

E-Commerce Adoption and Performance in Northern Vietnam's Tea Firms

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Abstract

This study investigates the determinants of e-commerce adoption and its impact on business performance among tea enterprises in Northern Vietnam, employing the Technology–Organization–Environment (TOE) framework. A structured questionnaire yielded 309 responses from 112 tea enterprises, and the data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The findings show that all three TOE dimensions—technological, organizational, and environmental—significantly shape the level of e-commerce adoption. Within this set of drivers, competitive pressure emerges as the most influential factor, whereas managerial support exerts the weakest effect. Furthermore, higher levels of e-commerce adoption are associated with enhanced business performance, particularly through market expansion, improved operational efficiency, and revenue growth. These results indicate that, even in a traditional industry context, digital adoption can generate measurable performance benefits once firms respond to external pressures and align internal resources accordingly. By providing enterprise-level evidence from agribusiness small and medium-sized enterprises (SMEs), this study extends the literature on e-commerce in developing-country settings and clarifies the relative salience of environmental, technological, and organizational drivers of adoption. It also offers practical insights for business leaders and policymakers seeking to foster innovation and competitiveness in the tea industry, emphasizing the importance of supportive ecosystems and firm-level readiness to maximize returns from e-commerce investments.

Keywords: Business Performance, E-Commerce Adoption, Tea Enterprises, TOE Framework, Vietnam.

Introduction

The Internet and e-commerce now underpin contemporary business practice, generating demonstrable economic, operational, strategic and developmental advantages. Economically, online commerce reduces transaction and coordination costs, widens market reach and bolsters profitability (1). Operationally, it streamlines supply-chain coordination, enhances information flow and strengthens customer relationship management (2). Strategically, digital channels heighten organizational agility, enable data-driven decision-making and create value across the supply chain (2-6). In the realm of sustainable development, e-commerce lowers trade barriers, stimulates employment and empowers small and medium-sized enterprises (SMEs) to internationalize (7). Acting as a catalyst for digital transformation, it obliges firms to innovate, re-engineer legacy processes and reconfigure business models to remain competitive (2-6). Collectively, these multifaceted roles position e-

commerce not merely as an operational tool but as a strategic engine of organizational performance and sustainable growth, a perspective formalized in integrative frameworks such as the Technology–Organization–Environment (TOE) paradigm. Over the past two decades, e-commerce adoption has accelerated worldwide; Vietnam has kept pace through concerted efforts by enterprises, public agencies and supporting institutions (8, 9). Although benefits—cost optimization and market expansion—are acknowledged, adoption levels remain heterogeneous across firm sizes and sectors, signaling an ongoing need for empirical enquiry. Against the backdrop of the Fourth Industrial Revolution, understanding how e-commerce enhances organizational efficiency and competitiveness is increasingly salient for both scholars and policymakers. Digital technologies are reshaping customer engagement and operational models in food and beverage value chains. Within this sector, Vietnam's tea industry-

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one of the country's principal agricultural exports—is exhibiting a clear, though uneven, shift towards online channels (10, 11). Recent research confirms that e-commerce adoption drives sales growth and competitiveness in beverage firms (8, 12). Yet, the specific mechanisms through which these gains materialize in tea enterprises have not been fully explored. Globally, the tea industries of Sri Lanka, India, and Kenya have long been recognized for their export orientation and early adoption of digital practices such as electronic tea auctions. For example, in Sri Lanka the shift to an online tea auction system was piloted and implemented during the COVID-19 lockdowns (13). In Kenya, studies of the Mombasa Tea Auction highlight ongoing efforts to digitize trading processes and introduce e-auction mechanisms to improve transparency and efficiency (14). In India, the introduction of electronic marketplace platforms in tea auctions was found to reduce price dispersion and improve market efficiency during 2000–2017 (15). By comparison, Vietnam is also among the world's top five tea exporters, yet academic work specifically examining how e-commerce shapes business outcomes in its tea sector remains scarce. This contextual contrast further motivates an in-depth investigation of e-commerce adoption among Vietnamese tea enterprises. Despite the growing literature on e-commerce adoption, most prior studies have focused on SMEs in trade, services, or manufacturing, with limited attention to agricultural enterprises (16, 17). Existing work often measures adoption in binary terms or concentrates on urban firms, overlooking the degree of adoption and its business implications in rural, resource-constrained settings (18). Moreover, few studies simultaneously analyze both the determinants of adoption and its performance outcomes in agriculture (19). This gap is particularly evident in Vietnam's tea industry—a traditional yet export-oriented sector—where evidence on digital transformation remains sparse (20). The novelty of this study lies in applying the TOE framework to identify technological, organizational, and environmental determinants of e-commerce adoption and to examine the role of adoption in enhancing firm performance. Focusing on tea enterprises provides new empirical insights into how digitalization

drives competitiveness in agricultural value chains under infrastructural and institutional constraints. Consequently, this study develops and tests a TOE-based empirical model using survey data from 309 respondents across 112 tea enterprises in Northern Vietnam. The study has two primary objectives: first, to identify the technological, organizational, and environmental determinants of e-commerce adoption; second, to evaluate the direct effect of e-commerce adoption on business performance. In this study, business performance is defined as operational efficiency, market expansion, and financial outcomes (e.g., revenue and sales growth). While the findings offer implications for the broader agricultural value chain, the central emphasis remains on adoption determinants and performance outcomes.

