levels of digital technology		
Low (Agriculture; Industry)	52	13.68
Moderate (Construction, Service)	175	46.05
High (Transportation, Multiple sectors)	153	40.26
No. Employees		
<10	57	15.00
10-50	289	76.05
>50	34	8.95
Awareness of digital technology in terms of adoption		
Active	57	15.00
Emerging	211	55.53
Potential	107	28.16
None	5	1.32
No. components of system for internal management		
0	15	3.95
1	341	89.74
>1	24	6.31
Procurement method		
Electronic Data Interchange (EDI)	61	16.05
Electronic Payment	319	83.95
No. methods for logistics		
0	91	23.95
>=1	289	76.05
Manufacturing		
Enterprise Resource Planning (ERP) system	221	58.16
IoT devices	58	15.26
Manufacturing Execution System (MES)	13	3.42
None	88	23.16
No. strategies for marketing		
0	57	15.00
1	228	60.00
>1	95	25.00
No. sales channels		
0	28	7.37
1	263	69.21
>1	89	23.42
Levels of expectations		
Low	106	27.89
Moderate	248	65.26
High	26	6.85
Levels of barriers		
Low	80	21.05
Moderate	180	47.37
High	120	31.58

3.2. The characteristics of factors for influencing digital transformation among participants

A total of 380 participants evaluated seven factors influencing DT: GS, ID, CD, LC, EnC, EmpC, and BMI. To analyze their impact on SMEs in the Central Highlands of Vietnam, these factors were grouped into three categories: technology, organization, and environment. The technology category included EnC and BMI, while the organization category encompassed LC and EmpC. The environment category comprised GS, ID, and CD.

Most participants agreed that these three categories significantly influenced DT, as reflected in their median values and interquartile ranges (IQR). The responses demonstrated a high level of agreement among participants regarding the impact of DT on enterprises. More than two-thirds of respondents acknowledged the importance of these factors, reinforcing their relevance in shaping the DT process. In terms of specific results, technology was recognized by 75.3% of participants (SE ±0.61), with a median standardized score of 58.0 [IQR: 50.0–63.0]. The organization was acknowledged by 75.3% of respondents (SE ±0.59), with a median standardized score of 58.0 [IQR: 50.0–65.0]. Similarly, environment category had the highest agreement, with 80.8% of participants (SE ±0.54) supporting its influence, and a median standardized score of 58.0 [IQR: 52.0–66.0]. These findings highlight the crucial role of environmental, technological, and organizational factors in driving DT among small and medium-sized enterprises in the region (Figure 1). Furthermore, our research identified significant correlations among the three factors related to DT measurement in the Central Highlands of Vietnam (Pearson’s coefficient $R \geq 0.29$, $p < 0.001$ all) (see Figure 2).

