

“Digital transformation as a moderator of green innovation and export performance: Evidence from Vietnamese exporting firms”

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DIGITAL TRANSFORMATION AS A MODERATOR OF GREEN INNOVATION AND EXPORT PERFORMANCE: EVIDENCE FROM VIETNAMESE EXPORTING FIRMS

Abstract

This study examines the relationships among green innovation, digital transformation, and export performance in Vietnamese exporting firms, with particular attention to the moderating role of digital transformation. Data were collected through a structured survey conducted between April and December 2025. The final sample comprised 292 valid firm-level responses, with one respondent representing each exporting firm. Respondents were managers, executives, or functional staff directly involved in export operations, production, logistics, or strategic decision-making. Ordinary least squares regression with an interaction term was employed to test the proposed relationships. When digital transformation was at its sample mean, green innovation was positively and significantly associated with export performance ($B = 0.169, p < 0.001$). Correspondingly, when green innovation was at its sample mean, digital transformation was positively and significantly associated with export performance ($B = 0.235, p < 0.001$). The interaction between green innovation and digital transformation was positive and statistically significant ($B = 0.587, p < 0.001$), indicating that the association between green innovation and export performance became more positive as digital transformation increased. Conditional-slope analysis revealed a crossover interaction: the relationship was negative at a selected lower level of digital transformation, positive at its sample mean, and substantially stronger at a selected higher level. The model explained 44.6% of the variance in export performance. These findings highlight the complementarity of green and digital capabilities and suggest that digital transformation is an important enabling condition for translating green innovation into stronger export-related outcomes in an emerging economy.

Keywords

innovation, transformation, export performance, exporting firms, moderating effect, emerging economy, Vietnam

JEL Classification

F14, O33, Q55

INTRODUCTION

In the context of globalization, exporting firms are increasingly confronted with two interrelated transformations. On the one hand, rapid digitalization is reshaping business operations, market access, and international trade processes through the adoption of advanced technologies such as artificial intelligence, big data, and e-commerce platforms. On the other hand, global markets are imposing stricter environmental standards, sustainability requirements, and traceability regulations, making environmentally responsible practices an increasingly important condition for maintaining access to international markets. These structural shifts are redefining the determinants of export competitiveness, particularly for firms operating in emerging economies.

The relevance of this issue is particularly evident in Vietnam, where export-oriented growth remains a central pillar of economic development. Vietnam's total merchandise trade reached about USD 930 billion in 2025, an increase of more than 18% compared with the previous year, while the country maintained a trade surplus of over USD 20 billion (Vietnam Customs, 2026). These figures indicate the growing scale and international exposure of Vietnamese firms, while also suggesting that they are becoming more sensitive to changing requirements in global markets, including digital trade processes, traceability systems, sustainability standards, and environmental compliance. At the global level, recent international trade reports and policy debates increasingly emphasize the role of digital technologies, including artificial intelligence, in reshaping international trade, market access, and firm competitiveness (WTO, 2025). At the same time, environmental and carbon-related trade requirements, such as the European Union's Carbon Border Adjustment Mechanism, signal that exporters must increasingly demonstrate environmental responsibility and supply-chain transparency, as CBAM entered a transitional phase during 2023–2025 and applies its definitive regime from 2026 (European Commission, n.d.).

For Vietnamese exporting firms, these developments create a dual pressure. While digital transformation offers opportunities to improve efficiency, transparency, and connectivity with global markets, green innovation has become increasingly important for complying with environmental regulations and maintaining access to key export destinations. However, many firms continue to face constraints in financial capacity, technological readiness, human resources, and institutional support, limiting their ability to respond effectively to these simultaneous demands. As a result, firms' ability to adapt to both digital and sustainability requirements remains uneven.

Although prior research has increasingly examined the importance of digital transformation and green innovation for firm performance, empirical evidence on how these factors jointly shape export outcomes remains limited, particularly at the firm level in transition economies. Most existing studies examine these drivers independently, paying insufficient attention to their complementarity and the possibility that their relationships with export performance are conditional. This limitation is important because green innovation may not automatically yield export benefits unless firms possess complementary digital capabilities that enable them to monitor environmental performance, improve traceability, communicate sustainability attributes, and respond more effectively to foreign customers and regulatory requirements. This gap is especially relevant in the Vietnamese context, where firms are undergoing rapid integration into global markets while facing increasing technological and environmental pressures.

The scientific problem, therefore, concerns the conditional nature of the relationship between green innovation and export performance. Although green innovation is generally expected to support environmental compliance, resource efficiency, and market differentiation, it remains unclear whether it is associated with stronger export performance across different organizational conditions or whether its export-related value depends on firms' level of digital transformation. Existing research has not sufficiently established whether digital transformation operates only as an independent determinant of export performance or also as a complementary capability that changes the strength and potentially the direction of the relationship between green innovation and export performance.

1. LITERATURE REVIEW AND HYPOTHESES

The relationship between innovation, digital transformation, and export performance has been increasingly discussed within strategic management and international business literature. This stream of research is primarily grounded in the

resource-based view (RBV), while institutional theory provides a complementary contextual explanation of firms' responses to external market pressures. The RBV posits that firms achieve sustained competitive advantage when they possess valuable, rare, inimitable, and non-substitutable resources (Wernerfelt, 1984; Barney, 1991). In this context, digital capabilities and green inno-

vation can be conceptualized as strategic organizational capabilities that enhance firm efficiency, adaptability, and differentiation (Teece, 2007; Luu, 2023). Meanwhile, institutional theory emphasizes that firms must respond to external pressures, such as environmental regulations, international standards, and stakeholder expectations, to maintain legitimacy and access to global markets (DiMaggio & Powell, 1983; Scott, 2014). Together, these perspectives suggest that internal organizational capabilities and external institutional pressures are both relevant to firms' export performance, particularly in the context of digitalization and sustainability transitions.

Export performance (EP) refers to the extent to which a firm achieves favorable outcomes from its activities in international markets. This term is commonly conceptualized as a multidimensional construct that includes financial outcomes, such as export sales growth and export profitability, as well as strategic outcomes, such as export market share and the achievement of export-related objectives (Cavusgil & Zou, 1994; Zou et al., 1998). In this study, export performance is treated as a firm-level outcome and measured through respondents' perceived assessments of improvements in export sales, profitability, market share, and strategic objectives. This subjective measurement approach is appropriate because firm-level export performance data are often difficult to obtain from private enterprises and because knowledgeable respondents' evaluations are widely used in export performance research (Zou et al., 1998).