In this study, we apply the TOE framework was developed to analyze factors influencing technology adoption of e-commerce among tea enterprises in Northern Vietnam. The TOE model consists of three key components: technology, organization, and environment. The technological context reflects the readiness, perceived benefits, and risks associated with adopting new technologies. The organizational context relates to internal characteristics of the enterprise such as size, structure, resources, and the level of managerial support. The environmental context includes competitive pressure, demands from customers and business partners, as well as the regulatory environment. Employing the TOE framework allows us to take a comprehensive and systematic approach to examining both internal and external conditions of the enterprise, thereby clarifying the drivers and barriers to digital transformation in the tea industry, a traditionally rooted sector that is increasingly being influenced by the need for innovation and integration.

Hypotheses Development

Technological factors refer to the aspects of technology infrastructure that are necessary for the adoption of e-commerce. One of the most common factors found in the literature is perceived compatibility, which is seen as the adaptability of e-commerce within the organization in relation to existing systems and infrastructure (17, 21–24). Another significant aspect is the perceived relative advantage of e-commerce adoption, which refers to the benefits

gained by businesses compared with traditional practices (4, 17). These are considered critical because without the necessary infrastructure, other technological enablers such as Internet connectivity and electronic payment methods would lack the essential platforms to function effectively (25).

Perceived relative advantage: The perceived relative advantage (PRA) refers to the benefits that users perceive from performing the behavior over traditional methods. The perceived relative advantage is among the most utilized characteristics in studies on e-commerce adoption (4, 17, 26). Studies on e-commerce support the notion that the relative advantage of technology has a positive and significant impact on the adoption of e-commerce through benefits that enterprises receive when adopting e-commerce, including increased revenues, improved customer service, and reduced costs (4, 17, 27).

Hypothesis H1: The perceived relative advantage is positively related to the adoption of e-commerce by tea enterprises.

Perceived compatibility: Perceived compatibility is defined as the degree to which an innovation aligns with the existing values and needs of potential adopters (28). Perceived compatibility with technological innovation plays a vital role in enterprises' consideration of e-commerce adoption (17, 21, 24, 25, 29). Many past studies have found a positive and statistically significant relationship between compatibility and e-commerce adoption in enterprises (17, 21, 24-26, 29). In this study, perceived compatibility describes the extent to which e-commerce aligns with existing business processes, suppliers, and customers.

Hypothesis H2: A tea enterprise with higher perceived compatibility is positively associated with e-commerce adoption.

Organizational factors refer to internal organizational characteristics that affect e-commerce adoption, including management attitude, financial resources, commitment, support, and motivation toward technological change (4-6, 17, 30). These factors promote the acceptance and diffusion of e-commerce technologies within business operations (6). Additionally, managerial awareness and knowledge about e-commerce solutions

significantly contribute to the decision-making process for adoption (5, 6, 31-33).

Financial resources: Financial resources are defined as the available capital for businesses to implement e-commerce without financial strain (29). However, there are divergent views in the literature. Some studies focus on the cost aspect, suggesting that high implementation costs are perceived as barriers to adoption (4, 16). In contrast, others view financial capability as an enabling factor when organizations have the necessary capital and commitment to invest in e-commerce (4, 23). This divergence may stem from contextual differences: in developing countries like Vietnam, limited capital access may amplify the perception of cost as a barrier, particularly for SMEs.

Hypothesis H3: Financial capability has a positive influence on e-commerce adoption by tea enterprises.

Managerial support: Managerial support is defined as managers' positive perception and commitment toward the adoption of information technology in their organizations (24). Managerial support facilitates strategic alignment, resource allocation, and organizational readiness for e-commerce adoption (4-6). When senior management champions digital transformation and supports technological investments, firms are more likely to overcome implementation challenges (31, 34, 35). While financial capability provides the means, managerial support ensures strategic commitment to deploy these resources effectively.

Hypothesis H4: Support from management is positively related to the adoption of e-commerce by tea enterprises.

Manager's awareness and knowledge: Previous studies consistently indicate that the knowledge and digital competence of managers are positively related to e-commerce adoption. This includes understanding security, trust, and platform quality as critical elements in the decision-making process. Managers who possess higher Information Technology (IT) literacy and digital awareness are more inclined to adopt innovative solutions (17, 33, 36, 37). Their competence enhances organizational confidence and facilitates a smoother transition toward digital platforms.

Hypothesis H5: The e-commerce knowledge of managers is positively related to the adoption of e-commerce by tea enterprises. Environmental

factors encompass the broader external conditions such as political, legal, market, and economic influences that can promote or hinder e-commerce adoption. These include government regulations, policies, incentives, and broader national initiatives supporting digital transformation (4, 5, 17, 21-23, 25, 31, 32, 38). Furthermore, environmental pressures from customers, competitors, and trading partners play a crucial role. Enterprises that feel higher levels of external pressure are more likely to adopt e-commerce (17, 21, 29). These three groups of factors provide the foundation for the development of the research model and hypotheses presented in the subsequent section.