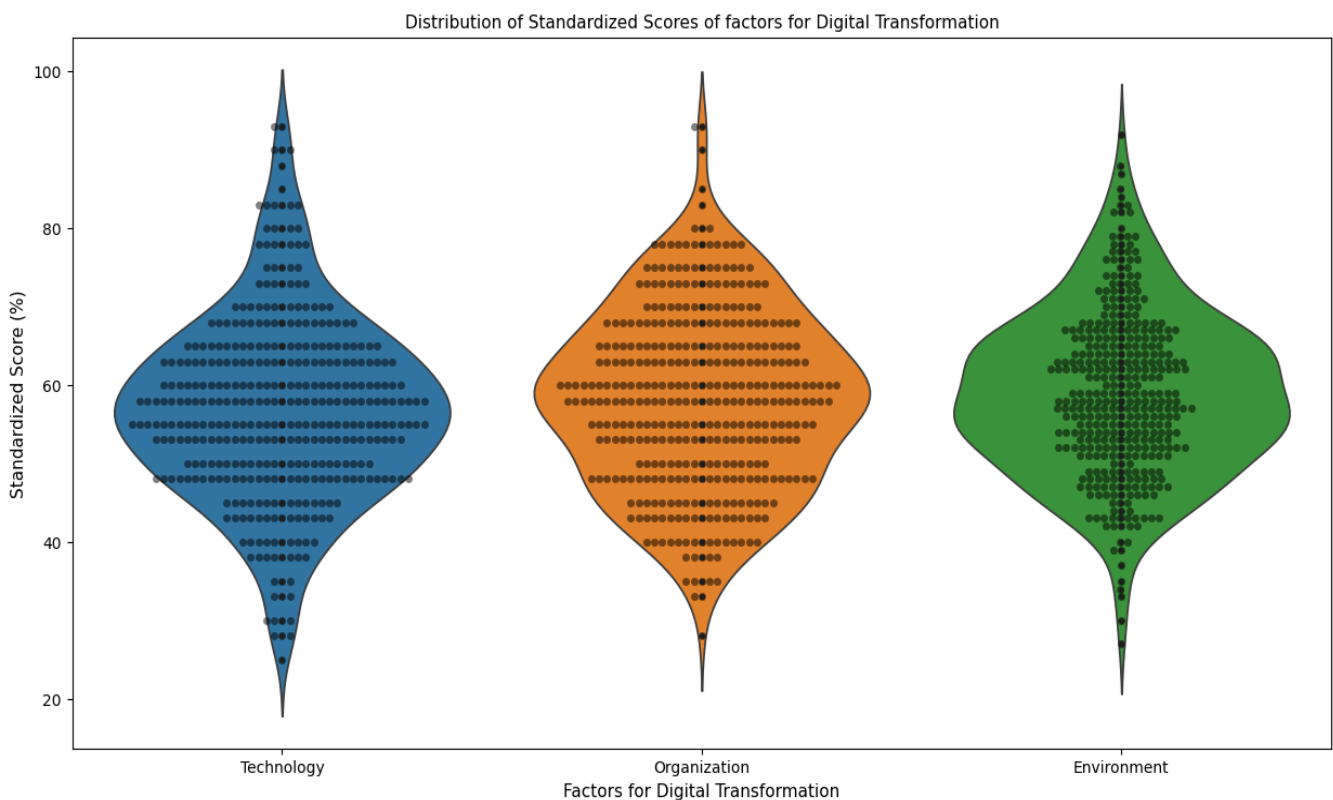


Figure 1 Standardized scores for each factor for influence measurement listed by participants.

3.3. Association of factors for quality measurement among participants

In our research, we analyzed the association between DT and the three key factors: technology, environment, and organization among SMEs. The results from the chi-square (χ^2) tests indicate a significant relationship between these factors and the adoption of DT, with all three factors showing highly significant results ($p < 0.001$). For technology, SMEs with technological readiness were more likely to adopt DT, with 243 enterprises embracing DT compared to only 59 enterprises without technological readiness. The chi-square test result ($\chi^2 = 20.03$, $p < 0.001$) confirms that the “technology” factor plays a significant role in facilitating DT adoption. Similarly, the “environment” factor showed a strong influence; 265 enterprises adopted DT, while only 37 enterprises without such conditions did so. The chi-square test ($\chi^2 = 43.75$, $p < 0.001$) highlights the “environment” factor had a significant impact on SMEs’ DT. Finally, the “organization” factor also demonstrated a strong association. SMEs with organizational readiness had 248 enterprises adopting DT, compared to only 54 enterprises that lacked these attributes. The chi-square test ($\chi^2 = 35.37$, $p < 0.001$) suggests that internal organizational factors, such as leadership and workforce adaptability, are critical for DT success (Table 2).