Green innovation (GI) has emerged as a critical capability enabling firms to reconcile economic performance with environmental sustainability. It encompasses the development and application of environmentally friendly products, processes, organizational practices, and marketing strategies to improve resource efficiency and reduce ecological impacts (Chen et al., 2006; Singh et al., 2024). Prior studies suggest that green innovation can enhance firms' ability to comply with stringent environmental standards in export markets, thereby reducing trade barriers and improving international competitiveness (Porter & Linde, 1995; Shu et al., 2024). In addition, green innovation may contribute to cost efficiency through reduced energy consumption, waste minimization, and improved re-

source utilization, while simultaneously supporting product differentiation and brand positioning in environmentally conscious markets (Ullah et al., 2024; Ngo, 2025; Tran et al., 2025). From an RBV perspective, green innovation represents a strategic capability because it allows firms to create value through efficiency improvement and differentiation. From an institutional perspective, it may also strengthen firms' legitimacy by enabling them to respond to environmental standards and stakeholder expectations in international markets. Empirical evidence from emerging-market and exporting-firm contexts suggests that green innovation is associated with stronger export-related and sustainability outcomes (Shu et al., 2024; Singh et al., 2024; Ullah et al., 2024; Ngo, 2025).

Digital transformation (DT), on the other hand, refers to the integration of digital technologies into business processes, organizational structures, and strategic decision-making to enhance firm performance and competitiveness (Vial, 2019; Luu, 2023). Recent studies emphasize that digital transformation extends beyond technological adoption, encompassing organizational change, capability development, and innovation-oriented culture (Warner & Wäger, 2019; Huang & Lau, 2024). In this study, digital transformation is understood as the firm-level use of digital technologies, digital platforms, international e-commerce, digitally skilled personnel, and data analytics to support business operations and export-related decision-making. In the context of export activities, digital transformation enables firms to access international markets more efficiently, improve supply chain coordination, and enhance transparency and traceability, all of which are increasingly critical in global trade (Kraus et al., 2022; Zhang et al., 2024; Bui et al., 2025). Furthermore, digital technologies such as artificial intelligence, big data analytics, and e-commerce platforms facilitate market intelligence, demand forecasting, and customer engagement, thereby supporting export performance in both scale and scope (Wang & Ye, 2023; Zhang et al., 2024). From the RBV and dynamic capabilities perspectives, digital transformation can be viewed as an enabling capability that helps firms reconfigure resources, process market information, and respond more effectively to changes in foreign markets. Accordingly, a growing body of empirical research provides evi-

dence of a positive relationship between digital transformation and firm-level export outcomes, particularly in dynamic and competitive environments (Luu, 2023; Wang & Ye, 2023; Zhang et al., 2024).

Beyond their independent relationships with export performance, recent studies have begun to explore the interaction between digital transformation and green innovation. This emerging perspective suggests that digital transformation acts as an enabling organizational capability that enhances the effectiveness of green innovation. Digital technologies support green product development through simulation and data analytics, optimize production processes by improving energy efficiency and resource allocation, and strengthen environmental monitoring and compliance systems (Huang & Lau, 2024; Zhu et al., 2024). At the same time, digital platforms facilitate green marketing and communication, allowing firms to convey sustainability attributes to international customers more effectively and to build trust in global markets (Ngo, 2025).

Moreover, digital transformation fosters knowledge ecosystems that accelerate the diffusion of green innovation practices. By reducing information asymmetry and improving access to international standards, digital tools enable firms to align their green strategies with market requirements more efficiently (Zhu et al., 2024). This logic suggests that green innovation may not automatically generate stronger export outcomes in the absence of complementary digital capabilities. For example, environmentally friendly products and processes may create limited market value if firms are unable to document compliance, ensure traceability, communicate sustainability attributes, or use data-driven tools to respond to foreign customer

requirements. Where complementary digital capabilities are insufficient, the implementation, coordination, documentation, and communication demands associated with green innovation may not be offset by corresponding export-related benefits. As a result, digital transformation may not only be directly associated with export performance but also strengthen the relationship between green innovation and export performance by increasing the efficiency, scalability, visibility, and market relevance of green practices. This complementary relationship implies that the benefits of green innovation may vary across firms with different levels of digital capability. In other words, firms with stronger digital transformation are expected to be better positioned to convert green innovation into export-related benefits.

Taken together, prior studies suggest that green innovation and digital transformation are both relevant to firms' export-related outcomes. The literature further indicates that digital capabilities may enhance the implementation, traceability, scalability, and market communication of green innovation, implying that its export-related value may vary across levels of digital transformation. However, empirical evidence on this conditional relationship remains limited, particularly in transition economies such as Vietnam, where exporting firms face simultaneous digital and environmental pressures.

The purpose of this study is to examine the relationships among green innovation, digital transformation, and export performance and to determine whether digital transformation moderates the relationship between green innovation and export performance in Vietnamese exporting firms. The proposed research model is presented in Figure 1.

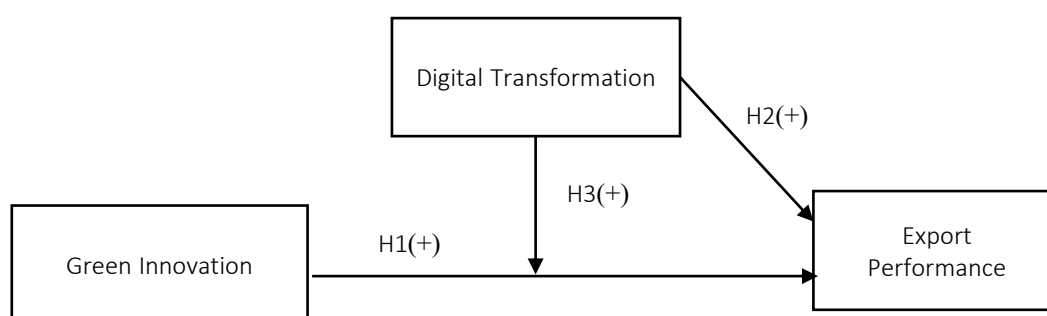


Figure 1. Proposed research model

The following hypotheses are proposed:

- H1: Green innovation is positively associated with firms' export performance.*
- H2: Digital transformation is positively associated with firms' export performance.*
- H3: Digital transformation moderates the relationship between green innovation and firms' export performance, such that the relationship becomes more positive as digital transformation increases.*

2. METHOD

This study adopted a quantitative, cross-sectional research design and used ordinary least squares regression with an interaction term to examine the relationships among green innovation, digital transformation, and firm-level export performance. The moderating role of digital transformation was examined by including an interaction term in the regression model (Aiken & West, 1991; Field, 2018; Hair et al., 2019). The regression model is specified as follows:

$$EP = a_0 + a_1GI_c + a_2DT_c + a_3(DT_c \cdot GI_c) + a_4EE + a_5SZ + \varepsilon, \quad (1)$$

where EP is export performance of Vietnamese firms, $a_0, a_1, \dots, a_5$ are regression coefficients to be estimated, GI_c and DT_c are the mean-centered composite scores of green innovation and digital transformation, respectively, $DT_c \cdot GI_c$ is the interaction term between digital transformation and green innovation, EE, SZ are control variables representing export experience and firm size (number of employees), ε is the error term.