Competitive Pressure: Competitive pressure is defined as the extent to which a company's competitive environment influences its decision to adopt e-commerce. Many studies confirm that it is one of the most critical external factors in predicting e-commerce adoption (29, 38, 39). Enterprises often adopt e-commerce to remain competitive and avoid falling behind in market positioning and innovation (6, 33).

Hypothesis H6: Competitive pressure has a positive impact on the adoption of e-commerce by tea enterprises.

Partner/Supplier Pressure: Partner or supplier pressure refers to the influence of trading partners who prefer to work with businesses that have adopted e-commerce systems. This pressure encourages firms to integrate digital platforms to maintain relationships and operational alignment (21, 26).

Hypothesis H7: Partner/supplier pressure has a positive impact on e-commerce adoption by tea enterprises.

Customer Pressure: Customer pressure stems from increasing expectations for digital services and online accessibility. It has been suggested that companies often upgrade their digital capabilities to satisfy customer demands (40). While several studies argue for a strong influence of customer pressure, others suggest its impact is negligible (41, 42), indicating that the effect may be context-dependent.

Hypothesis H8: Customer pressure has a positive impact on e-commerce adoption by tea enterprises.

Support from government: Government support plays an important role in motivating the adoption

of e-commerce in different countries. This support can manifest through policy frameworks, financial investments, and infrastructure development, enhancing the technological landscape necessary for e-commerce growth (4, 5, 21, 32, 38). Government policies create a conducive environment by establishing regulations that protect consumers and businesses, thereby increasing trust in online transactions (32, 38). Moreover, support can eliminate barriers in resources and skills, improve IT readiness through investments in Internet access and payment systems, and enhance digital skills via training programs (5, 6, 12, 21). The moderating role of government support in influencing the relationship between owner characteristics and e-commerce adoption has also been highlighted (33).

Hypothesis H9: Government support has a positive impact on e-commerce adoption by tea enterprises.

E-commerce adoption: The adoption of e-commerce brings numerous benefits to enterprises, including increased operational efficiency, sales, competitiveness, and market access (5, 6). System quality, content, trust, and support also significantly impact customer satisfaction and the success of e-commerce (4). However, some studies highlighted seven key factors influencing the success of e-commerce: leadership, strategy, governance, organization, technology, customers, and suppliers. E-commerce adoption helps enterprises improve performance, reduce costs, attract more customers, enhance service quality, and increase competitiveness (5, 6, 16). Previous studies have also emphasized that the higher the level of e-commerce adoption, the greater the effectiveness achieved (43).

Hypothesis H10: The level of e-commerce adoption has a positive impact on business performance in tea enterprises.

The following Methodology section presents the approach employed to test the proposed TOE-based hypotheses concerning factors influencing e-commerce adoption and its impact on the performance of tea enterprises in Northern Vietnam.

Methodology

Data Collection and Sampling

This study aims to provide empirical evidence on

the effectiveness of e-commerce adoption among tea enterprises in Northern Vietnam. The selection of this region is based on several considerations. First, tea enterprises are predominantly concentrated in Northern Vietnam, where the climate is highly suitable for tea cultivation (44). It was reported by the Vietnam Tea Association that this region accounts for approximately 80% of the country's total tea plantation area (44). Second, in recent years, both the government and various organizations have provided substantial support for the tea industry. Agricultural development programs—particularly the One Commune One Product (OCOP) initiative and sustainability-oriented production support schemes—have created favorable conditions for tea enterprises to adopt new technologies, including e-commerce (45). These initiatives have enabled firms in the region to access and implement online platforms to expand their market reach. However, as noted earlier, empirical studies on the effectiveness of e-commerce adoption in this context remain limited. This gap hinders a comprehensive understanding of both the theoretical foundations and practical implications of digital transformation in the sector. To ensure data reliability, a purposive sampling strategy was employed with three eligibility

criteria: First, enterprises had to be headquartered in Northern Vietnam; Second, they must have operated in the tea industry for at least two years to ensure business stability; Finally, respondents were required to be either business owners or mid-level managers with sufficient knowledge of their company's e-commerce activities. Based on these criteria, both online and paper-based questionnaires were distributed. Each survey package included a cover letter outlining the study's objectives, emphasizing its academic purpose, and assuring confidentiality of all information provided—thus encouraging honest and accurate responses. The data collection was conducted from October 2024 to January 2025. A total of 112 tea enterprises that met the inclusion criteria were selected, with four questionnaires sent to each enterprise. By the end of the survey period, 341 responses were received, yielding a response rate of 76%. After screening for completeness and consistency, 309 valid responses were retained for analysis using SmartPLS 4. The sample size satisfies the commonly accepted rule of thumb that requires at least five observations per indicator variable see in Table 1(46).

Table 1: Descriptive Statistics of the Sample

Type of Business	Indicator	Number	Percentage (%)
N = 112			
Small		76	67.86
Medium		23	20.54
Large		13	11.60
Field			
Manufacturing		2	1.78
Trade and services		17	15.18
Manufacturing, Trade and Services		93	83.04
Operation time			
Under 5 years		10	8.93
From 5 to 10 years		21	18.75
Over 10 years		81	72.32
n = 309			
Gender			
Male		191	61.81
Female		118	38.19
Position			
Frontline management		93	30.09
Mid-level leadership		129	41.75
Executive leadership		87	28.16

*Note: n = number of respondents; N = number of enterprises

A descriptive summary of the sample is presented in Table 1. Of the 112 tea enterprises surveyed,

67.86% were small-sized firms, 20.54% were medium-sized, and 11.60% were large-sized.