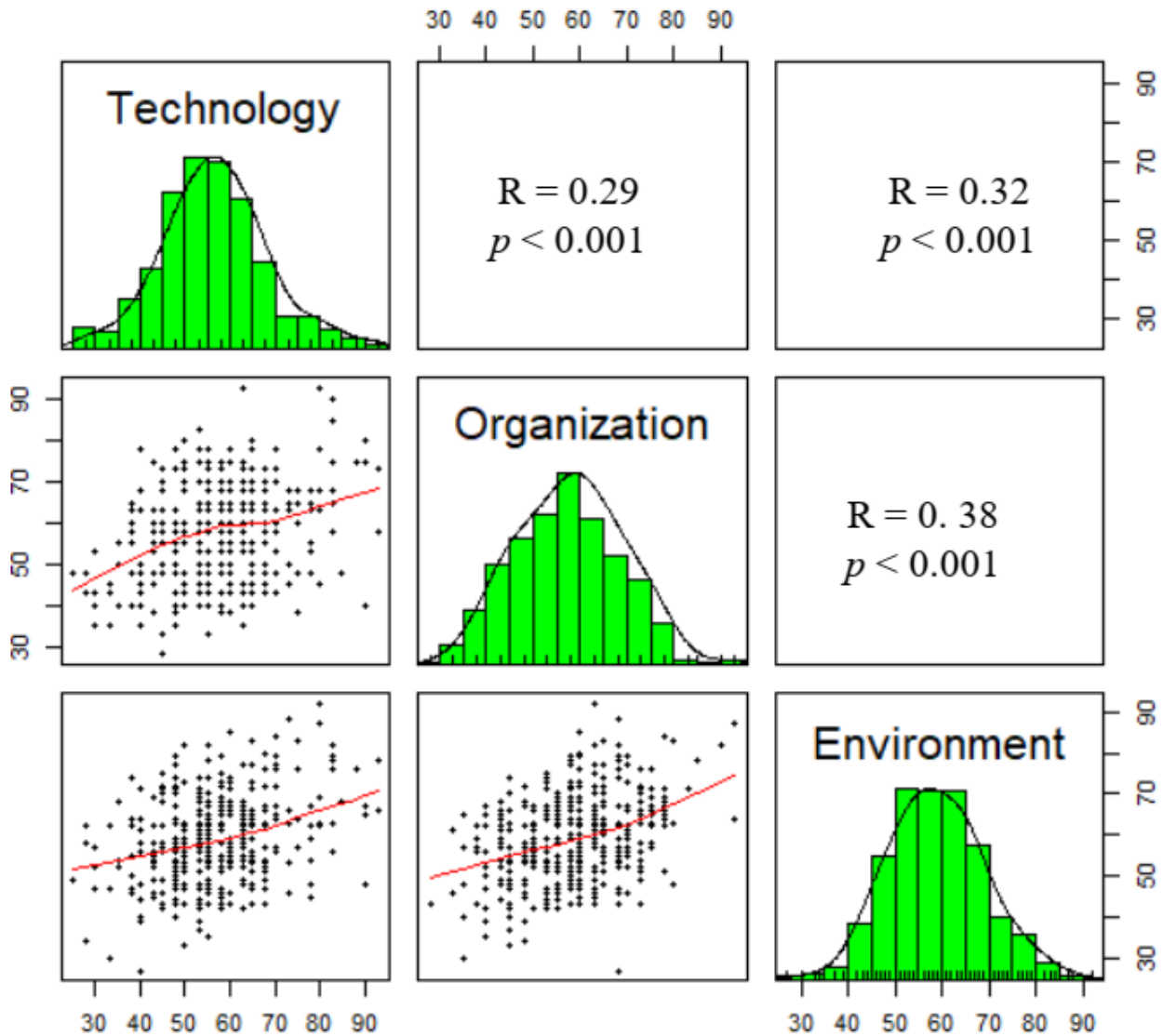


Figure 2 The correlation among four factors for quality measurement of participants.

Table 2 The association between factors for influencing DT among enterprises (n = 380).

	Digital Transformation (n=302)			χ^2
	Yes	No		
Technology (n=286)	Yes	243	43	20.03***
	No	59	37	
Organization (n=286)	Yes	248	38	35.37***
	No	54	40	
Environment (n=307)	Yes	265	42	43.75***
	No	37	36	

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

3.4. Predictors for quality of ethnic minority human resources

The results from both univariable and multivariable logistic regression analyses provide insights into the factors influencing the DT of SMEs. In the univariable models, eight variables were identified as influencing DT: number of employees, manufacturing, number of marketing strategies, number of sales channels, levels of barriers, technology, organization, and environment. Among these, several factors had a notable impact. SMEs with only one sales channel (OR = 1.947, 95% CI: 1.11–3.38, $p = 0.019$) and those employing a single marketing strategy (OR = 2.197, 95% CI: 1.25–3.84, $p = 0.006$) were significantly associated with DT. These variables were selected in the multivariable model. However, findings from the multivariable analysis revealed that only technology (OR = 2.476, $p = 0.003$), organization (OR=3.514, $p < 0.001$), and environment (OR = 4.461, $p < 0.001$) remained significantly associated with the DT of SMEs. The detailed factor analysis for quality measurement is presented in Table 3.