Because the model includes an interaction term, the lower-order coefficients represent conditional rather than general relationships. Specifically, a_1 represents the estimated relationship between green innovation and export performance when digital transformation is at its sample mean, whereas a_2 represents the estimated relationship between digital transformation and export performance when green innovation is at its sample

mean. The interaction coefficient a_3 indicates how the conditional slope relating green innovation to export performance changes as digital transformation varies.

The conditional relationship between green innovation and export performance was derived from the regression model as follows:

$$\frac{\partial EP}{\partial GI_c} = a_1 + a_3 + DT_c. \quad (2)$$

The target population comprised firms operating in Vietnam that were engaged in export activities during the study period. A non-probability purposive sampling approach based on predefined eligibility criteria was used to recruit eligible firms and respondents. Firms were eligible if they had actual export activities, while respondents had to be directly involved in export operations, production, logistics, or strategic decision-making. The firm was the primary unit of analysis. One respondent from each participating firm provided information on the firm's green innovation practices, digital transformation, and export performance. Respondents included managers, executives, and functional staff working in areas relevant to the study. The functional staff category referred to operational or functional employees involved in export-related activities, production, logistics, or related organizational processes. Thus, eligibility was based on respondents' functional involvement in the organizational activities examined rather than on managerial title alone. Only one usable response was retained from each firm to avoid duplicate firm-level observations.

The survey (Appendix A) was conducted between April and December 2025, primarily through online questionnaire distribution, supplemented by direct distribution. A total of 315 completed questionnaires were received. After screening for firm eligibility, respondent eligibility, duplicate firm entries, and completeness, 23 questionnaires were excluded, leaving 292 usable firm-level responses for analysis. Participation was voluntary. Responses were collected anonymously and used exclusively for academic purposes. No personally identifying information was collected, and respondents provided informed consent before completing the questionnaire.

Potential common method bias was mitigated through procedural remedies and assessed using Harman's single-factor diagnostic. Anonymity and confidentiality were emphasized to reduce evaluation apprehension and socially desirable responding (Podsakoff et al., 2003). The questionnaire also presented the focal constructs in separate sections. Harman's single-factor diagnostic was conducted by entering all 13 focal measurement items into an unrotated principal component analysis and examining the proportion of variance accounted for by the first component.

All focal variables were measured using multi-item scales adapted from previous studies and contextualized for Vietnamese exporting firms. A five-point Likert-type scale ranging from 1 ("strongly disagree") to 5 ("strongly agree") was used for all measurement items (Likert, 1932; Hair et al., 2019). Green innovation was measured using four indicators: environmentally friendly products, environmentally friendly production processes, green marketing practices, and environmentally oriented management practices. These indicators were treated as related components of an overall green innovation construct. Digital transformation was measured through the application of artificial intelligence, digital customer-management platforms, international e-commerce, digitally skilled personnel, and customer data analytics. Export performance was assessed using perceived changes in export sales, export profitability, export market share, and the achievement of export-related strategic objectives.

Export experience and firm size were included as control variables and coded using ascending ordinal categories. Their coefficients capture the estimated linear trend in export performance across successively higher-coded categories, holding the other variables constant. Because the category intervals were unequal, the coefficients were interpreted as ordinal trend estimates rather than as effects associated with equal increments in years of export experience or numbers of employees.

Composite scores for green innovation, digital transformation, and export performance were calculated by averaging the corresponding measurement items after assessing their internal consistency and the joint three-component measure-

ment structure. The resulting scores represent respondents' perceptions of firm-level practices and performance rather than independently audited organizational measures.

The data were analyzed using IBM SPSS Statistics. Cronbach's alpha was first calculated to assess the internal consistency of each multi-item scale. The measurement structure was assessed by entering all 13 measurement items into a joint principal component analysis with Varimax rotation and Kaiser normalization. The Kaiser-Meyer-Olkin measure and Bartlett's test of sphericity were used to assess the suitability of the item-correlation matrix for component extraction. Components with eigenvalues greater than 1 were retained, subject to the theoretical interpretability of the rotated solution. The rotated component matrix was examined to determine whether the items formed the three theoretically specified constructs of digital transformation, green innovation, and export performance.

Subsequently, multiple regression analysis was used to estimate the relationships among green innovation, digital transformation, and export performance. Before constructing the interaction term, green innovation and digital transformation were mean-centered. Mean-centering facilitates interpretation of the lower-order coefficients and reduces nonessential multicollinearity between an interaction term and its component variables (Aiken & West, 1991). The interaction term ($DT_c \times GI_c$) was calculated by multiplying the mean-centered green innovation and digital transformation scores.

The conditional effects of green innovation were estimated at three selected mean-centered values of digital transformation ($DT_c = -1$, $DT_c = 0$, and $DT_c = +1$). These values were within the observed range of the mean-centered digital transformation scores, which extended from -1.78 to 1.33 . They represented digital transformation levels one unit below the sample mean, at the sample mean, and one unit above the sample mean, respectively. Standard errors, t -statistics, p -values, and 95% confidence intervals were calculated for each conditional slope, and an interaction plot was constructed to illustrate the form of the moderation relationship. The interaction plot displayed mean-

centered green innovation values from -1 to $+1$, which were also within its observed range of -1.62 to 1.47 . The selected values -1 and $+1$ therefore represent observed centered scores rather than one standard deviation below and above the sample mean.

Tolerance and variance inflation factor (VIF) values were examined to assess multicollinearity among the explanatory variables. The Durbin-Watson statistic was used to assess residual autocorrelation. The distribution of the regression residuals was assessed using a histogram of standardized residuals superimposed on a normal curve. Linearity and homoscedasticity were examined using a scatterplot of standardized residuals against standardized predicted values. Given the cross-sectional research design, the estimated coefficients are interpreted as conditional statistical associations rather than causal effects.

Table 1 presents the characteristics of the surveyed Vietnamese firms regarding export experience, main export markets, annual revenue, and firm size. Regarding export experience, 27.74% of the firms had less than 3 years, while 40.07% had between 3 and 5 years. Firms with five to fewer than ten years of export experience accounted for 21.92%, whereas 10.27% had at least ten years of export experience. The most frequently report-

ed main export-market categories were the USA, Australia, and Canada, accounting for 28.77% of the sample. This was followed by non-ASEAN Asian markets (24.66%), Europe (17.47%), ASEAN markets (16.10%), and other markets (13.01%). The largest annual revenue category comprised firms reporting revenue between VND 50 billion and less than VND 100 billion, representing 33.22% of the sample. In terms of firm size, 67.47% of firms had fewer than 100 employees, while 32.54% had 100 or more.

