

# Multidimensional Data-Driven Modeling of Sustainable E-Commerce Development with Direct and Interaction Effects

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## Abstract

Sustainable e-commerce development has become a critical issue for emerging economies as digital markets expand rapidly, alongside growing concerns about regulatory effectiveness, trust, and resource efficiency. This study investigates the key factors influencing sustainable e-commerce development in Vietnam by explicitly integrating Institutional Theory, the Technology–Organization–Environment (TOE) framework, and the Resource-Based View (RBV) into a unified structural equation modeling (SEM) framework. Institutional Theory is operationalized through regulatory quality, capturing the role of formal rules and enforcement mechanisms in shaping market stability and legitimacy. The TOE framework is reflected in digital infrastructure, government support, and competitive pressure, which together represent technological readiness and environmental conditions. RBV is operationalized through resource availability and management capacity, emphasizing firms' internal capabilities to sustain long-term e-commerce performance. In addition, trust is incorporated as both a direct determinant and a moderating mechanism that strengthens the effectiveness of institutional and organizational factors. A mixed-method research design was employed. The qualitative phase involved in-depth discussions with 35 policymakers, business managers, and e-commerce platform managers to refine the theoretical integration and measurement scales. Based on these insights, a structured questionnaire was administered to frequent online shoppers in Ho Chi Minh City and Dong Nai Province, yielding 653 valid responses. SEM results indicate that regulatory quality, digital infrastructure, government support, competitive pressure, resource availability, and trust all have significant positive effects on sustainable e-commerce development. Resource availability and regulatory quality exert the strongest impacts, while trust and management capacity significantly moderate the effects of regulatory quality and resource availability, respectively. By explicitly mapping institutional, technological, organizational, and relational constructs into a coherent SEM framework, this study provides a theoretically grounded and empirically validated model of sustainable e-commerce development in an emerging economy context. The findings offer valuable implications for policymakers and practitioners seeking to foster a resilient, trustworthy, and sustainable e-commerce ecosystem in Vietnam and similar developing economies.

*Keywords:* Sustainable E-Commerce Development, Regulatory Quality, Digital Infrastructure, Trust, Structural Equation Modeling

## 1. Introduction

The rapid expansion of e-commerce has fundamentally transformed business models, consumer behavior, and economic structures worldwide. In emerging economies, e-commerce is increasingly viewed as a key driver of digital transformation, market integration, and inclusive growth [1]. However, alongside its rapid growth, e-commerce also raises significant concerns related to regulatory effectiveness, consumer trust, data security, market competition, and environmental sustainability. As a result, the issue of sustainable e-commerce development has attracted growing attention from both scholars and policymakers.

Sustainable e-commerce development extends beyond short-term market growth to encompass long-term economic viability, social responsibility, and environmental efficiency. While prior studies have examined determinants of e-commerce adoption and performance, relatively limited attention has been paid to the factors that ensure the sustainability of e-commerce systems, particularly in emerging economies [2]. Existing research often focuses on technological readiness or consumer behavior in isolation, without sufficiently integrating institutional, organizational, and relational dimensions. This gap highlights the need for a more comprehensive framework that explains how

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multiple factors jointly influence sustainable e-commerce development. Vietnam provides a particularly relevant context for this investigation. Over the past decade, Vietnam has experienced rapid growth in e-commerce, driven by increasing internet penetration, widespread smartphone usage, and supportive digital transformation policies. Despite these advancements, the Vietnamese e-commerce market continues to face challenges, including regulatory gaps, uneven digital infrastructure, limited managerial capacity among firms, and persistent concerns about consumer trust. These challenges raise critical questions regarding how Vietnam can move beyond rapid expansion toward a more sustainable and resilient e-commerce ecosystem.

In recent years, Vietnam's e-commerce market has experienced strong expansion, with annual growth rates consistently exceeding 20%, while internet penetration has surpassed 70% of the population, and smartphone usage has become widespread, particularly in urban areas. These trends have positioned Vietnam among the fastest-growing e-commerce markets in Southeast Asia, creating both significant opportunities and sustainability-related challenges.

To address these issues, this study proposes an integrated research model grounded in Institutional Theory, the Technology–Organization–Environment (TOE) framework, and the Resource-Based View (RBV). The model examines the effects of regulatory quality, digital infrastructure, government support, competitive pressure, resource availability, and trust on sustainable e-commerce development [3], [4]. Furthermore, the study investigates the interaction roles of trust and management capacity in strengthening the impacts of regulatory quality and resource availability, respectively. By incorporating these interaction mechanisms, the study advances understanding of the conditions under which institutional and organizational factors translate into sustainable outcomes.

Methodologically, this research adopts a mixed-method approach. A qualitative phase involving discussions with policymakers, business managers, and e-commerce platform managers was conducted to refine the conceptual framework and measurement scales [5]. Subsequently, a large-scale survey of frequent online shoppers across Vietnam's major economic regions was conducted, and the data were analyzed using Structural Equation Modeling (SEM). This approach ensures both contextual relevance and empirical rigor.

The contributions of this study are threefold. First, it enriches the literature on e-commerce sustainability by proposing and empirically validating a multidimensional model in an emerging economy context. Second, it provides empirical evidence on the relative importance of regulatory, technological, organizational, and trust-related factors in driving sustainable e-commerce development. Third, the findings offer practical insights for policymakers and practitioners seeking to promote a sustainable, trustworthy, and competitive e-commerce environment in Vietnam and similar developing economies.

Beyond addressing existing gaps, this study offers several novel contributions compared to prior e-commerce sustainability models, particularly those applied in emerging markets. First, rather than examining regulatory, technological, or organizational factors in isolation, the study explicitly integrates Institutional Theory, the TOE framework, and the Resource-Based View into a single structural equation modeling framework. Second, the model incorporates trust and management capacity as moderating mechanisms, revealing how institutional and resource-based factors translate into sustainable e-commerce outcomes under different relational and managerial conditions. This integrative, interaction-based approach extends existing sustainability models by offering a more nuanced explanation of sustainable e-commerce development in an emerging economy context.

## 2. Theoretical Framework and Hypothesis Development

### 2.1. Theoretical Foundations

This study draws upon three complementary theoretical perspectives: Institutional Theory, the Technology–Organization–Environment (TOE) framework, and the Resource-Based View (RBV) to explain sustainable e-commerce development in an emerging economy context [2], [6]. Institutional Theory emphasizes the role of formal rules, regulations, and enforcement mechanisms in shaping organizational behavior and market outcomes. In the context of e-commerce, institutional quality influences transaction security, consumer protection, data privacy, and market transparency, all of which are essential for building trust and ensuring long-term sustainability [7].