Table 3 Predictors of factors influencing digital technology among enterprises.

Factors	Univariable models			Multivariable model*		
	OR	95% CI	p-value	OR	95% CI	p-value
Types of enterprises (Baseline = "Limited liability company")						
Joint-stock company	1.21	0.58 ; 2.77	0.630			
Others	1.06	0.37 ; 3.80	0.918			
Business sector in terms of adoptive levels of digital technology (Baseline: Moderate)						
Low (Agriculture; Industry)	1.326	0.63 ; 3.07	0.482			
High (Transportation, Multiple sectors)	1.136	0.65 ; 2.05	0.663			
No. Employees (Baseline: <10)						
10-50	0.513	0.20 ; 1.12	0.119	0.606	0.11 ; 2.73	0.530
>50	0.389	0.13 ; 1.16	0.092	0.447	0.07 ; 2.47	0.365
Awareness of digital technology in terms of adoption (Baseline: None)						
Active	2.256	0.28 ; 15.07	0.400			
Emerging	2.940	0.38 ; 18.32	0.246			
Potential	2.305	0.29 ; 14.69	0.375			
No. components of system for internal management (Baseline: >1)						
0	1.053	0.22 ; 5.89	0.950			
1	1.019	0.33 ; 2.64	0.971			
Procurement method (Baseline: Electronic Payment)						
Electronic Data Interchange (EDI)	0.939	0.45 ; 1.81	0.857			
No. methods for logistics (Baseline = 0)						
>=1	0.941	0.51 ; 1.67	0.840			
Manufacturing (Baseline: Enterprise Resource Planning (ERP) system)						
IoT devices	1.314	0.65 ; 2.83	0.460	1.31	0.52 ; 3.46	0.573
Manufacturing Execution System (MES)	3.692	0.70 ; 68.06	0.214	2.740	0.39 ; 58.43	0.392
None	1.626	0.87 ; 3.22	0.143	2.056	0.36 ; 15.35	0.445
No. strategies for marketing (Baseline: >1)						
0	1.837	0.85 ; 4.18	0.131	0.33	0.03 ; 2.60	0.312
1	2.197	1.25 ; 3.84	0.006	1.249	0.38 ; 4.06	0.713
No. sales channels (Baseline: >1)						
0	1.513	0.58 ; 4.49	0.422	2.580	0.30 ; 27.56	0.412
1	1.947	1.11 ; 3.38	0.019	1.222	0.40 ; 3.67	0.721
Levels of expectations (Baseline: Moderate)						
Low	1.229	0.68 ; 2.26	0.498			
High	1.232	0.66 ; 2.40	0.525			
Levels of barriers (Baseline: High)						
Low	2.038	1.02 ; 4.29	0.051	1.090	0.19 ; 5.47	0.919
Moderate	1.900	1.09 ; 3.32	0.023	1.070	0.41 ; 2.67	0.887
Technology (Baseline: No)						
Yes	3.352	1.97 ; 5.70	<0.001	2.476	1.35 ; 4.51	0.003
Organization (Baseline: No)						
Yes	4.834	2.84 ; 8.27	<0.001	3.514	1.94 ; 6.37	<0.001
Environment (Baseline: No)						
Yes	6.139	3.51 ; 10.83	<0.001	4.461	2.39 ; 8.38	<0.001

*Intercept = -1.15951; SE = 0.8925.