Table 2 presents the characteristics of the survey respondents. Managers accounted for 32.88% of respondents, executives for 19.86%, and functional staff for 47.26%. Thus, 52.74% of the questionnaires were completed by respondents holding managerial or executive positions. Functional staff respondents were directly involved in export-related activities, production, logistics, or related organizational processes.

Regarding professional experience, 37.33% of respondents reported three to five years of experience, and another 37.33% reported more than five years. Overall, 74.66% had at least three years of professional experience, while 25.34% had less than three years. Male respondents accounted for 57.53% of the sample and female respondents for 42.47%.

Table 1. Profile of surveyed exporting firms (N = 292)

Characteristic	Category	Frequency	Percentage (%)
Export Experience	< 3 years	81	27.74
	3 to under 5 years	117	40.07
	5 to under 10 years	64	21.92
	10 to under 20 years	26	8.90
	≥ 20 years	4	1.37
Main Export Markets	Europe	51	17.47
	USA, Australia, Canada	84	28.77
	Non-ASEAN Asia	72	24.66
	ASEAN	47	16.10
	Others	38	13.01
Annual Revenue	< 3 billion VND	40	13.70
	3 to under 50 billion VND	62	21.23
	50 to under 100 billion VND	97	33.22
	100 to under 500 billion VND	58	19.86
	≥ 500 billion VND	35	11.99
Firm Size (Number of employees)	< 10 employees	44	15.07
	10 to 49 employees	77	26.37
	50 to 99 employees	76	26.03
	100 to 199 employees	71	24.32
	≥ 200 employees	24	8.22

Table 2. Profile of survey respondents (N = 292)

Respondent Attribute	Category	Frequency	Percentage (%)
Position	Manager	96	32.88
	Executive	58	19.86
	Functional staff	138	47.26
Work Experience	< 3 years	74	25.34
	3–5 years	109	37.33
	> 5 years	109	37.33
Gender	Male	168	57.53
	Female	124	42.47

3. RESULTS

The internal consistency of the measurement scales was assessed using Cronbach's alpha (α), as presented in Table 3. All three scales exceeded the commonly recommended threshold of 0.70 (Hair et al., 2019). Green innovation had the highest Cronbach's alpha ($\alpha = 0.857$), followed by digital transformation ($\alpha = 0.839$) and export performance ($\alpha = 0.818$). These results indicate satisfactory internal consistency for the three multi-item scales.

A joint principal component analysis with Varimax rotation was conducted on all 13 measurement items. The Kaiser–Meyer–Olkin measure was 0.778, exceeding the recommended minimum value of 0.60 (Hair et al., 2019). Bartlett's test of sphericity was statistically significant, $\chi^2(78) = 1,875.653$, $p < 0.001$, indicating that the item-correlation matrix was suitable for component extraction. Three components were retained and jointly accounted for 65.862% of the total variance. The rotated solution corresponded to the three theoretically specified constructs. Table 4 shows that

digital transformation items loaded on the first component, with loadings ranging from 0.774 to 0.875. The green innovation items loaded on the second component, with loadings ranging from 0.799 to 0.873, while the export performance items loaded on the third component, with loadings ranging from 0.761 to 0.838. The clear clustering of the items across the three components provides preliminary support for the proposed three-component measurement structure.

Harman's single-factor diagnostic showed that the first unrotated component accounted for 27.538% of the total variance, which was below the commonly used threshold of 50%. This result indicates that no single factor dominated the covariance among the measurement items. Nevertheless, because the explanatory and outcome variables were reported by the same respondents at the same point in time, the possibility of common method bias cannot be completely ruled out.

The multiple regression results are presented in Table 5. The overall model was statistically signif-

Table 3. Measurement items, sources, and reliability of constructs

Construct	Code	Measurement Item	Source	Cronbach's alpha
Green Innovation (GI)	GI1	The firm develops environmentally friendly products	Chen et al. (2006); Ullah et al. (2024)	0.857
	GI2	The firm applies environmentally friendly production processes		
	GI3	The firm adopts green marketing practices		
	GI4	The firm implements environmentally oriented management practices		
Digital Transformation (DT)	DT1	The firm applies artificial intelligence in operations	Vial (2019); Luu (2023)	0.839
	DT2	The firm uses digital platforms to manage customer relationships		
	DT3	The firm engages in international e-commerce activities		
	DT4	The firm employs digitally skilled personnel		
	DT5	The firm utilizes customer data analytics for decision-making		
Export Performance (EP)	EP1	The firm's export sales have increased	Zou et al. (1998); Bui et al. (2025)	0.818
	EP2	The firm's export profitability has improved		
	EP3	The firm's export market share has increased		
	EP4	The firm has achieved its export strategic objectives		

Table 4. Results of joint principal component analysis

Item	Digital transformation	Green innovation	Export performance
DT2	0.875		
DT1	0.816		
DT3	0.808		
DT5	0.800		
DT4	0.774		
GI2		0.873	
GI1		0.864	
GI3		0.810	
GI4		0.799	
EP1			0.838
EP3			0.831
EP4			0.797
EP2			0.761

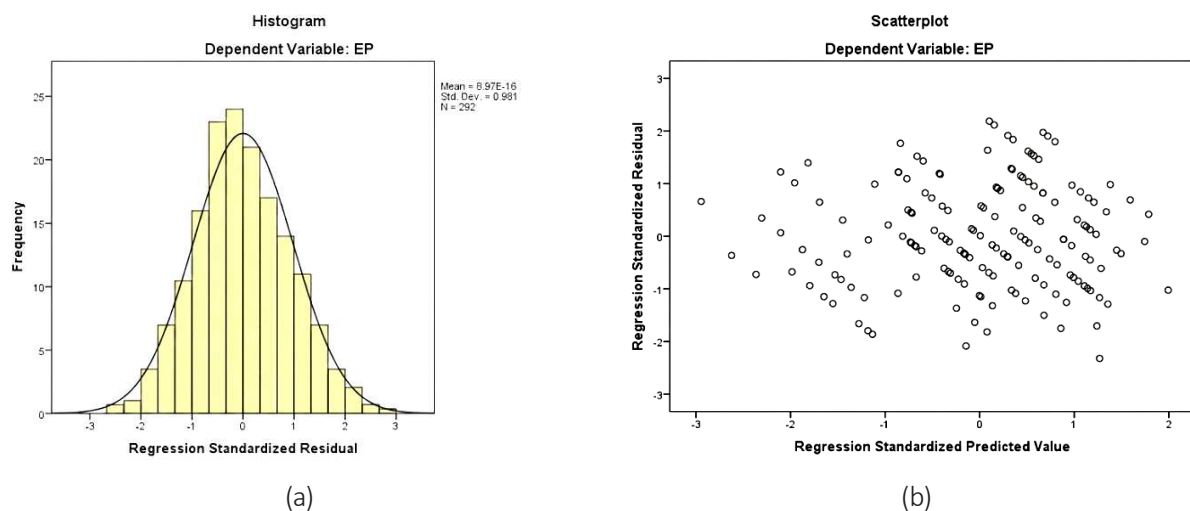
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) = 0.778;
Bartlett's test of sphericity: $\chi^2(78) = 1,875.653$, $p < 0.001$.