The TOE framework provides a holistic lens for understanding technology adoption and development by considering technological, organizational, and environmental contexts. In this study, digital infrastructure represents the technological dimension, resource availability and management capacity reflect the organizational dimension, while regulatory quality, government support, and competitive pressure capture the environmental context [8]. Within the TOE framework, the environmental context refers to external conditions that shape organizational decisions but are beyond firms' direct control. Government support is classified under this context because it reflects external policy incentives, regulations, and public interventions that influence firms' e-commerce activities. Similarly, competitive pressure comprises market-level forces arising from competitors and platform dynamics that externally constrain and motivate firms to adopt sustainable e-commerce practices.

The Resource-Based View (RBV) argues that firms achieve sustainable performance by possessing and effectively utilizing valuable, rare, and inimitable resources. In e-commerce, financial capital, digital technologies, human resources, data, and managerial capabilities are critical for sustaining competitive advantage and long-term development [9]. By integrating these three frameworks, this study develops a comprehensive model to explain how institutional, technological, organizational, and relational factors jointly influence sustainable e-commerce development.

## 2.2. Regulatory Quality and Sustainable E-commerce Development

Regulatory quality refers to the clarity, consistency, transparency, and effectiveness of laws and regulations governing e-commerce activities, including electronic transactions, consumer protection, data privacy, and cybersecurity [3], [10]. High-quality regulations reduce uncertainty and transaction costs, thereby encouraging firms to invest in compliant and long-term e-commerce strategies [11]. From an institutional perspective, effective regulatory frameworks enhance market legitimacy and stability, which are essential for sustainable development [12]. High regulatory quality reduces legal uncertainty, enhances market transparency, and protects consumer rights in e-commerce transactions. Clear, effectively enforced regulations encourage firms to invest in compliant, long-term digital strategies, thereby fostering a stable, sustainable e-commerce ecosystem. However, some studies argue that regulatory interventions or government support may also create compliance burdens or market distortions, potentially constraining innovation and long-term sustainability. Despite these concerns, this study posits that in emerging economies such as Vietnam, well-designed and effectively enforced institutional mechanisms are more likely to facilitate sustainable e-commerce development.

H1: Regulatory quality has a positive effect on sustainable e-commerce development.

## 2.3. Digital Infrastructure and Sustainable E-commerce Development

Digital infrastructure encompasses internet connectivity, digital payment systems, logistics platforms, cloud services, and cybersecurity infrastructure [5], [13]. According to the TOE framework, technological readiness is a critical determinant of digital development. Strong digital infrastructure enables efficient operations, reduces resource waste, and supports environmentally responsible practices, thereby contributing to sustainable e-commerce development [14]. Well-developed digital infrastructure enables reliable online transactions, efficient data processing, and secure payment systems [15]. Strong connectivity and technological readiness reduce operational inefficiencies and resource waste, supporting environmentally and economically sustainable e-commerce development.

H2: Digital infrastructure positively influences sustainable e-commerce development.

## 2.4. Government Support and Sustainable E-commerce Development

Government support includes policy incentives, financial assistance, training programs, and public investments to promote e-commerce adoption and sustainability [7], [16]. In emerging economies, government intervention plays a vital role in addressing market failures and supporting firms' digital transformation. Supportive policies can lower entry barriers and encourage sustainability-oriented practices [17], [18]. Government support through policy incentives, training programs, and public investments reduces entry barriers and capability gaps for firms [19]. Such support encourages the adoption of sustainable e-commerce practices, particularly among small and medium-sized enterprises in emerging economies.

H3: Government support positively impacts sustainable e-commerce development.

## 2.5. Competitive Pressure and Sustainable E-commerce Development

Competitive pressure reflects the intensity of competition faced by firms from rivals and digital platforms [20]. Market competition compels firms to innovate, improve service quality, and adopt sustainable practices to maintain long-term competitiveness [15], [21]. In e-commerce, competition increasingly centers on trust, transparency, and operational efficiency. Intense competitive pressure compels e-commerce firms to innovate, improve service quality, and enhance transparency [22], [23]. To maintain long-term competitiveness, firms increasingly adopt sustainable practices that strengthen trust, efficiency, and customer loyalty in digital markets. Nevertheless, prior research also suggests that excessive competitive pressure may lead to short-term cost-cutting or opportunistic behaviors that undermine sustainability objectives. In the context of e-commerce, this study argues that competition increasingly centers on trust, transparency, and service quality, thereby supporting sustainable development rather than eroding it.

H4: Competitive pressure positively affects sustainable e-commerce development.

## 2.6. Resource Availability and Sustainable E-commerce Development

Resource availability refers to firms' access to financial, technological, and human resources necessary for e-commerce operations [24]. According to RBV, sufficient resources enable firms to invest in digital technologies, compliance systems, and sustainable practices, thereby enhancing long-term performance [25], [26]. Adequate financial, technological, and human resources enable firms to invest in digital systems, compliance mechanisms, and sustainable operations [27]. According to the resource-based view, such resource endowments are essential for achieving sustainable e-commerce performance.

H5: Resource availability positively influences sustainable e-commerce development.

## 2.7. Trust and Sustainable E-commerce Development

Trust represents confidence in the reliability, security, and integrity of e-commerce platforms and transactions [28]. Trust reduces perceived risks and transaction costs, increases participation, and enhances market stability [21], [29]. As such, trust is a fundamental driver of sustainable e-commerce development [30]. Trust reduces perceived risks related to online transactions, data security, and product quality [31], [32]. Higher levels of trust increase consumer participation, repeat purchases, and platform stability, thereby supporting the long-term sustainability of e-commerce ecosystems. Conversely, several studies note that trust can be fragile or context-dependent and may not always translate into sustained market participation. Nevertheless, this study maintains that trust plays a critical role in reducing perceived risk and reinforcing institutional effectiveness in emerging e-commerce environments.

H6: Trust positively affects sustainable e-commerce development.

## 2.8. The Moderating Role of Trust

It is important to distinguish between trust and regulatory enforcement, as the two constructs operate through distinct mechanisms. Trust is conceptualized in this study as a psychological and relational construct reflecting market participants' confidence in the reliability and integrity of e-commerce platforms and institutions. In contrast, regulatory enforcement represents a formal institutional mechanism that compels compliance through rules and sanctions. Accordingly, trust does not substitute for enforcement but conditions how regulatory quality is perceived and translated into sustainable e-commerce outcomes. Regulatory quality may influence sustainable e-commerce development not only directly but also by strengthening trust among market participants [33], [34]. Effective regulations enhance institutional trust, which in turn amplifies the positive impact of regulatory quality on sustainability outcomes [35]. Regulatory quality is more effective when market participants trust regulatory institutions and enforcement mechanisms [36]. Higher trust strengthens the positive impact of regulatory quality by increasing compliance, participation, and confidence in the e-commerce environment.