Regarding business activities, the majority (83.04%) operated across manufacturing, trade, and services, while 1.78% specialized exclusively in manufacturing and 15.18% operated solely in trade and services.

In terms of operational experience, 72.32% of the enterprises had been in operation for over ten years, 18.75% for 5 to 10 years, and 8.93% for fewer than five years. Among the 309 individual respondents, 61.81% were male and 38.19% female. Regarding organizational roles, 41.75% held mid-level management positions, 30.09% were in frontline roles, and 28.16% occupied executive-level positions. These characteristics offer a comprehensive view of the managerial context in which e-commerce adoption is taking place.

Questionnaire Development

This study primarily employs a quantitative approach. To ensure reliability, the research adopts measurement scales from previous studies. Additionally, minor modifications were made to align the scales with the study's context and objectives. The "Perceived Relative Advantage" scale was adapted from prior studies (4, 17). The "Perceived Compatibility" scale was derived from prior research (17). The "Financial Resources" scale was based on prior research (6, 16). The scales for "Management Support", "Manager's Awareness and Knowledge", and "Pressure from Customers" were adapted from prior studies (6). Meanwhile, the scales for "Pressure from Competitors" and "Pressure from Trading Partners" were adapted from previous studies (29). Lastly, the "Support from Government" scale was adapted from prior literature (38). Finally, the scales for "E-commerce adoption" and "Business Performance" were adapted from (5, 6, 16, 17, 43, 47). E-commerce adoption was measured as the degree of adoption using four items (EA1–EA4) that capture the extent to which enterprises integrated e-commerce into their business activities. These items reflect breadth and intensity of adoption (rather than a binary classification) and were assessed on a five-point Likert scale. Specifically, business performance was measured using five observed items (BP1–BP5), adapted from prior studies. These items capture improvements in operational efficiency (e.g., cost reduction, improved processes), market expansion (e.g., access to new customers and markets), and

financial outcomes (e.g., sales and revenue growth), along with enhanced customer relationships and competitiveness. Since the original scales were designed in English, a careful translation process was implemented to maintain consistency. Before distributing the questionnaire to respondents, the original scales were translated into Vietnamese by two independent language experts. Additionally, the translated scales were reviewed by e-commerce specialists to assess their appropriateness. The feedback confirmed that the scales were suitable for large-scale data collection. All measurement items were structured using a 5-point Likert scale, ranging from "Strongly Disagree" (1) to "Strongly Agree" (5).

Common Method Bias

To mitigate common method bias, we first ensured the anonymity and confidentiality of respondents by clearly stating in the cover letter that there were no correct or incorrect responses. Additionally, following established recommendations, we utilized an item-randomization technique to randomize both the sequence and type of questions, thereby enhancing the objectivity and reliability of the data collection process (48).

To examine potential non-response bias, we compared the data collected during the initial phase (first 20%) and the final phase (last 20%) of the survey based on exploitation, exploration, and embeddedness scores. An independent samples t-test was conducted on these variables, and the results indicated that non-response bias did not pose a significant issue in this study. Furthermore, to evaluate common method bias, we employed Harman's single-factor test, in which an exploratory factor analysis showed that a single factor accounted for 22.4% of the total variance. This result suggests that common method bias is not a critical concern in this research.

Data Analysis

During the evaluation of the measurement model, we assessed the reliability of the measurement scales using Cronbach's Alpha and Composite Reliability (CR), where values of 0.7 or higher were required to ensure internal consistency (49). Next, we examined convergent validity by assessing the factor loadings of each observed variable, with a required threshold of 0.7 or higher. Additionally, the average variance extracted (AVE) needed to be at least 0.5 to confirm that the observed variables

adequately converged on their respective latent constructs (50). To ensure discriminant validity, we applied the Fornell-Larcker Criterion and the Heterotrait-Monotrait Ratio (HTMT), where the HTMT value had to be below 0.85 to confirm that latent variables were distinct and did not overlap conceptually (51). Once the measurement model met the necessary criteria, we proceeded with the evaluation of the structural model. First, we assessed multicollinearity by calculating the variance inflation factor (VIF), ensuring that all values remained below 5 to rule out serious multicollinearity issues (49). Next, we analyzed path coefficients to determine the impact of independent variables on dependent variables, followed by statistical significance testing using bootstrapping analysis, with a required p-value below 0.05 (52). Additionally, we evaluated the explanatory power of the model through the R^2 coefficient, ensuring an acceptable level to confirm the model's ability to account for the variance in the dependent variable. Finally, we examined the f^2

value to assess effect size to verify predictive relevance, ensuring that these values met the necessary criteria for a robust predictive model (53).