Note: Extraction method: principal component analysis. Rotation method: Varimax with Kaiser normalization. Rotation converged in five iterations. Loadings below 0.50 were suppressed. DT = Digital transformation; GI = Green innovation; EP = Export performance.

Table 5. Regression results for export performance as the dependent variable

Variables	Unstandardized B	Std. Error	T	p-value	Tolerance	VIF
(Constant)	0.070	0.155	0.451	0.653		
GI _c	0.169***	0.047	3.597	< 0.001	0.876	1.141
DT _c	0.235***	0.047	4.952	< 0.001	0.859	1.164
DT _c × GI _c	0.587***	0.045	13.042	< 0.001	0.925	1.082
EE	-0.104*	0.045	-2.299	0.022	0.995	1.005
SZ	-0.006	0.037	-0.165	0.869	0.989	1.011

Note: GI_c = mean-centered green innovation; DT_c = mean-centered digital transformation; EE = export experience; SZ = firm size. EE and SZ were entered using ascending ordinal category codes. The interaction term DT_c × GI_c was computed from the mean-centered scores; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$.



Note: Panel (a) presents the histogram of regression standardized residuals with a superimposed normal curve. Panel (b) presents regression standardized residuals plotted against regression standardized predicted values. The dependent variable is export performance (EP), and $N = 292$.

Figure 2. Residual diagnostic plots for the regression model

icant ($F_{(5,286)} = 46.108, p < 0.001$). The model accounted for 44.6% of the observed variance in export performance ($R^2 = 0.446$, adjusted $R^2 = 0.437$).

The regression diagnostics did not indicate substantial violations of the examined assumptions. The histogram of standardized residuals was approximately bell-shaped and centered around zero, with a mean close to zero and a standard deviation of 0.981. The scatterplot of standardized residuals against standardized predicted values showed that the residuals were distributed on both sides of zero without a clear curved or funnel-shaped pattern. These results in Figure 2 indicate no substantial departure from residual normality, linearity, or homoscedasticity.

Because the regression model includes an interaction term, the lower-order coefficients represent conditional relationships. When digital transformation was at its sample mean, green innovation was positively and statistically significantly associated with export performance ($B = 0.169, p < 0.001$). This finding provides conditional support for H1 at the reference level of digital transformation. Correspondingly, when green innovation was at its sample mean, digital transformation was positively and statistically significantly associated with export performance ($B = 0.235, p < 0.001$), providing conditional support for H2 at the reference level of green innovation.

The interaction between green innovation and digital transformation was positive and statistically significant ($B = 0.587, p < 0.001$). Because green innovation and digital transformation were mean-centered, the interaction coefficient indicates that a one-unit increase in mean-centered digital transformation was associated with a 0.587-unit increase in the conditional slope relating green innovation to export performance. This result supports H3 and indicates that the relationship between green innovation and export performance

becomes more positive as digital transformation increases.

Substituting the estimated coefficients from Table 5 into the conditional-slope expression specified in the Method section yielded:

$$\frac{\widehat{\partial EP}}{\partial GI_c} = 0.169 + 0.587 \cdot DT_c. \quad (3)$$

Accordingly, the estimated slope relating green innovation to export performance was 0.169 when digital transformation was at its sample mean. The coefficient 0.587 represents the estimated change in this slope associated with a one-unit increase in mean-centered digital transformation.

The observed mean-centered scores ranged from -1.78 to 1.33 for digital transformation and from -1.62 to 1.47 for green innovation. Thus, the selected moderator values of $DT_c = -1, 0$, and $+1$, as well as the plotted GI_c range from -1 to $+1$, were contained within the observed data ranges. Table 6 presents the conditional slopes of green innovation at three selected centered values of digital transformation. At ($DT_c = -1$), the conditional effect was negative and statistically significant ($B = -0.418, SE = 0.051, t = -8.196, p < 0.001, 95\% CI [-0.518, -0.318]$). When digital transformation was at its sample mean ($DT_c = 0$), green innovation had a positive and statistically significant conditional effect on export performance ($B = 0.169, SE = 0.047, t = 3.596, p < 0.001, 95\% CI [0.076, 0.262]$). At ($DT_c = 1$), the conditional effect became substantially more positive ($B = 0.756, SE = 0.077, t = 9.818, p < 0.001, 95\% CI [0.604, 0.908]$).

The results indicate a crossover interaction. At the selected lower value of digital transformation, green innovation was negatively associated with export performance. At the sample mean of digital transformation, the relationship was positive, while at the selected higher value, it became sub-

Table 6. Conditional slopes of GI at selected values of DT

Mean-centered DT_c	Conditional slope of GI_c	SE	t	p-value	95% CI
-1	-0.418	0.051	-8.196	< 0.001	[-0.518, -0.318]
0	0.169	0.047	3.596	< 0.001	[0.076, 0.262]
1	0.756	0.077	9.818	< 0.001	[0.604, 0.908]

stantially stronger. Thus, digital transformation changes both the magnitude and the direction of the estimated relationship between green innovation and export performance across the selected centered values.

Figure 3 illustrates the corresponding interaction pattern. The line representing ($DT_c = -1$) slopes downward, whereas the lines representing ($DT_c = 0$) and ($DT_c = 1$) slope upward, with the steepest positive slope at the selected higher level of digital transformation. This pattern is consistent with the positive interaction coefficient and indicates that the association between green innovation and export performance becomes increasingly positive as digital transformation deepens.