H7: Trust moderates the relationship between regulatory quality and sustainable e-commerce development.

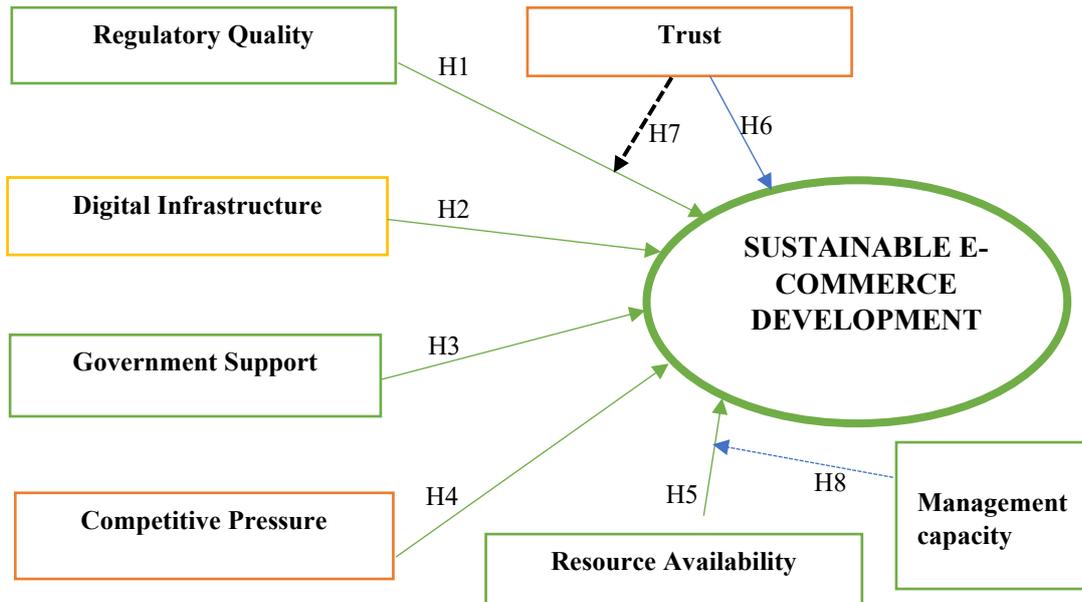
## 2.9. The Moderating Role of Management Capacity

Management capacity refers to a firm's ability to plan, coordinate, and deploy resources effectively [37]. Strong management capacity enables firms to transform available resources into sustainable e-commerce performance, thereby

strengthening the impact of resource availability [38], [39]. Management capacity determines how effectively firms deploy available resources. Strong managerial capabilities enhance strategic decision-making and coordination, enabling firms to transform resources into sustainable e-commerce outcomes [40] more efficiently.

H8: Management capacity moderates the relationship between resource availability and sustainable e-commerce development.

The model incorporates two interaction mechanisms: trust strengthens the relationship between regulatory quality and sustainable e-commerce development. At the same time, management capacity enhances the effect of resource availability on sustainable e-commerce development. The conceptual model provides a comprehensive framework for explaining sustainable e-commerce development in an emerging economy context, as presented in figure 1.



**Figure 1.** A research model for critical factors influencing sustainable E-commerce development

Figure 1 illustrates the conceptual framework proposed in this study to examine the determinants of sustainable e-commerce development. The model integrates key factors derived from institutional, technological, organizational, and relational perspectives. Specifically, regulatory quality, digital infrastructure, government support, competitive pressure, resource availability, and trust are hypothesized to have direct effects on sustainable e-commerce development. In addition to these direct relationships, the model incorporates two interaction mechanisms to capture more nuanced effects. Trust is proposed to strengthen the impact of regulatory quality on sustainable e-commerce development, reflecting the role of institutional credibility and consumer confidence. Similarly, management capacity is expected to enhance the effectiveness of resource availability by enabling firms to transform resources into sustainable outcomes. Overall, figure 1 presents a comprehensive, theoretically grounded framework that captures the complex, multidimensional nature of sustainable e-commerce development, particularly in emerging economies such as Vietnam.

### 3. Research Data and Methodology

This study adopted a mixed-method research design, combining qualitative and quantitative approaches to ensure both theoretical robustness and empirical validity. The mixed-method approach is particularly appropriate for investigating sustainable e-commerce development, a complex and multidimensional phenomenon influenced by institutional, technological, organizational, and behavioral factors. By integrating qualitative insights with quantitative testing, the study enhances construct validity, contextual relevance, and the explanatory power of the proposed research model. The research was conducted in two sequential phases. The qualitative phase was used to refine the conceptual framework and measurement scales, while the quantitative phase aimed to empirically test the hypothesized relationships using structural equation modeling [41].

### 3.1. Qualitative Phase

The qualitative phase involved in-depth discussions with 35 managers, including economic policymakers, enterprise managers, and e-commerce platform managers. These participants were selected using purposive sampling based on their professional experience, managerial roles, and direct involvement in e-commerce development and digital transformation. This diverse group of experts ensured multiple perspectives on regulatory, technological, and organizational aspects of sustainable e-commerce development. Semi-structured discussion guidelines were used to facilitate open, in-depth exchanges while maintaining consistency across interviews. The discussions focused on identifying critical factors influencing sustainable e-commerce development, clarifying causal relationships among constructs, and evaluating the relevance of proposed measurement items within the Vietnamese context. Examples of guiding questions included: “Which regulatory or institutional factors most strongly influence the long-term sustainability of e-commerce in Vietnam?”, “How do resource constraints and managerial capabilities affect firms’ ability to sustain e-commerce operations?”, and “What role does trust play in shaping sustainable online transactions?”.

Qualitative data were analyzed using thematic analysis. Key themes related to regulatory quality, digital infrastructure, government support, competitive pressure, resource availability, trust, and management capacity were identified and compared across participants. The qualitative findings confirmed the relevance of the proposed constructs and provided valuable insights into the contextual nuances of Vietnam’s e-commerce ecosystem. Based on the qualitative results, construct definitions were refined, ambiguous items were revised or removed, and new items were added where necessary. The outcomes of this phase served as the basis for developing the official survey questionnaire, ensuring strong content validity and practical relevance.

### 3.2. Quantitative Phase

The quantitative phase employed a structured questionnaire developed from the qualitative findings and relevant literature. All constructs were measured using multi-item scales, with items adapted to the Vietnamese e-commerce context. A five-point Likert scale ranging from 1 (“strongly disagree”) to 5 (“strongly agree”) was used to capture respondents’ perceptions.