Results

Measurement Model

During the measurement model evaluation process see in Table 2, the authors examined key indicators to ensure the reliability and validity of the scales. The results showed that all observed variables had outer loadings above 0.7, ranging from 0.706 to 0.934, meeting the criteria for convergent validity. This indicates that the observed variables have a high correlation with their respective latent constructs. Additionally, Cronbach's Alpha values ranged from 0.751 to 0.912, all exceeding the 0.7 threshold, demonstrating strong internal consistency of the scales. Moreover, the Composite Reliability (CR) values were all above 0.85, confirming the high reliability of the measurement scales.

Table 2: Outer Loadings, Cronbach's Alpha, CR, and AVE values

Variables	Items	Outer Loadings	Cronbach's Alpha	CR	AVE
PRA	PRA1	0.742	0.868	0.905	0.657
	PRA2	0.826			
	PRA3	0.886			
	PRA4	0.841			
	PRA5	0.749			
PC	PC1	0.861	0.855	0.912	0.775
	PC2	0.919			
	PC3	0.859			
FR	FR1	0.846	0.911	0.938	0.791
	FR2	0.934			
	FR3	0.875			
	FR4	0.900			
MS	MS1	0.792	0.776	0.870	0.690
	MS2	0.861			
	MS3	0.838			
MAK	MAK1	0.848	0.751	0.856	0.666
	MAK2	0.807			
	MAK3	0.792			
PCs	PCs1	0.924	0.912	0.938	0.792
	PCs2	0.895			
	PCs3	0.919			
	PCs4	0.817			
PTP	PTP1	0.886	0.884	0.920	0.744
	PTP2	0.898			
	PTP3	0.851			
	PTP4	0.812			

PFC	PFC1	0.919			
	PFC2	0.897	0.887	0.930	0.815
	PFC3	0.892			
SG	SG1	0.845			
	SG2	0.818	0.844	0.895	0.681
	SG3	0.829			
	SG4	0.809			
EA	EA1	0.876			
	EA2	0.860	0.903	0.932	0.775
	EA3	0.867			
	EA4	0.917			
BP	BP1	0.880			
	BP2	0.868			
	BP3	0.914	0.887	0.918	0.692
	BP4	0.706			
	BP5	0.775			

The authors also examined the Average Variance Extracted (AVE) to assess the level of convergence of the observed variables with their latent constructs, with results ranging from 0.657 to 0.815, all surpassing the 0.5 threshold. This suggests that the observed variables explain a significant portion of the variance in their respective latent constructs. Overall, the analysis results confirm that the measurement model meets the necessary criteria for reliability and validity, providing a solid foundation for the subsequent structural model analysis.

Regarding discriminant validity, the results in Table 3 indicates that all latent variables meet the

Fornell-Larcker Criterion, confirming the discriminant validity of the constructs in the model. Specifically, the highest value in each column is always the value on the diagonal, representing the square root of the AVE of each variable, and these values are greater than the correlation coefficients in the same column. This confirms that the measurement variables in the model are conceptually distinct and do not overlap (50). Thus, the Fornell-Larcker test results affirm the discriminant validity of all variables in the model, ensuring the validity of the measurement scale and supporting the subsequent analytical steps.

Table 3: Fornell-Larcker Criterion

	PCs	PFC	PTP	BP	SG	FR	PC	MAK	PRA	EA	MS
PCs											
PFC	0.586										
PTP	0.470	0.522									
BP	0.554	0.687	0.439								
SG	0.562	0.583	0.455	0.527							
FR	0.611	0.723	0.472	0.714	0.584						
PC	0.509	0.438	0.268	0.470	0.387	0.471					
MAK	0.462	0.426	0.395	0.555	0.474	0.408	0.231				
PRA	0.477	0.462	0.496	0.461	0.487	0.468	0.305	0.462			
EA	0.806	0.728	0.642	0.767	0.725	0.739	0.599	0.612	0.635		
MS	0.504	0.447	0.251	0.442	0.432	0.549	0.451	0.503	0.475	0.628	

Goodness of Fit Analysis

To evaluate the overall fit of the model, several goodness-of-fit (GoF) indices were examined, including Standardized Root Mean Square Residual (SRMR), Normed Fit Index (NFI), and R^2 . The SRMR value for the estimated model is 0.064,

which is below the 0.08 threshold recommended in prior research (54), indicating a good model fit. Similarly, the NFI value of 0.767 is close to the recommended 0.9 threshold (49), supporting the acceptability of the model fit. Additionally, the model's GoF value is 0.708, which exceeds the 0.36

threshold commonly used to indicate a large model fit (55). Furthermore, the coefficient of determination (R^2) value was analyzed to assess the explanatory power of the structural model. The results show that $R^2 = 0.479$ for BP and $R^2 = 0.782$ for EA, suggesting that the independent variables explain 47.9% of the variance in BP and 78.2% of the variance in EA. The Adjusted R^2 values (0.478 for BP and 0.775 for EA) indicate minimal loss of explanatory power after adjusting for the number of predictors, further supporting the robustness of the model. Overall, the results confirm that the proposed model demonstrates a good fit and strong explanatory power, making it suitable for analyzing the relationships between the studied variables.