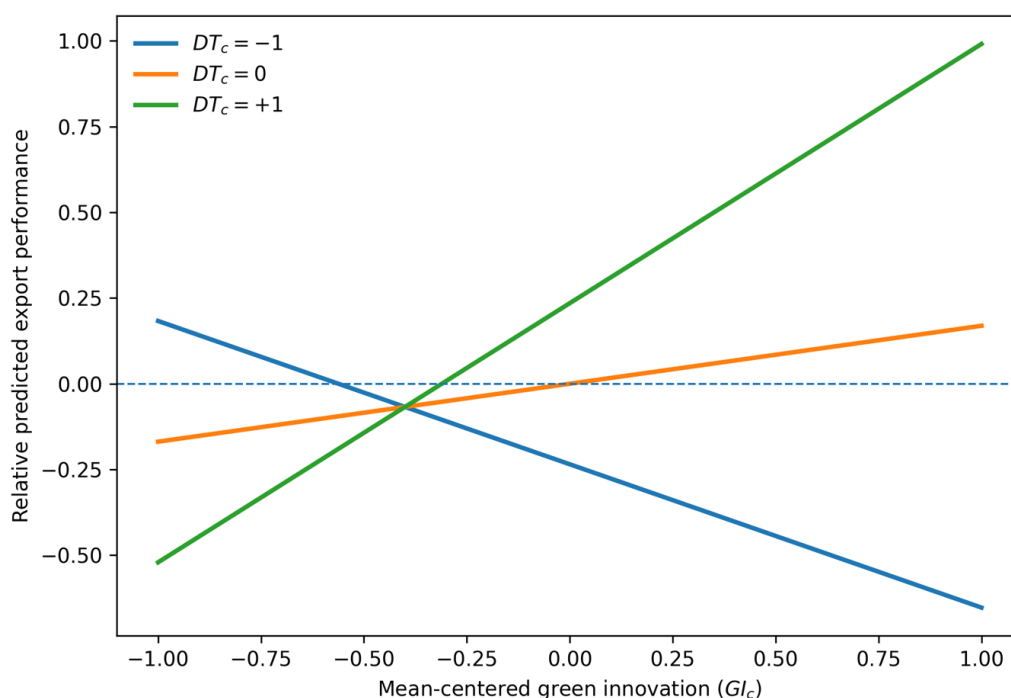
Regarding the control variables, export experience (EE) had a negative and statistically significant ordinal-trend coefficient ($B = -0.104, p = 0.022$). This result indicates that higher-coded categories of export experience were associated with lower reported export performance, after the other variables in

the model were held constant. Firm size (SZ) was not statistically significant ($B = -0.006, p = 0.869$), indicating no statistically detectable association between the coded firm-size categories and export performance in the estimated model.

The tolerance values ranged from 0.859 to 0.995, while the VIF values ranged from 1.005 to 1.164. These values do not indicate problematic multicollinearity among the explanatory variables (Hair et al., 2019). The Durbin-Watson statistic was 2.079, indicating no substantial residual autocorrelation (Field, 2018). Given the cross-sectional design, the regression coefficients are interpreted as conditional statistical associations rather than causal effects.

The hypothesis testing results are summarized in Table 7.

Accordingly, H1 and H2 are conditionally supported at the respective reference levels of digital transformation and green innovation, whereas H3 is supported by the positive and statistically significant interaction effect.



Note: The figure presents relative predicted export performance at selected mean-centered values of digital transformation ($DT_c = -1, 0$, and $+1$), with the control variables held fixed. The intercept and the fixed contribution of the control variables are omitted; therefore, zero represents a relative prediction rather than an actual export performance score. The selected DT_c and plotted GI_c values fall within their observed ranges of -1.78 to 1.33 and -1.62 to 1.47 , respectively. The values -1 and $+1$ are selected centered scores and do not represent ± 1 standard deviation.

Figure 3. Interaction between green innovation and digital transformation in predicting export performance

4. DISCUSSION

The findings of this study provide empirical evidence on the conditional relationships among green innovation, digital transformation, and export performance in an emerging economy context. Rather than treating green innovation and digital transformation as independent determinants, the study highlights their complementary relationship, with digital transformation serving as a moderating factor. When digital transformation was at its sample mean, green innovation was positively associated with export performance. Correspondingly, digital transformation was positively associated with export performance when green innovation was at its sample mean. More importantly, the significant interaction and conditional-slope results show that the green innovation and export performance relationship varies substantially across levels of digital transformation. Accordingly, this relationship was negative at the selected lower value of digital transformation, positive at the sample mean, and substantially more positive at the selected higher value. Thus, digital transformation changes both the magnitude and the direction of the estimated relationship between green innovation and export performance.

First, the positive conditional relationship between green innovation and export performance at the mean level of digital transformation is consistent with the view that sustainability-oriented capabilities are relevant for firms competing in international markets. Previous studies indicate that green innovation may help firms respond to environmental regulations, sustainability requirements, and market expectations in export markets (Shu et al., 2024; Ullah et al., 2024). From an RBV perspective, green innovation may represent a strategic capability by supporting resource efficiency and product differentiation. From an institutional perspective, it may also strengthen organizational legitimacy in environmentally sensitive markets. In the Vietnamese context, this relationship is relevant because exporting firms are increasingly exposed to environmental standards, traceability requirements, and sustainability expectations from foreign customers and regulatory bodies.

However, the simple-slopes results show that the relationship between green innovation and export performance is not uniformly positive. At the selected

lower value of digital transformation, green innovation was negatively associated with export performance. This crossover pattern suggests that green innovation practices may not translate into improved export-related outcomes when complementary digital capabilities are insufficient. One plausible interpretation is that adopting environmentally oriented products, processes, marketing practices, and management practices may entail implementation and coordination demands that are difficult to translate into market value without adequate digital systems for information processing, traceability, customer communication, and data-supported decision-making. These mechanisms were not directly measured and should therefore be regarded as theoretically plausible interpretations rather than empirically tested explanations. The result extends previous research by showing that the export-related value of green innovation depends on the technological and organizational conditions under which it is implemented.

Second, the positive conditional relationship between digital transformation and export performance is consistent with prior research emphasizing the relevance of digital capabilities to international business outcomes (Luu, 2023; Wang & Ye, 2023; Zhang et al., 2024). Digital technologies may support export activities through improved market intelligence, customer relationship management, international e-commerce participation, supply-chain coordination, and data-driven decision-making. From the RBV and dynamic capability perspectives, digital transformation can be interpreted as an enabling capability that helps firms process market information and reconfigure organizational resources in response to changing foreign-market requirements. The coefficient for digital transformation should nevertheless be interpreted at its reference condition, representing the relationship between digital transformation and export performance when green innovation is at its sample mean. In the context of Vietnamese exporting firms, the result indicates that digital transformation is associated not only with internal operational processes but also with firms' reported export-related outcomes. The potential benefits of digital transformation are unlikely to arise solely from the acquisition of individual technologies. They may depend on firms' capacity to integrate digital platforms, data analytics, digitally skilled personnel, and international e-commerce into

export operations and strategic decision-making. This interpretation is consistent with the view that digital transformation involves the development of organizational capabilities rather than solely the adoption of technology.