The questionnaire consisted of two main sections. The first section collected demographic information, including gender, age, marital status, income level, and online shopping experience. The second section measured the latent constructs in the research model: regulatory quality, digital infrastructure, government support, competitive pressure, resource availability, trust, management capacity, and sustainable e-commerce development. A pilot test was conducted with a small group of respondents to assess clarity, wording, and response time. Minor adjustments were made to improve readability and comprehension before full-scale data collection [41]. Based on the pilot test results, several refinements were made to the questionnaire. Specifically, ambiguous wording in items related to regulatory quality and trust was clarified, overlapping items were merged to reduce redundancy, and minor linguistic adjustments were introduced to improve respondent comprehension. In addition, the overall questionnaire length was slightly reduced to minimize respondent fatigue, while preserving the content validity of all constructs.

The target population for the quantitative study comprised frequent online shoppers in Ho Chi Minh City and Dong Nai Province, two major economic and e-commerce hubs in Southern Vietnam. These locations were selected for their high internet penetration, purchasing power, and active participation in e-commerce. A total of 700 questionnaires were distributed using a combination of online and offline survey methods. Respondents were screened to ensure that they had prior experience with online shopping. After data cleaning and screening for missing values and inconsistent responses, 653 valid questionnaires were retained for analysis, yielding a response rate of approximately 93.3%. The sample size exceeded the minimum requirements for SEM analysis, ensuring adequate statistical power.

The study employed Structural Equation Modeling (SEM) to analyze the data and test the proposed hypotheses. SEM is well-suited for this research, as it allows simultaneous estimation of multiple relationships among latent variables and accounts for measurement error. In addition, SEM enables the examination of both direct and interaction effects within a single comprehensive model. The analysis followed a two-step approach: (1) evaluation of the measurement model and (2) assessment of the structural model. The measurement model was assessed to ensure the reliability and validity of the constructs. Internal consistency reliability was evaluated using Cronbach’s alpha and Composite Reliability (CR), with threshold values of 0.70 or higher indicating acceptable reliability. Convergent validity was

assessed using Average Variance Extracted (AVE), with values above 0.50 considered satisfactory. Discriminant validity was examined by comparing the square root of AVE for each construct with the inter-construct correlations, as well as by evaluating the heterotrait–monotrait (HTMT) ratio.

These procedures ensured that each construct was empirically distinct from the others in the model. The structural model was evaluated by examining standardized path coefficients, t-statistics, and p-values obtained via bootstrapping. The significance of the hypotheses was determined using conventional criteria ( $p < 0.05$ ). The model’s explanatory power was assessed using the coefficient of determination ( $R^2$ ) for sustainable e-commerce development. Interaction effects were tested to examine the moderating roles of trust and management capacity. Product indicator approaches were used to construct interaction terms, and bootstrapping was applied to assess their statistical significance [41].

Table 1 shows that this study employed a rigorous mixed-method approach to investigate sustainable e-commerce development in Vietnam. The integration of qualitative insights with quantitative SEM analysis enhances the robustness of the findings and provides a comprehensive understanding of the factors influencing sustainability in e-commerce. The methodological design ensures that the results are both empirically sound and contextually meaningful, thereby strengthening the study’s contributions to theory and practice.

**Table 1.** Theoretical model evaluation criteria

Criterion	Threshold (Theory)	Notes
Outer Loading ( $\lambda$ )	$\geq 0.70$ (retain); 0.40–0.70 consider removal if AVE/CR improves	Indicator reliability
Indicator Reliability ( $\lambda^2$ )	$\geq 0.50$ (desirable)	
Cronbach's Alpha ( $\alpha$ )	$\geq 0.70$ (exploratory $\geq 0.60$ acceptable)	Internal consistency
Composite Reliability (CR)	0.70–0.95 (avoid $>0.95$ )	Preferred over $\alpha$
rho_A	$\geq 0.70$	Consistent reliability
Average Variance Extracted (AVE)	$\geq 0.50$	Convergent validity
VIF (Outer)	$< 5.0$ (strict $<3.3$ )	Indicator collinearity

## 4. Study Results

### 4.1. Descriptive Statistics

This study is based on a valid sample of 653 respondents who are frequent online shoppers in Ho Chi Minh City and Dong Nai Province. Descriptive statistical analysis was conducted to provide an overview of respondents' demographic characteristics and to assess the sample's representativeness within the research context.

Regarding gender distribution, the sample shows a relatively balanced structure with a slight predominance of female respondents. Specifically, 384 respondents were female, while 269 respondents were male. This distribution reflects the increasing participation of women in online shopping activities in Vietnam, particularly in urban and peri-urban areas, where e-commerce adoption rates are high. Regarding marital status, the majority of respondents were married 403, while 250 were single. Regarding age, the sample is dominated by middle-aged consumers. The largest group is respondents aged 35 to 45, who represent the sample. This is followed by the 25-35 age group; this age structure indicates that individuals in their most economically active years constitute the core segment of frequent online shoppers, underscoring the data's relevance for analyzing sustainable e-commerce development. Regarding average monthly income, a relatively high-income profile is observed. Respondents earning above 25 million VND per month, while those earning between 20 and 25 million VND. Together, these two groups comprise more than 73% of the sample. Respondents with incomes between 15 and 20 million VND. This income distribution suggests that frequent online shoppers tend to have stable and relatively high purchasing power. Finally, regarding the online shopping experience, the majority of respondents reported long-term engagement with online shopping platforms. Specifically, 10-15 years of experience, and more than 15 years. This indicates that the sample consists mainly of experienced users, which strengthens the reliability of their perceptions regarding trust, regulatory quality, and sustainable e-commerce

development. The demographic characteristics indicate that the sample is appropriate and robust for SEM analysis and for examining the determinants of sustainable e-commerce development in Vietnam.

#### 4.2. Testing Critical Factors Influencing Sustainable E-commerce Development

Table 2 presents the results of the reliability and convergent validity assessment for the constructs used in the research model. The measurement quality was evaluated using Cronbach’s alpha (CA), Composite Reliability (CR), and Average Variance Extracted (AVE), in accordance with established SEM guidelines.

