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Factors Driving Green Logistics Adoption Intention Among Smes in an Emerging Economy: an Extended Technology-Organization-Environment (Toe) Framework.

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Abstract: This study investigates the determinants of green logistics adoption intentions among small and medium enterprises (SMEs) in Vietnam by extending the traditional Technology-Organization-Environment (TOE) framework. While conventional models often assume a deterministic path, this research introduces Perceived Economic and Environmental Usefulness (PEEU) as a vital cognitive mediator to explain how contextual pressures are translated into strategic intentions. Data were collected via a survey of SME decision-makers in Vietnam and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) through SmartPLS 4. The empirical results robustly validate all eight hypothesized relationships, accounting for 31.7% of the variance in Perceived Economic and Environmental Usefulness (PEEU) and 36.0% of the variance in Green Logistics Adoption Intention (GLAI). Technological readiness, top management commitment, and stakeholder pressure exert significant direct positive effects on both PEEU and GLAI. Crucially, mediation analysis confirms that PEEU acts as a robust partial mediator across all three dimensions, demonstrating that contextual factors achieve maximum efficacy when filtered through a positive managerial evaluation of dual economic-ecological utility. These findings enrich the green supply chain literature by shifting the analytical boundary toward a cognitive-contextual integration within transition economies. Practically, the study provides a strategic blueprint for SME owners to leverage green logistics for sustainable competitive advantage, while offering actionable insights for policymakers to design market-based incentives that enhance the perceived economic viability of eco-innovations, thereby converting mandatory compliance into proactive corporate adoption.

Keywords: *Green logistics, TOE framework, Strategic cognition, Perceived usefulness, SMEs, Vietnam, PLS-SEM.*

I. Introduction

In the contemporary era of global climate change and accelerating environmental degradation, transitioning toward sustainability has evolved from a voluntary corporate social responsibility initiative into an absolute strategic imperative (Sarkis, 2021). As one of the vanguard developing nations committing to a net-zero carbon emission target by 2050 at the COP26 summit, Vietnam is undergoing a profound structural shift toward a green and circular economy. Within this systemic transformation, the logistics sector stands out as a critical yet highly carbon-intensive node. Traditional logistical activities, heavily reliant on fossil fuels and inefficient warehousing, constitute a primary driver of global greenhouse gas (GHG) emissions (Piprani et al., 2024). Consequently, the adoption of green logistics - defined as the systematic integration of environmentally friendly practices into transportation, distribution, and reverse logistics - has emerged as a vital mechanism to mitigate ecological damage while maintaining economic fluidness (Centobelli et al., 2020).

In emerging market economies like Vietnam, small and medium enterprises (SMEs) form the backbone of the private sector, representing over 97% of all active firms and contributing significantly to national GDP and employment. Despite their collective economic weight, SMEs concurrently generate a substantial cumulative ecological footprint. However, compared to their larger multinational counterparts, SMEs face unique, asymmetric constraints, including severe capital limitations, technical deficiencies, and a lack of formalized environmental management systems (Hillary, 2004; El-Kassar & Singh, 2019). While macroeconomic policies and state regulations heavily incentivize ecological restructuring, the baseline adoption rate of green logistics among Vietnamese SMEs remains markedly low and fragmented. Extant literature in the green supply chain domain has heavily favored large-scale enterprises in developed

economies, leaving a glaring empirical and theoretical gap regarding the behavioral mechanics of SMEs operating within volatile, transitional institutional settings (Chu et al., 2019).