Structural Model

The hypothesis testing results indicate that all hypotheses are accepted with high statistical significance ($p < 0.05$) (see Table 4 and Figure 1). H1 ($\beta = 0.107$, $t = 3.539$, $p = 0.000$, $f^2 = 0.034$)

shows that PRA has a positive impact on EA, although the effect size is small. Similarly, H2 ($\beta = 0.147$, $t = 4.748$, $p = 0.000$, $f^2 = 0.071$) confirms that PC significantly influences EA with a moderate effect. H3 ($\beta = 0.112$, $t = 2.919$, $p = 0.004$, $f^2 = 0.026$) and H4 ($\beta = 0.092$, $t = 2.744$, $p = 0.006$, $f^2 = 0.026$) indicate that FR and MS have positive but minor effects on EA. H5 ($\beta = 0.109$, $t = 3.278$, $p = 0.001$, $f^2 = 0.040$) and H6 ($\beta = 0.271$, $t = 6.450$, $p = 0.000$, $f^2 = 0.178$) show that MAK and PCs have strong effects on EA, particularly PCs, which exhibit a large impact. H7 ($\beta = 0.162$, $t = 4.926$, $p = 0.000$, $f^2 = 0.080$) and H8 ($\beta = 0.111$, $t = 2.787$, $p = 0.006$, $f^2 = 0.027$) demonstrate that PTP and PFC positively influence EA with a moderate effect. H9 ($\beta = 0.156$, $t = 4.124$, $p = 0.000$, $f^2 = 0.068$) confirms that SG has a significant impact on EA. Notably, H10 ($\beta = 0.692$, $t = 19.785$, $p = 0.000$, $f^2 = 0.921$) reveals that EA has a very strong effect on BP, with an impact far exceeding other hypotheses. These results highlight the crucial role of EA in driving BP.

Table 4: Hypotheses Testing

Hypotheses	Relationship	β	SD	t	p	f^2	Decision
H1	PRA → EA	0.107	0.030	3.539	0.000	0.034	Accepted
H2	PC → EA	0.147	0.031	4.748	0.000	0.071	Accepted
H3	FR → EA	0.112	0.038	2.919	0.004	0.026	Accepted
H4	MS → EA	0.092	0.034	2.744	0.006	0.026	Accepted
H5	MAK → EA	0.109	0.033	3.278	0.001	0.040	Accepted
H6	PCs → EA	0.271	0.042	6.450	0.000	0.178	Accepted
H7	PTP → EA	0.162	0.033	4.926	0.000	0.080	Accepted
H8	PFC → EA	0.111	0.040	2.787	0.006	0.027	Accepted
H9	SG → EA	0.156	0.038	4.124	0.000	0.068	Accepted
H10	EA → BP	0.692	0.035	19.785	0.000	0.921	Accepted

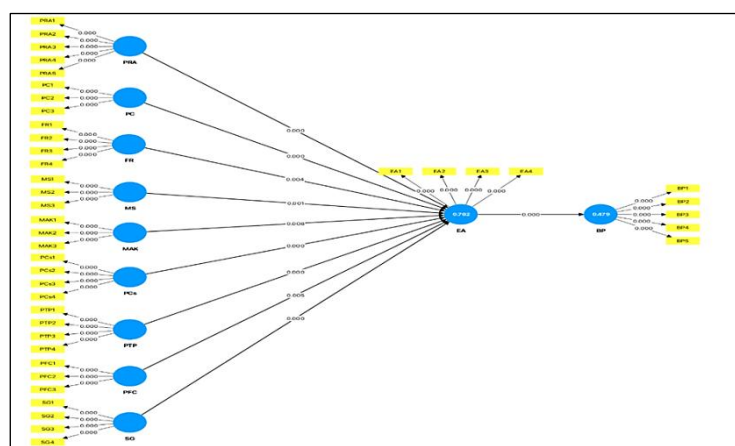


Figure 1: PLS-SEM Results

Discussion

By providing empirical evidence, this study makes a significant contribution to the field of e-commerce adoption among tea enterprises. It explains the relationship between nine factors influencing the level of e-commerce adoption and its effectiveness, including Perceived Relative Advantage (PRA), Perceived Compatibility (PC), Financial Resources (FR), Managerial Support (MS), Manager's Awareness and Knowledge (MAK), Pressures from Competitors (PCs), Pressures from Trading Partners (PTP), Pressures from Customers (PFC), and Support from Government (SG). The integration of these factors creates an ecosystem that facilitates the transition of tea enterprises toward adopting e-commerce in both their business operations and production processes.

The Factor with the Greatest Influence on E-Commerce Adoption

Our findings show that perceived relative advantage has a positive but modest effect on e-commerce adoption. This result is consistent with the diffusion of innovation theory, which highlights relative advantage as an important but not always dominant predictor (16, 18, 28), while evidence from Malaysia indicated it as the strongest determinant (17). By comparison, perceived compatibility emerged as the strongest technological determinant in our study. This finding aligns with prior studies that emphasized the role of compatibility with existing infrastructure and processes in SME adoption (27, 56). In contrast, relative advantage was reported as more influential for US SMEs, underscoring contextual differences between developed and developing economies (57). These results suggest that in Vietnamese tea enterprises, the benefits of e-commerce are recognized, but alignment with available resources and organizational structures plays a more decisive role.