4. Discussion

Our research delved deeply into the influence of DT among SMEs in the Central Highlands of Vietnam. Our findings highlighted that 80.8% (SE ±0.54) of participants acknowledged the importance of environmental factors, followed by 75.3% (SE ±0.61) for technological factors and 75.3% (SE ±0.59) for organizational factors. These results suggest that external pressures, internal technological capacity, and leadership readiness significantly contribute to DT. Moreover, the majority of SMEs (81.58%) were limited liability companies, with 76.05% employing between 10 and 50 employees, demonstrating that medium-sized enterprises dominate the digital adoption landscape. Our research found a significant occurrence of all factors in the three categories. The environment category had the highest level of agreement, with a median standardized score of 58.0 [IQR: 52.0–66.0]. This median standardized score was also the score for the technology and organization categories, which were 58.0 [IQR: 50.0–63.0] and 58.0 [IQR: 50.0–65.0], respectively. The high prevalence of these factors (environment, organization, and technology) further underscores enabling digital adoption regarding the importance of leadership readiness, employee engagement, and enterprise capability.

These findings are consistent with studies from advanced economies, where organizational readiness and technological capability have been emphasized as critical for successful DT (Dörr et al., 2023; Kraft et al., 2022). However, unlike many

Western contexts in which internal innovation and firm-level strategies are the primary drivers, our results highlight the stronger influence of environmental factors such as government support, industry development, and customer demand. This pattern is more aligned with evidence from developing economies, including studies in the Middle East and Africa, where external institutional and market pressures play a more decisive role in driving DT (Al-Hajri et al., 2024; Bilal et al., 2024). Thus, our findings situate the Central Highlands within a global spectrum: while SMEs share common drivers with international peers, they also display context-specific reliance on external supports that reflect the socio-economic and regulatory environment of Vietnam (Haq & Abid, 2024; Kursa & Rudnicki, 2010; Manikandan et al., 2024; Shahriar, 2025; Shaikh, 2025; Shang et al., 2024; Zaid et al., 2025).

Our research identified significant predictors of DT among SMEs based on univariable and multivariable logistic regression analyses. The result with univariable logistic regression showed that the number of employees, manufacturing sector, number of marketing strategies, number of sales channels, levels of barriers, technology, organization, and environment influenced DT among SMEs. Moreover, the multivariable logistic regression's result also confirmed that technology, organization, and environment significantly influenced DT among SMEs ($p \leq 0.003$ all). Similar findings have been reported in Asia and Latin America, where firm size and organizational factors often interact with external market demands to shape DT readiness (Li, Wang, et al., 2024; Valdez-Juárez et al., 2024). However, the relatively high explanatory power of environmental factors in our study marks a divergence from North American and European contexts, where SMEs typically rely more on internal innovation capacity and digital infrastructure (Bianchini et al., 2023; Skare et al., 2023; Valdez-Juárez et al., 2023; Zaid et al., 2025). Therefore, policymakers and leaders should be concerned and prioritize reducing barriers, encouraging enterprises to adopt DT, and facilitating a smooth transition into DT. These results aligned with other research emphasizing that factors were high prevalence (Al-Hajri et al., 2024; Bilal et al., 2024; Dörr et al., 2023; Hanh, 2020; Li, Aman, et al., 2024; Mushi, 2024; Nguyen et al., 2022; Phiet, 2024; Shang et al., 2024; Valdez-Juárez et al., 2024).

Despite the positive findings, this study has some limitations. The research focuses on SMEs in the Central Highlands of Vietnam, and the results may not be fully generalizable to other regions. In addition, the research relies on self-reported data, which may introduce bias in assessing DT levels.

5. Conclusions

This study examined the prevalence and predictors of DT among SMEs in the Central Highlands of Vietnam. The findings highlighted that DT was influenced by technological, organizational, and environmental factors, all of which showed strong statistical correlations ($p < 0.001$) and were significant statistical predictors in the model ($p \leq 0.003$ for all). Additionally, five factors (number of employees, manufacturing, number of marketing strategies, number of sales channels, and levels of barriers) were also determined predictors influencing the DT. The results emphasized the need for targeted strategies to promote DT among SMEs. Policymakers should focus on strengthening regulatory frameworks, offering financial incentives, and fostering a supportive ecosystem for digital adoption. Future research could include the geographical scope, with longitudinal studies, and explore qualitative insights to deeply understand the barriers and potentially relevant factors of geography influencing DT among SMEs.

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Ethical considerations

Consent was duly acquired from all participants during the data collection process.

Conflict of Interest

The authors declare no conflicts of interest.

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