To address these distinct gaps, this study utilizes the Technology-Organization-Environment (TOE) framework (Tornatzky & Fleischer, 1990) as its foundational theoretical lens. The TOE framework possesses robust explanatory power for organizational-level innovation adoption by categorizing determinants into technological readiness, organizational characteristics, and environmental pressures. Nonetheless, contemporary empirical evidence suggests that external institutional pressures and internal resource configurations do not automatically translate into behavioral intentions; rather, they are cognitively processed through management's strategic evaluation of value Huang & Huang (2024). To capture this underlying cognitive mechanism, this study extends the classical TOE framework by introducing *Perceived Economic and Environmental Usefulness* as a critical mediating variable. Specifically, the proposed structural model evaluates how three primary contextual dimensions - namely Stakeholder Pressure (Environmental), Technological Readiness (Technological), and Top Management Commitment (Organizational)—interact to shape managerial perceptions of utility, which ultimately drives the firm's *Green Logistics Adoption Intention*.

By validating this extended framework, the study aims to deliver substantial theoretical and practical contributions. Theoretically, it enriches the green supply chain management literature by introducing a highly nuanced, mediated cognitive pathway that explains *why* and *how* contextual factors activate green intentions specifically within the SME ecosystem of an emerging market. Practically, utilizing Partial Least Squares Structural Equation Modeling (PLS-SEM) via SmartPLS 4, the empirical findings will offer actionable data-driven insights for policymakers designed to construct targeted regulatory incentives, while concurrently providing SME owners with a strategic blueprint to leverage green logistics as a catalyst for sustainable competitive advantage.

II. Literature Review and Hypothesis Development

2.1 Theoretical Foundation: The TOE Framework and Strategic Cognition

The Technology-Organization-Environment (TOE) framework, developed by Tornatzky and Fleischer (1990), asserts that corporate innovation adoption is dictated by a tripartite context: *technological characteristics* (availability and equipment capability), *organizational traits* (internal structures, culture, and resource slack), and *environmental conditions* (industry maturity, competitors, and regulatory landscapes). While highly effective in explaining technical adoptions, classical TOE assumes a deterministic mechanism, implying that external forces or internal assets automatically trigger adoption intentions Huang & Huang (2024).

However, in the context of resource-constrained Small and Medium Enterprises (SMEs), structural choices are heavily centralized around managerial perceptions. According to the Natural Resource-Based View (NRBV) and upper echelons theory, corporate green behavior depends on how decision-makers cognitively filter external pressures and internal capabilities into recognized values, specifically Perceived Economic and Environmental Usefulness (PEEU) (Lin & Ho, 2011; Chu et al., 2019). PEEU reflects the extent to which a manager believes implementing green logistics will simultaneously optimize operational efficiency (e.g., fuel savings, lower waste management costs) and ecological alignment (e.g., reduced emissions, compliance safety). Thus, this study positions PEEU as the vital cognitive bridge connecting the three TOE contexts to the ultimate Green Logistics Adoption Intention (GLAI).

2.2 Hypothesis Development

2.2.1 Technological Readiness, PEEU, and Green Logistics Adoption Intention

Technological readiness captures both physical infrastructure (e.g., energy-efficient fleet availability, eco-warehousing facilities) and human IT capabilities within an SME (Centobelli et al., 2020). When an enterprise possesses a baseline level of digital infrastructure and tech-savvy personnel, the perceived complexity of transitioning to sustainable practices decreases significantly. Managerial echelons can easily visualize how advanced green practices—such as intelligent route-optimization software or automated inventory tracking—can seamlessly overlay onto their existing workflows to reduce resource waste and fuel consumption (Piprani et al., 2024). Consequently, high technological readiness acts as an internal enabler that directly amplifies the perceived utility of eco-innovations.

H1: *Technological readiness exerts a positive effect on the perceived economic and environmental usefulness of green logistics.*

Beyond cognitive evaluation, technological readiness also serves as a direct predictor of organizational intent. According to the TOE framework, a firm is fundamentally constrained or empowered by its current technological boundary (Tornatzky & Fleischer, 1990). SMEs that exhibit robust technological compatibility and digital literacy face lower technical barriers and switching costs. This technical ease directly translates into a higher institutional willingness and immediate readiness to commit to green logistics practices (Chu et al., 2019).