Financial resources were found to positively influence e-commerce adoption, consistent with studies showing that sufficient capital facilitates investment (16, 29). By contrast, Malaysian SMEs reported financial barriers as more prominent, suggesting that context-specific differences in credit access and cost perceptions may explain why Vietnamese firms view capital as an enabler rather than a constraint (17).

Interestingly, managerial support had the weakest effect among organizational factors. In other contexts, top management commitment was identified as a critical driver of e-commerce projects (58). However, our finding is more aligned with studies in Thai SMEs, where external pressures outweighed internal leadership (5). This suggests that in Vietnamese tea enterprises, digital adoption is less reliant on individual leadership and more strongly shaped by external competitive forces and resource constraints.

Managerial awareness and knowledge were confirmed to positively affect adoption, underscoring the importance of digital competence among decision-makers (33, 36). This includes IT literacy, which enhances confidence in adopting e-commerce solutions (32). In the context of Vietnamese tea enterprises, this underscores the role of managerial digital skills in overcoming technological uncertainty and building trust in online platforms.

Competitive pressure was identified as the strongest environmental determinant of adoption. This result supports findings emphasizing the role of industry rivalry in driving SMEs toward digital adoption (56). Similarly, competition was found to be decisive for Indonesian SMEs (27), suggesting that in Vietnam's tea industry, external competitive forces outweigh internal organizational resources (17).

Partner and supplier pressure also had a meaningful positive effect on adoption. This aligns with TOE-based findings where pressure from business partners is a significant environmental factor (59). It is also consistent with the logic in analysis of e-commerce adoption by SMEs using TOE that pressures from suppliers and business network partners push firms toward digital alignment (60). Such pressure underlines the interconnected nature of supply chains in e-commerce. SMEs may adopt digital tools to keep up with partners' expectations, reduce coordination costs, or sustain relationships across the value network.

Customer pressure was confirmed to positively affect adoption, echoing findings that growing customer expectations for online services push firms to digitalize (36). However, unlike studies in developed economies where customer demand is the dominant driver, in the Vietnamese tea context customer pressure was moderate, indicating that

many firms are still at an early stage of digital maturity. Government support played an enabling role, consistent with prior studies highlighting the importance of policy frameworks, infrastructure, and training initiatives (21, 32). Our findings also resonate with evidence from Malaysia (61), which highlighted that supportive regulation builds trust in online transactions. In Vietnam, initiatives such as the OCOP program and digitalization strategies have created a conducive environment.

However, infrastructural disparities—particularly in remote mountainous areas with weak logistics and high transaction costs—remain a critical barrier to balanced adoption, despite generally reliable connectivity in provincial centers. These contrasts indicate that, beyond government support, infrastructural bottlenecks persist as a major obstacle that policymakers need to address to ensure balanced adoption across regions.

The Effect of E-Commerce Adoption on Organizational Performance

The positive and significant effect of e-commerce adoption on business performance confirms that digitalization enhances operational efficiency, market expansion, and financial outcomes for tea enterprises. This result is in line with studies in Indonesia and Vietnam (16, 19), which showed that adoption improves productivity, sales, and competitiveness. Similar findings were reported in Indonesian MSMEs, where adoption enhanced both efficiency and customer reach (10), and also strengthened market and financial performance in traditional drink SMEs (27). At the same time, this study highlights market expansion as a particularly salient outcome for Vietnamese tea enterprises. This resonates with findings that underlined the export potential of Vietnamese tea (20), and highlighted the importance of global competitiveness for tea exports (62). Compared with studies in manufacturing sectors, which emphasized cost efficiency and logistics, our results suggest that agricultural firms prioritize market access and brand visibility (9, 47). Recent studies further reinforce the efficiency dimension, showing that adoption reduces operational costs (2) and improves marketing performance through innovation and digital engagement (59). Together, these findings confirm that e-commerce adoption is not only a technological shift but also a strategic

pathway toward sustainable competitiveness in the agricultural sector.

Conclusion

In conclusion, this study—based on the Technology–Organization–Environment (TOE) framework—finds that technological, organizational, and environmental factors significantly influence e-commerce adoption among tea enterprises in Northern Vietnam. Nine key determinants across these domains were identified as significant drivers of adoption. Competitive pressure (an environmental factor) emerged as the most powerful predictor of adoption, whereas managerial support (an organizational factor) had the weakest effect. This suggests that intense market competition motivates tea firms to adopt e-commerce, while internal managerial support for adoption remains relatively weak. Furthermore, the analysis shows that higher levels of e-commerce adoption are associated with improved business performance, such as market expansion, operational efficiency, and revenue growth. Overall, the findings underscore the importance of a holistic approach to fostering e-commerce: enhancing technological readiness, strengthening organizational commitment, and addressing external market pressures. By focusing exclusively on the TOE framework, this study provides a comprehensive perspective on e-commerce diffusion in the tea sector and highlights implications for managers and policymakers seeking to leverage e-commerce adoption to enhance business outcomes.