Third, the moderating role of digital transformation represents the central contribution of this study. The crossover interaction provides more specific evidence than the interaction coefficient alone, showing that across the selected values of digital transformation, the estimated relationship between green innovation and export performance changes from negative to positive and subsequently becomes substantially more positive. This result is consistent with studies suggesting that digital technologies may facilitate green innovation through improved information processing, environmental monitoring, operational optimization, and decision-making (Huang & Lau, 2024; Zhu et al., 2024). The present study extends this literature by demonstrating that the complementarity between green and digital capabilities is also associated with firm-level export performance. The finding has implications for the RBV because it indicates that the performance value of a strategic capability may be contingent on the availability of complementary capabilities. Green innovation may help firms address environmental requirements and differentiate their offerings, while digital transformation may enhance the traceability, scalability, visibility, and market communication of green practices. In this sense, digital transformation serves as an enabling condition for firms' ability to translate green innovation into export-related outcomes. The result is also consistent with institutional theory, insofar as the alignment of internal green and digital capabilities may help firms respond to environmental standards and digital requirements in international markets. However, because institutional pressures were not measured directly, the findings do not constitute a direct empirical test of the institutional mechanisms involved.

The negative ordinal-trend coefficient for export experience indicates that higher-coded export experience categories were associated with lower reported export performance after controlling for other variables. However, it does not establish that export experience itself reduces export per-

formance. The experience categories were ordinal and unequally spaced, and the study did not measure possible explanatory mechanisms such as organizational inertia, market composition, or differences in strategic adaptation. Firm size, meanwhile, showed no statistically detectable linear trend in the estimated model. These control-variable findings are therefore treated as ancillary rather than as primary substantive conclusions.

From a managerial perspective, the findings indicate that Vietnamese exporting firms may benefit from coordinating their green innovation and digital transformation initiatives. The crossover interaction suggests that implementing green innovation without sufficient digital capability may not be associated with improved export performance. Firms may therefore need to develop digital foundations alongside green initiatives, including data-management systems, digital customer interfaces, traceability tools, international e-commerce capabilities, and digitally skilled personnel. Such alignment may improve firms' capacity to document environmental performance, communicate sustainability attributes, coordinate export processes, and respond to foreign-market requirements. These implications concern strategic alignment rather than a causal guarantee that particular investments will improve performance.

From a policy perspective, the results support coordinated policy instruments that facilitate the joint development of green and digital capabilities among exporting firms, particularly those with limited technological and organizational resources. Programs addressing green innovation or digital transformation in isolation may be less effective when firms lack the complementary capabilities required to integrate the two. Relevant support may include access to digital infrastructure, technology-transfer initiatives, training in digital and sustainability-related skills, assistance with traceability and environmental information systems, and institutional support for digital trade and green export practices. Because the study did not identify a statistically significant firm-size effect and used a non-probability sample, these policy implications apply to capability constraints among exporters rather than constituting direct evidence of effects specific to SMEs or the entire population of Vietnamese exporting firms.

CONCLUSION

This study examined the relationships among green innovation, digital transformation, and export performance in Vietnamese exporting firms, with particular attention to the moderating role of digital transformation. The findings show that green innovation was positively associated with export performance when digital transformation was at its sample mean, while digital transformation was positively associated with export performance when green innovation was at its sample mean. More importantly, digital transformation significantly moderated the relationship between green innovation and export performance. The conditional-slope analysis revealed a crossover interaction: the relationship was negative at the selected lower level of digital transformation, positive at the sample mean, and substantially more positive at the selected higher level. The model explained 44.6% of the observed variance in export performance.

These findings indicate that green innovation should not be viewed only as a response to environmental requirements, but as a strategic capability whose export-related value depends on complementary digital capabilities. The novelty of the study lies in demonstrating this crossover moderating role of digital transformation, showing that green innovation is not uniformly associated with stronger export performance across different levels of digital transformation. For managers, the results suggest that green innovation and digital transformation should be developed in a coordinated manner, with digital systems, data capabilities, traceability tools, and digitally supported sustainability practices helping firms implement, document, and communicate their green initiatives more effectively. For policymakers, the findings support integrated programs that facilitate the joint development of green and digital capabilities among exporting firms rather than treating these areas as separate policy domains, particularly for firms facing technological, financial, or human-capital constraints.

Future research should examine these relationships using longitudinal or multi-source designs, validate the measurement structure with confirmatory approaches, and investigate the organizational and institutional mechanisms through which digital transformation may strengthen the export-related value of green innovation across different countries and groups of exporting firms.

AUTHOR CONTRIBUTIONS

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REFERENCES

1. Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Sage.
2. Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17(1), 99-120. <https://doi.org/10.1177/014920639101700108>
3. Bui, V. V., Vo, H. K., & Tran, T. T. (2025). Export performance of Vietnamese manufacturing SMEs: A PLS-SEM test of resource-based determinants, absorptive capacity, and international competition. *Problems and Perspectives in Management*, 23(4), 602-619. [https://doi.org/10.21511/ppm.23\(4\).2025.41](https://doi.org/10.21511/ppm.23(4).2025.41)
4. Cavusgil, S. T., & Zou, S. (1994). Marketing strategy-performance relationship: An investigation of the empirical link in export market ventures. *Journal of Marketing*, 58(1), 1-21. <https://doi.org/10.1177/002224299405800101>
5. Chen, Y.-S., Lai, S.-B., & Wen, C.-T. (2006). The influence of green innovation performance on corporate advantage in Taiwan. *Journal of Business Ethics*, 67(4), 331-339. <https://doi.org/10.1007/s10551-006-9025-5>
6. DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, 48(2), 147-160. <https://doi.org/10.2307/2095101>
7. European Commission. (n.d.). *Carbon border adjustment mechanism*. European Commission, Taxation and Customs Union. Retrieved from https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en
8. Field, A. P. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE Publications. Retrieved from <https://repo.darmajaya.ac.id/5678/1/Discovering%20Statistics%20Using%20IBM%20SPSS%20Statistics%20%28%20PDFDrive%20%29.pdf>
9. Hair, Jr J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate data analysis* (8th ed.). Cengage Learning. Retrieved from https://eli.johogo.com/Class/CCU/SEM/_Multivariate%20Data%20Analysis_Hair.pdf
10. Huang, Y., & Lau, C. (2024). Can digital transformation promote the green innovation quality of enterprises? Empirical evidence from China. *PLOS ONE*, 19(3), Article e0296058. <https://doi.org/10.1371/journal.pone.0296058>
11. Kraus, S., Durst, S., Ferreira, J. J., Veiga, P., Kailer, N., & Weinmann, A. (2022). Digital transformation in business and management research: An overview of the current status quo. *International Journal of Information Management*, 63, Article 102466. <https://doi.org/10.1016/j.ijinfomgt.2021.102466>
12. Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology*, 22(140), 5-55. Retrieved from https://legacy.vote-view.com/pdf/Likert_1932.pdf
13. Luu, T. D. (2023). Digital transformation and export performance: A process mechanism of firm digital capabilities. *Business Process Management Journal*, 29(5), 1436-1465. <https://doi.org/10.1108/BPMJ-01-2023-0024>
14. Ngo, Q. H. (2025). How Vietnamese exporting SMEs translate green practices into export performance through incremental and radical green innovation. *Sage Open*, 15(2). <https://doi.org/10.1177/21582440251341988>
15. Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, 88(5), 879-903. <https://doi.org/10.1037/0021-9010.88.5.879>
16. Porter, M. E., & Linde, C. van der. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives*, 9(4), 97-118. <https://doi.org/10.1257/jep.9.4.97>
17. Scott, W. R. (2014). *Institutions and organizations: ideas, interests and identities* (4th ed.). SAGE Publications, Inc. Retrieved from <https://uk.sagepub.com/en-gb/eur/institutions-and-organizations/book237665>
18. Shu, C., Zhao, J., Yao, Q., & Zhou, K. Z. (2024). Green innovation and export performance in emerging market firms: A legitimacy-based view. *Management and Organization Review*, 20(1), 85-110. <https://doi.org/10.1017/mor.2023.40>
19. Singh, V. K., Keshari, A., Singh, D., Singh, P. C., & Gautam, A. (2024). Green export strategies and SMEs export performance: Mediating roles of innovation, readiness, and activities. *Journal of Innovation and Entrepreneurship*, 13(1), Article 87. <https://doi.org/10.1186/s13731-024-00451-y>
20. Teece, D. J. (2007). Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, 28(13), 1319-1350. <https://doi.org/10.1002/smj.640>
21. Tran, T. T., Bui, V. V., & Do, T. T. (2025). The impact of social responsibility on the competitive advantage of small and medium-sized enterprises in Hanoi, Vietnam. *Problems and Perspectives in Management*, 23(1), 325-338. [https://doi.org/10.21511/ppm.23\(1\).2025.24](https://doi.org/10.21511/ppm.23(1).2025.24)
22. Ullah, S., Ahmad, T., Kukreti, M., Sami, A., & Shaukat, M. R. (2024). How organizational readiness for green innovation, green innovation performance and knowledge integration affects sustainability performance of exporting firms. *Journal of Asia Business Studies*, 18(2), 519-537. <https://doi.org/10.1108/JABS-02-2023-0056>
23. Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*, 28(2), 118-144. <https://doi.org/10.1016/j.jsis.2019.01.003>