**Table 2.** Reliability and Convergent Validity Analysis

Factors	Number of items	Mean	Standard deviation	Cronbach's alpha	Composite reliability	Average variance extracted	VIF
COM	4	3.102	0.912	0.931	0.948	0.819	3.418
DIG	4	3.235	0.954	0.938	0.956	0.843	4.190
GOV	4	3.324	0.985	0.862	0.885	0.667	3.228
MAN	3	3.305	0.946	0.906	0.936	0.830	3.490
REG	4	3.146	0.957	0.911	0.937	0.790	2.998
RES	3	3.092	0.964	0.894	0.934	0.825	2.918
SED	3	3.155	0.913	0.822	0.893	0.736	1.853
TRU	4	3.204	0.931	0.860	0.901	0.697	2.236

(1) Internal consistency reliability was assessed using Cronbach’s alpha. The results indicate that all constructs exceed the recommended threshold of 0.70, demonstrating satisfactory reliability. Specifically, Cronbach’s alpha values range from 0.822 (SED) to 0.938 (DIG). These findings confirm that the measurement items within each construct are internally consistent and reliably capture the underlying latent variables. Notably, the constructs Competitive Pressure (COM) and Digital Infrastructure (DIG) exhibit particularly high reliability, with Cronbach’s alpha values above 0.93, indicating excellent internal consistency.

(2) Composite Reliability (CR) values for all constructs range from 0.885 (GOV) to 0.956 (DIG), well above the recommended minimum of 0.70. This further confirms the robustness of the measurement scales and suggests that the constructs are measured with high precision. The high CR values also indicate that the indicators collectively provide a strong representation of their respective latent variables.

(3) Convergent validity was assessed using the Average Variance Extracted (AVE). As shown in table 2, all AVE values exceed the commonly accepted threshold of 0.50, ranging from 0.667 (GOV) to 0.843 (DIG). This demonstrates that each construct explains more than 50% of the variance of its observed indicators, thereby confirming adequate convergent validity. In particular, constructs such as DIG, MAN, RES, and COM exhibit AVEs above 0.80, indicating strong convergence between the observed measures and the latent constructs.

(4) The mean values of the constructs range from 3.092 to 3.324, suggesting that respondents generally expressed moderate to relatively positive perceptions of the factors influencing sustainable e-commerce development. The standard deviation values, which range from 0.912 to 0.985, indicate an acceptable level of variability in respondents’ perceptions without excessive dispersion. Finally, the results in table 2 confirm that the measurement model demonstrates high reliability and satisfactory convergent validity, providing a solid foundation for subsequent structural model analysis and hypothesis testing using SEM. In addition to construct-level reliability and validity, item-level diagnostics were examined. All measurement items exhibited satisfactory outer loadings exceeding the recommended threshold of 0.70, and variance inflation factor (VIF) values were below the critical value of 5.0, indicating no significant multicollinearity concerns (table 2).

Table 3 presents the Discriminant validity, which was further assessed using the heterotrait–monotrait ratio (HTMT). As reported in table 3, all HTMT values, including those involving the interaction constructs (TRU × REG and MAN

× RES), are well below the conservative threshold of 0.85, indicating satisfactory discriminant validity among all constructs. These results confirm that the measurement model demonstrates adequate construct distinctiveness.

**Table 3.** Heterotrait–Monotrait Ratio (HTMT)

Codes	COM	DIG	GOV	MAN	REG	RES	SED	TRU	TRU x REG	MAN x RES
COM	-									
DIG	0.089	-								
GOV	0.060	0.201	-							
MAN	0.111	0.067	0.135	-						
REG	0.038	0.178	0.061	0.128	-					
RES	0.069	0.142	0.144	0.079	0.608	-				
SED	0.100	0.234	0.136	0.068	0.516	0.575	-			
TRU	0.074	0.144	0.057	0.081	0.057	0.036	0.117	-		
TRU x REG	0.023	0.076	0.107	0.095	0.177	0.271	0.252	0.024	-	
MAN x RES	0.070	0.114	0.057	0.051	0.018	0.020	0.085	0.074	0.018	-

Table 4 presents the results of the structural model analysis, including path coefficients, standard deviations, t-statistics, p-values, and hypothesis testing outcomes. The structural relationships were assessed using SEM with bootstrapping procedures to evaluate the significance of both direct and moderating effects. The results indicate that all proposed hypotheses are empirically supported, demonstrating the robustness of the research model in explaining sustainable e-commerce development. Regarding the direct effects, regulatory quality (REG) has a significant and positive impact on sustainable e-commerce development ( $\beta = 0.238$ ,  $t = 6.234$ ,  $p < 0.001$ ), supporting H1. This finding highlights the crucial role of effective, transparent regulatory frameworks in fostering a stable, sustainable e-commerce environment. Digital infrastructure (DIG) also positively and significantly affects sustainable e-commerce development ( $\beta = 0.171$ ,  $t = 5.195$ ,  $p < 0.001$ ), confirming H2. This result emphasizes that high-quality digital connectivity, payment systems, and technological infrastructure are essential drivers of sustainable e-commerce performance.

**Table 4.** Structural model results and hypothesis testing

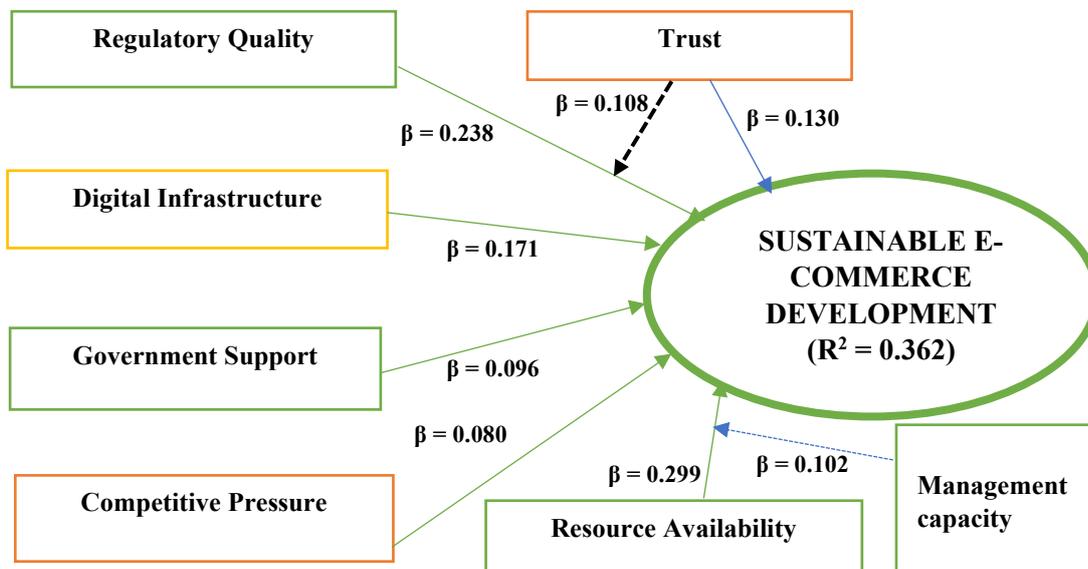
Hypothesis	Relationships	Original sample	Standard deviation	P values	CI 2.5%	CI 97.5%	Supported hypothesis
H1	REG → SED	0.238	0.038	0.000	0.034	0.140	Yes
H2	DIG → SED	0.171	0.033	0.000	0.106	0.233	Yes
H3	GOV → SED	0.096	0.037	0.010	0.027	0.167	Yes
H4	COM → SED	0.080	0.031	0.010	0.011	0.162	Yes
H5	RES → SED	0.299	0.039	0.000	0.164	0.313	Yes
H6	TRU → SED	0.130	0.031	0.000	0.223	0.374	Yes
H7	TRU x REG → SED	0.108	0.033	0.001	0.080	0.191	Yes
H8	MAN x RES → SED	0.102	0.039	0.009	0.036	0.168	Yes