Theoretical Implications

This study contributes to the theoretical discourse on technology adoption by reinforcing and extending key factors identified in prior research. It highlights the critical influence of organizational factors – notably top management support and awareness – on the acceptance of new technologies, consistent with earlier findings, which corroborate that when leaders demonstrate commitment and understand the benefits of e-commerce, it promotes successful implementation (4, 5, 17). Furthermore, the study offers an integrated perspective by examining technological, organizational, and environmental dimensions concurrently. In doing so, this perspective aligns with the view that technological and regulatory contexts are interlinked, as robust policy support

can alleviate technological barriers to adoption (22). By incorporating multiple contextual factors within a single framework, our approach answers the call for comprehensive models of innovation adoption. This holistic view advances existing theory beyond siloed approaches, demonstrating how addressing interdependent factors together yields a more complete understanding of e-commerce adoption in emerging markets (22).

Practical Implications

Technological context: From a technology standpoint, businesses should invest in improving their IT infrastructure and digital capabilities to facilitate e-commerce adoption. Ensuring adequate technical infrastructure (e.g. reliable Internet connectivity and secure payment systems) and enhancing IT knowledge among employees can reduce barriers to adoption (4). Managers are advised to clearly communicate and demonstrate the relative advantages of e-commerce to their staff and stakeholders. When the potential benefits of the technology are well understood – such as expanded market reach or efficiency gains – organizations are more likely to embrace it (5, 17). In practice, this means providing training and sharing success cases to build a strong perception of usefulness, which in turn fosters a positive attitude toward adopting the technology.

Organizational context: At the organizational level, strong leadership and a supportive culture are vital for successful e-commerce implementation. Top management should champion digital initiatives and allocate sufficient resources (time, budget, and personnel) to e-commerce projects, as their commitment can motivate the entire organization to adapt. Our findings suggest that companies with management teams who prioritize innovation and change management tend to navigate the adoption process more effectively. This supports prior studies showing that management attitude and support significantly drive technology acceptance (4, 5, 17). Practically, organizations should also develop clear strategies and provide training programs to increase employee readiness. By improving internal competencies and easing resistance to change, firms can enhance their organizational readiness for e-commerce and, consequently, improve the chances of successful adoption.

Environmental context: In the environmental dimension, external support and pressures play a crucial role in e-commerce adoption. The government, in particular, has a key role in establishing a favorable environment through supportive policies, infrastructure development, and regulatory frameworks (22). Strengthening legal regulations for online transactions, improving nationwide Information and Communication Technology infrastructure, and offering incentives or training programs for SMEs can all help eliminate barriers and build trust in digital business. This recommendation is in line with the TOE framework's emphasis on the broader environment and is supported by prior research showing that external factors—such as industry competition and government support—significantly shape technology adoption (19). Additionally, competitive pressure can spur firms to innovate; thus, industry associations and market leaders should encourage knowledge sharing and highlight success stories of e-commerce to create a ripple effect. In summary, enhancing the external ecosystem with robust government support, effective regulations, and active industry engagement can substantially accelerate e-commerce diffusion in developing country contexts (22). Policies should also prioritize investment in logistics and supply-chain infrastructure for remote tea-growing areas to reduce geographic disparities in adoption.

Limitations and Future Research

This study presents several limitations that should be acknowledged and addressed in future research. First, the empirical investigation focuses exclusively on tea enterprises located in Northern Vietnam. As a result, the findings may not be fully generalizable to all tea businesses across the country. Future studies are encouraged to extend the model to a broader geographic scope, encompassing tea enterprises from Central and Southern Vietnam, to capture regional variations in e-commerce adoption.

Second, the study is context-specific and limited to a single developing country at a specific point in time. Expanding the research to tea enterprises in other developing countries or conducting longitudinal studies over time would enrich the current understanding of e-commerce adoption dynamics. Such comparative studies could provide valuable insights into cross-national differences

and temporal trends in the adoption and performance outcomes of e-commerce in the agricultural sector.

Finally, while the study incorporates key technological, organizational, and environmental factors, it does not account for certain regulatory and structural variables such as firm size, business age, or ownership type, which may influence adoption behaviors and outcomes. Moreover, additional factors such as cyber security concerns, cultural resistance to digital transformation, Internet infrastructure quality, and Internet speed may also play significant roles in shaping the adoption of e-commerce in developing economies. Future research should consider integrating these variables to develop more comprehensive models that better reflect the complexity of the digital transformation process in the agricultural sector.

Abbreviations

TOE: Technology–Organization–Environment, PLS-SEM: Partial Least Squares Structural Equation Modeling, PLS: Partial Least Squares, SEM: Structural Equation Modeling, SME/SMEs: Small and Medium-sized Enterprises, B2B: Business-to-Business, OCOP: One Commune One Product, SRMR: Standardized Root Mean Square Residual, NFI: Normed Fit Index, GoF: Goodness of Fit, CR: Composite Reliability, AVE: Average Variance Extracted, VIF: Variance Inflation Factor, R²: Coefficient of Determination, EA: E-commerce adoption.

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Author Contributions

All authors made equal contributions.

Conflict of Interest

There is no conflict of interest with the content of this article.

Declaration of Artificial Intelligence (AI) Assistance

Generative AI and AI-assisted technologies were employed to enhance the clarity, grammar, and readability of the manuscript. The authors carefully reviewed, edited, and verified all content

generated with these tools, and they take full academic responsibility for the integrity and originality of the work.

Ethics Approval

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