24. Vietnam Customs. (2026). *Preliminary assessment of Vietnam international merchandise trade performance in full year of 2025*. Retrieved from <https://www.customs.gov.vn/index.jsp?pageId=4967&tkId=9371&group=undefined&category=Scheduled%20analysis>
25. Wang, F., & Ye, L. (2023). Digital transformation and export quality of Chinese products: An analysis based on innovation efficiency and total factor productivity. *Sustainability*, 15(6), Article 5395. <https://doi.org/10.3390/su15065395>
26. Warner, K. S. R., & Wäger, M. (2019). Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. *Long Range Planning*, 52(3), 326-349. <https://doi.org/10.1016/j.lrp.2018.12.001>
27. Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal*, 5(2), 171-180. <https://doi.org/10.1002/smj.4250050207>
28. World Trade Organization (WTO). (2025). *World trade report 2025: Making trade and AI work together to the benefit of all*. Retrieved from https://www.wto.org/english/res_e/booksp_e/wtr25_e.pdf
29. Zhang, C., Qiu, P., Zhang, L., Hong, X., & Wang, D. (2024). The impact of digital transformation on enterprises' export stability: Evidence from listed companies in China. *International Review of Financial Analysis*, 96, Article 103582. <https://doi.org/10.1016/j.irfa.2024.103582>
30. Zhu, Q., Huang, S.-Z., & Koompai, S. (2024). Digital transformation as a catalyst for green innovation: An examination of high-tech enterprises in China's Yangtze River Delta. *Sustainable Futures*, 8, Article 100277. <https://doi.org/10.1016/j.sfsf.2024.100277>
31. Zou, S., Taylor, C. R., & Osland, G. E. (1998). The EXPERF scale: A cross-national generalized export performance measure. *Journal of International Marketing*, 6(3). <https://doi.org/10.1177/1069031X9800600304>

APPENDIX A. Survey questionnaire

This survey is conducted for academic research purposes to examine the relationships among digital transformation, green innovation, and export performance of Vietnamese firms.

Participation in this survey is entirely voluntary, and all responses are collected anonymously. You may choose not to answer any question or withdraw from the survey at any time without any consequences. All information provided will be kept strictly confidential and used solely for research purposes. There are no right or wrong answers. Please respond based on your firm's actual practices and experience.

Thank you very much for your valuable time and support.

Section A. Firm and respondent information						
A1. Gender	☐ Male ☐ Female					
A2. Your position in the firm	☐ Manager ☐ Executive ☐ Functional Staff					
A3. Your work experience	☐ Less than 3 years ☐ 3–5 years ☐ More than 5 years					
A4. Export experience of your firm	☐ Less than 3 years ☐ 3 to under 5 years ☐ 5 to under 10 years ☐ 10 to under 20 years ☐ 20 years and above					
A5. Main export market of your firm	☐ Europe ☐ USA, Australia, Canada ☐ Non-ASEAN Asia ☐ ASEAN ☐ Others:.....					
A6. Annual revenue of your firm	☐ Less than VND 3 billion ☐ VND 3 to under 50 billion ☐ VND 50 to under 100 billion ☐ VND 100 to under 500 billion ☐ VND 500 billion and above					
A7. Firm size (number of employees)	☐ Fewer than 10 employees ☐ 10 to 49 employees ☐ 50 to 99 employees ☐ 100 to 199 employees ☐ 200 employees and above					

Section B. Assessment of key factors influencing export performance of Vietnamese firms							
Please rate each of the following statements, based on your firm's practices and experience in export activities.							
Responses are measured on a five-point Likert scale (1–5, from strongly disagree to strongly agree).							
No.	Statements	Code	1	2	3	4	5
1. Green Innovation (GI)							
1.1	The firm develops environmentally friendly products	GI1					
1.2	The firm applies environmentally friendly production processes	GI2					
1.3	The firm adopts green marketing practices	GI3					
1.4	The firm implements environmentally oriented management practices	GI4					
2. Digital Transformation (DT)							
2.1	The firm applies artificial intelligence in its operations	DT1					
2.2	The firm uses digital platforms to manage customer relationships	DT2					
2.3	The firm engages in international e-commerce activities	DT3					
2.4	The firm employs digitally skilled personnel	DT4					
2.5	The firm utilizes customer data analytics for decision-making	DT5					
3. Export Performance (EP)							
3.1	The firm's export sales have increased	EP1					
3.2	The firm's export profitability has improved	EP2					
3.3	The firm's export market share has increased	EP3					
3.4	The firm has achieved its export strategic objectives	EP4					