Similarly, government support (GOV) has a statistically significant positive influence on sustainable e-commerce development ( $\beta = 0.096$ ,  $t = 2.578$ ,  $p = 0.010$ ), supporting H3. Although the effect size is relatively smaller, the finding suggests that policy incentives and governmental assistance play a meaningful role in promoting sustainable e-commerce practices. Competitive pressure (COM) also positively affects sustainable e-commerce development ( $\beta = 0.080$ ,  $t = 2.573$ ,  $p = 0.010$ ), thereby supporting H4. This indicates that market competition encourages firms to innovate and adopt more sustainable and trustworthy e-commerce strategies. Among all direct effects, resource availability (RES) exhibits the most decisive influence on sustainable e-commerce development ( $\beta = 0.299$ ,  $t = 7.701$ ,  $p < 0.001$ ),

providing strong support for H5. This result underscores the central importance of financial, technological, and human resources in achieving sustainable e-commerce outcomes. Furthermore, trust (TRU) significantly and positively impacts sustainable e-commerce development ( $\beta = 0.130$ ,  $t = 4.214$ ,  $p < 0.001$ ), supporting H6. This confirms that trust is a critical determinant of long-term participation and stability in e-commerce markets.

Regarding the interaction (moderating) effects, the interaction between trust and regulatory quality ( $TRU \times REG$ ) is positive and statistically significant ( $\beta = 0.108$ ,  $t = 3.246$ ,  $p = 0.001$ ), supporting H7. This finding suggests that trust strengthens the positive effect of regulatory quality on sustainable e-commerce development. Similarly, the interaction between management capacity and resource availability ( $MAN \times RES$ ) has a significant positive impact on sustainable e-commerce development ( $\beta = 0.102$ ,  $t = 2.628$ ,  $p = 0.009$ ), supporting H8. This result indicates that management capacity enhances the effectiveness with which available resources are transformed into sustainable e-commerce performance. Overall, the structural model results provide strong empirical evidence that regulatory, technological, organizational, and relational factors jointly contribute to sustainable e-commerce development, with both direct and interaction effects playing significant roles.

Figure 2 illustrates the results of the structural equation model (SEM) used to examine the critical factors influencing sustainable e-commerce development. The model presents standardized path coefficients along with corresponding p-values, providing a visual summary of both direct and interaction effects among the latent constructs. The structural model explains a substantial proportion of variance in Sustainable E-commerce Development (SED), with an  $R^2$  value of 0.362. This indicates that approximately 36.2% of the variance in sustainable e-commerce development is jointly explained by regulatory quality, digital infrastructure, government support, competitive pressure, resource availability, trust, and the interaction effects included in the model. According to SEM guidelines, this level of explanatory power can be considered moderate to substantial, particularly in social science and behavioral research contexts.



**Figure 2.** Testing critical factors influencing sustainable E-commerce development

As shown in figure 2, resource availability (RES) exerts the most substantial direct effect on sustainable e-commerce development ( $\beta = 0.299$ ,  $p < 0.001$ ), highlighting the central role of financial, technological, and human resources in supporting sustainable e-commerce operations. Regulatory quality (REG) also exerts a strong, significant direct influence on SED ( $\beta = 0.238$ ,  $p < 0.001$ ), confirming the importance of an effective and transparent regulatory environment. In addition, digital infrastructure (DIG) has a positive and significant effect on sustainable e-commerce development ( $\beta = 0.171$ ,  $p < 0.001$ ), underscoring the role of reliable connectivity, digital payment systems, and technological readiness. Trust (TRU) further contributes significantly to SED ( $\beta = 0.130$ ,  $p < 0.001$ ), indicating that confidence in e-commerce platforms and transactions is essential for long-term sustainability.

Although relatively minor in magnitude, the effects of government support (GOV) ( $\beta = 0.096$ ,  $p = 0.010$ ) and competitive pressure (COM) ( $\beta = 0.080$ ,  $p = 0.010$ ) remain statistically significant, suggesting that policy incentives

and market competition also play meaningful roles in shaping sustainable e-commerce development. Importantly, [Figure 2](#) also illustrates the model's interaction effects. The interaction between trust and regulatory quality ( $TRU \times REG$ ) shows a positive and significant impact on sustainable e-commerce development ( $\beta = 0.108$ ,  $p = 0.001$ ), indicating that higher levels of trust strengthen the positive impact of regulatory quality on sustainability outcomes. Similarly, the interaction between management capacity and resource availability ( $MAN \times RES$ ) is significant ( $\beta = 0.102$ ,  $p = 0.009$ ), suggesting that management capacity enhances the effectiveness with which available resources are transformed into sustainable e-commerce performance. Finally, [figure 2](#) provides strong visual and empirical evidence that sustainable e-commerce development is driven by a combination of regulatory, technological, organizational, and relational factors, as well as by critical interaction mechanisms that amplify these effects. The findings reinforce the multidimensional nature of sustainability in e-commerce and validate the proposed research model.

### 4.3. Discussion of Findings

This study provides comprehensive empirical evidence on the determinants of sustainable e-commerce development in Vietnam by integrating regulatory, technological, organizational, and relational perspectives within a structural equation modeling framework. Based on data collected from 653 frequent online shoppers in HCMC and Dong Nai Province, the findings confirm that sustainable e-commerce development is a multidimensional phenomenon influenced by both direct effects and interaction mechanisms. The results strongly support the proposed research model and contribute meaningful insights to the existing literature on e-commerce sustainability in emerging economies.

(1) The results demonstrate that regulatory quality (REG) has a significant and positive impact on sustainable e-commerce development. This finding is consistent with Institutional Theory, which emphasizes the role of formal rules and enforcement mechanisms in shaping organizational behavior and market outcomes [13], [42]. In the Vietnamese context, where e-commerce markets are rapidly expanding but still face challenges in consumer protection, data privacy, and counterfeit goods, robust regulations reduce uncertainty and foster a more predictable, trustworthy environment. The empirical evidence suggests that clear, effectively enforced regulations encourage firms to invest in compliant, long-term e-commerce strategies, thereby enhancing sustainability. This finding aligns with prior studies highlighting the importance of institutional quality in digital market development, particularly in emerging economies.

(2) Digital infrastructure (DIG) is found to influence sustainable e-commerce development positively. This result reinforces the technological dimension of the Technology–Organization–Environment (TOE) framework, which posits that technological readiness is a prerequisite for effective digital transformation [17], [43]. Robust internet connectivity, secure payment systems, and reliable digital platforms enable seamless transactions, reduce operational inefficiencies, and support environmentally sustainable practices such as paperless transactions and optimized logistics. In Vietnam, ongoing investments in digital infrastructure have played a crucial role in accelerating e-commerce adoption. The findings indicate that digital infrastructure not only supports growth but also contributes to sustainability by enhancing system reliability and reducing resource waste.

(3) The analysis reveals a significant positive effect of government support (GOV) on sustainable e-commerce development. Although the magnitude of this effect is smaller than that of other factors, it remains statistically meaningful [23], [44]. This suggests that policy incentives, training programs, and public investments support sustainable e-commerce practices. Government support is significant for Small And Medium-Sized Enterprises (SMEs), which often face resource constraints and capability gaps. In Vietnam, initiatives to promote digital transformation and support e-commerce adoption appear to create favorable conditions for sustainable development. This finding is consistent with the view that government intervention can correct market imperfections and encourage responsible digital business practices.

(4) Competitive pressure (COM) is shown to have a positive and significant effect on sustainable e-commerce development. This result suggests that market competition acts as a catalyst for innovation and improvement in e-commerce practices [28], [32], [45]. In highly competitive environments, firms are compelled to enhance service quality, increase transparency, and build stronger customer relationships. In the context of e-commerce, competition increasingly revolves around trust, delivery reliability, and compliance with sustainability standards rather than price alone. The findings imply that competitive pressure encourages firms to adopt sustainable practices to differentiate and

enhance long-term competitiveness, supporting arguments in the literature that competition can drive sustainability-oriented innovation.

(5) Among all direct effects, resource availability (RES) emerges as the most influential determinant of sustainable e-commerce development. This finding strongly supports the Resource-Based View (RBV), which posits that access to valuable and strategic resources is fundamental to achieving sustainable competitive advantage [39], [46], [47]. E-commerce sustainability requires substantial investments in technology, human capital, cybersecurity, logistics, and data analytics. Firms with greater resource availability are better equipped to implement sustainable practices, manage operational risks, and adapt to regulatory and market changes. In Vietnam's rapidly evolving digital economy, resource-rich firms are better positioned to sustain long-term e-commerce growth, underscoring the critical role of resource endowments.

(6) Trust (TRU) is found to have a significant positive effect on sustainable e-commerce development. This result underscores the central role of trust in digital environments characterized by information asymmetry and perceived risk [48], [49]. Trust reduces consumers' concerns about transaction security, data privacy, and product quality, thereby increasing participation and repeat purchasing. At a broader level, trust enhances the stability of the e-commerce ecosystem and reduces transaction and monitoring costs. The findings confirm that trust is not merely a relational outcome but a key driver of sustainability in e-commerce markets.

Beyond direct effects, this study makes an essential contribution by examining interaction mechanisms. The results indicate that trust moderates the relationship between regulatory quality and sustainable e-commerce development [34] [50]. Specifically, higher levels of trust strengthen the positive impact of regulatory quality on sustainability outcomes. This finding suggests that regulations are more effective when they are perceived as credible and trustworthy by market participants. Even well-designed rules may have a limited impact if trust in institutions is low. Therefore, trust serves as a critical transmission mechanism through which regulatory quality translates into sustainable e-commerce development. This insight extends prior research by highlighting the complementary roles of formal institutions and informal trust in digital markets.

(7) The interaction between management capacity (MAN) and resource availability (RES) is found to enhance sustainable e-commerce development significantly. This result emphasizes that resources alone are insufficient to achieve sustainability unless they are effectively managed [39], [51]. Strong management capacity enables firms to allocate resources strategically, integrate sustainability considerations into decision-making, and respond proactively to environmental and market challenges. In line with RBV, this finding demonstrates that managerial capabilities play a vital role in transforming resource availability into sustainable performance. For e-commerce firms in Vietnam, investments in organizational skills, digital leadership, and strategic planning are therefore essential for maximizing the sustainability benefits of available resources.

(8) The findings suggest that a synergistic combination of institutional quality, technological readiness, organizational resources, managerial capabilities, market dynamics, and trust drives sustainable e-commerce development in Vietnam. The model's relatively high explanatory power indicates that these factors jointly provide a robust explanation of sustainability outcomes in the e-commerce sector. Notably, the results highlight that sustainability is not solely a technological or regulatory issue but requires coordinated efforts across multiple dimensions. From a theoretical perspective, this study contributes to the literature by integrating Institutional Theory, the TOE framework, and the RBV into a unified model of sustainable e-commerce development. The empirical evidence supports the relevance of these theoretical lenses and demonstrates how they interact in an emerging economy context. By incorporating interaction effects, the study also advances understanding of the mechanisms through which regulatory and resource-based factors influence sustainability outcomes.

Inclusion, the discussion of findings reveals that achieving sustainable e-commerce development in Vietnam requires more than rapid digital growth. It depends on high-quality regulations, strong digital infrastructure, supportive government policies, competitive market dynamics, sufficient resources, effective management, and, critically, trust among market participants. These insights provide a solid foundation for developing targeted policy interventions and managerial strategies to foster a more sustainable and resilient e-commerce ecosystem.

## 5. Conclusion and Recommendations

### 5.1. Conclusion

This study examined the critical factors influencing sustainable e-commerce development in Vietnam by integrating regulatory, technological, organizational, and relational perspectives within a structural equation modeling framework. Using data collected from 653 frequent online shoppers in Ho Chi Minh City and Dong Nai Province, the findings provide robust empirical evidence on both direct and interaction effects shaping sustainable e-commerce outcomes. The results indicate that regulatory quality, digital infrastructure, government support, competitive pressure, resource availability, and trust all have significant positive impacts on sustainable e-commerce development. Although the findings are largely consistent with prior research highlighting the positive roles of institutions, resources, and technology, evidence from other emerging markets has shown mixed results. In some contexts, excessive regulatory intervention or intense competition may constrain innovation and undermine sustainability. The results of this study suggest that Vietnam's ongoing institutional reforms and growing digital trust may mitigate such effects, underscoring the context-dependent nature of sustainable e-commerce development. Among these factors, resource availability and regulatory quality are the most influential drivers, underscoring the importance of both organizational capacity and institutional effectiveness. Furthermore, the study confirms the critical role of trust in strengthening the impact of regulatory quality, as well as the importance of management capacity in enhancing the effectiveness of resource utilization. Finally, the findings suggest that sustainable e-commerce development in Vietnam is not solely driven by technological advancement or market expansion, but requires a coordinated ecosystem that includes effective regulations, strong digital infrastructure, capable management, sufficient resources, and high levels of trust. By providing a comprehensive, empirically validated model, this study contributes to the growing literature on e-commerce sustainability. It offers valuable insights for policymakers, practitioners, and scholars seeking to promote sustainable digital commerce in emerging economies.

### 5.2. Policy Recommendations

Based on the empirical findings and the magnitude of the standardized beta coefficients, this study proposes a set of policy recommendations to promote sustainable e-commerce development in Vietnam. The prioritization of policy actions is based on the relative strength of each factor's impact on sustainable e-commerce development, thereby ensuring the efficient allocation of public resources and policy efforts.

(1) Strengthening resource availability should be the top policy priority, as it has the most substantial direct effect on sustainable e-commerce development ( $\beta = 0.299$ ). Policymakers should focus on improving firms' access to financial capital, digital technologies, skilled human resources, and supporting ecosystems. This can be achieved through targeted financial support programs, preferential credit schemes for e-commerce and digital transformation projects, and public-private partnerships that facilitate access to advanced technologies and logistics infrastructure. In addition, policies aimed at developing digital skills and managerial talent are essential to ensure that firms, tiny and medium-sized enterprises (SMEs), can effectively leverage available resources to achieve sustainable outcomes.

(2) Improving regulatory quality should be prioritized as a core institutional reform, given its strong influence on sustainable e-commerce development ( $\beta = 0.238$ ) and its significant interaction with trust. Policymakers should enhance the clarity, consistency, and enforceability of regulations related to e-commerce transactions, data protection, cybersecurity, consumer rights, and dispute resolution. Transparent and predictable regulatory frameworks reduce uncertainty and foster long-term investment in sustainable e-commerce practices. Furthermore, regulatory reforms should be accompanied by effective enforcement mechanisms to ensure compliance and maintain market integrity, thereby reinforcing institutional credibility.

(3) Continued investment in digital infrastructure is essential, as digital infrastructure has a substantial positive effect on sustainable e-commerce development ( $\beta = 0.171$ ). Government efforts should focus on expanding high-quality broadband coverage, improving digital payment systems, strengthening cybersecurity infrastructure, and promoting interoperability among digital platforms. Special attention should be given to reducing the digital divide between urban and peri-urban areas to ensure inclusive and sustainable e-commerce growth. Investments in green digital

infrastructure, such as energy-efficient data centers and intelligent logistics systems, should also be encouraged to align digital expansion with environmental sustainability goals.

(4) Policies aimed at building and maintaining trust in the e-commerce ecosystem should be emphasized, given the significant effect of trust on sustainable e-commerce development ( $\beta = 0.130$ ) and its role in strengthening the impact of regulatory quality. Policymakers should enhance consumer protection mechanisms, maintain data privacy and cybersecurity regulations, and promote transparency in online transactions. Public awareness campaigns and digital literacy programs can further improve consumer confidence and trust in e-commerce platforms. In addition, fostering trust between government agencies, businesses, and consumers is crucial for ensuring the effectiveness of regulatory interventions. Government support programs should be refined and made more effective, as they positively influence sustainable e-commerce development ( $\beta = 0.096$ ). Rather than broad-based interventions, policymakers should design targeted support initiatives tailored to specific industry needs, firm sizes, and stages of digital maturity. Support programs should prioritize sustainability-oriented practices, such as green logistics, responsible data governance, and ethical digital marketing.

(5) Competitive pressure should be leveraged as a policy tool, despite its relatively smaller effect size ( $\beta = 0.080$ ). Policymakers should promote fair competition by preventing monopolistic practices, ensuring a level playing field, and encouraging innovation. Competitive markets incentivize firms to improve service quality, transparency, and sustainability standards, thereby contributing to long-term e-commerce development. Effective policies for sustainable e-commerce development in Vietnam should prioritize resource availability and regulatory quality, followed by investments in digital infrastructure and trust-building mechanisms, while complementing these efforts with targeted government support and competition-enhancing measures. While the policy recommendations are discussed in order of their estimated effect sizes, their practical implementation may face different levels of feasibility and political constraints. Regulatory reforms and infrastructure investments often require substantial coordination, financial resources, and institutional capacity, which may limit short-term implementation. In contrast, initiatives aimed at enhancing trust and managerial capabilities can be more readily implemented at the organizational or platform level. Policymakers should therefore consider both impact and feasibility when prioritizing interventions to promote sustainable e-commerce development.

The study acknowledges several limitations that should be considered when interpreting the findings. First, the data were collected from frequent online shoppers in Ho Chi Minh City and Dong Nai Province, which may limit the generalizability of the results to other regions of Vietnam, particularly rural areas where digital infrastructure and e-commerce adoption levels differ. Second, the study employed a cross-sectional research design, which restricts the ability to infer causal relationships among the examined variables. Longitudinal studies would provide deeper insights into how sustainable e-commerce development evolves. Third, the use of self-reported survey data may introduce common-method bias and subjective-perception bias, despite the application of established reliability and validity tests. Finally, although the model incorporates key regulatory, technological, and organizational factors, other potentially relevant variables, such as environmental awareness, platform governance, and cultural influences, were not included. Future research could address these limitations by expanding the sample scope, adopting longitudinal designs, and incorporating additional explanatory variables. In addition, this study may be subject to endogeneity and measurement error, common concerns in SEM-based research. Although the proposed model is theoretically grounded and validated through multiple reliability and validity checks, unobserved variables or reciprocal relationships may still influence the estimated paths. Future studies could address these issues by employing longitudinal designs, instrumental variable approaches, or alternative measurement strategies to further strengthen causal inference.

## 6. Declarations

### 6.1. Author Contributions

Conceptualization: M.T.L., P.T.T.; Methodology: P.T.T.; Software: M.T.L.; Validation: M.T.L. and P.T.T.; Formal Analysis: M.T.L. and P.T.T.; Investigation: M.T.L.; Resources: P.T.T.; Data Curation: P.T.T.; Writing Original Draft Preparation: M.T.L. and P.T.T.; Writing Review and Editing: P.T.T. and M.T.L.; Visualization: M.T.L.; All authors have read and agreed to the published version of the manuscript.

## 6.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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## 6.4. Institutional Review Board Statement

Not applicable.

## 6.5. Informed Consent Statement

Not applicable.

## 6.6. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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