H2: *Technological readiness exerts a positive effect on green logistics adoption intention.*

2.2.2 Top Management Commitment, PEEU, and Green Logistics Adoption Intention

In SMEs, structural configurations and strategic reorientations are heavily centralized around the cognitive values of upper echelons. Top management commitment reflects the degree to which senior executives prioritize, endorse, and allocate resources toward environmental sustainability goals (El-Kassar & Singh, 2019). When leadership is genuinely committed to ecological preservation, they actively foster an eco-organizational culture. Under such leadership, green initiatives are not dismissed as cost burdens; instead, they are evaluated as double-benefit assets capable of driving long-term operational efficiency (fuel and material savings) while simultaneously elevating corporate brand equity (Sarkis, 2021).

H3: *Top management commitment exerts a positive effect on the perceived economic and environmental usefulness of green logistics.*

Concurrently, executive willpower is the primary driver for turning strategic goals into concrete actions within resource-constrained SMEs. Because implementing green logistics involves capital reallocation, risk-taking, and operational disruption, it cannot occur without explicit executive backing (Zailani et al., 2015). Strong management commitment directly signals the organization's strategic intent, overcoming internal resistance and creating a direct, powerful pathway toward the formal adoption of green logistics practices.

H4: *Top management commitment exerts a positive effect on green logistics adoption intention.*

2.2.3 Stakeholder Pressure, PEEU, and Green Logistics Adoption Intention

The external environmental context of an SME is continuously shaped by stakeholder pressures, predominantly stemming from tightening government environmental regulations, demanding green consumers, and strict B2B clients within global supply chains (Chu et al., 2019). When external bodies exert high coercive, normative, or mimetic pressures, decision-makers experience a cognitive shift. Institutional demands clarify the explicit utility of green practices, prompting managers to recognize that green logistics adoption is a strategic necessity to avoid legal penalties (regulatory utility), retain lucrative corporate vendor contracts (economic utility), and satisfy societal expectations (social utility) (Huang et al., 2024).

H5: *Stakeholder pressure exerts a positive effect on the perceived economic and environmental usefulness of green logistics.*

Simultaneously, stakeholder pressure serves as a direct external catalyst for behavioral modification. Under the lens of institutional theory, SMEs often comply with external expectations to maintain institutional legitimacy and secure critical market survival resources. High stakeholder pressure forces an enterprise to proactively form intentions to adopt green logistics, ensuring they are not market-isolated or competitively displaced by early-adopting rivals (Huang et al., 2024; Chu et al., 2019).

H6: *Stakeholder pressure exerts a positive effect on green logistics adoption intention.*

2.2.4 Perceived Usefulness and Green Logistics Adoption Intention

Organizational behavior theories dictate that a firm's intent to execute a specific strategic shift is a direct function of its calculated utility. When SME executives strongly perceive that adopting green logistics yields substantial economic dividends (e.g., energy efficiency, reduced physical waste) paired with critical environmental value (e.g., carbon reduction, enhanced green reputation), their behavioral intention to adopt these practices intensifies (Lin & Ho, 2011). Without a clear, quantified perception of utility, sustainable logistics will be shelved as a highly risky and expensive venture due to the severe resource constraints that typically plague the SME sector. Therefore, perceived utility stands as the immediate cognitive precursor to concrete corporate adoption intentions.

H7: *Perceived economic and environmental usefulness exerts a positive effect on green logistics adoption intention.*

2.2.5 The Mediating Role of PEEU (Partial Mediation Structure)

Integrating the structural paths formulated above, this study proposes a comprehensive, mediated framework. Technological readiness, top management commitment, and stakeholder pressure represent the critical technological, organizational, and external environmental inputs driving corporate change. However, these factors do not operate in a vacuum. Instead, they are cognitively processed and calculated through the firm's strategic evaluation of value, operationalized as PEEU (Huang et al., 2024).

Because we hypothesize that the TOE dimensions exert both direct behavioral influences (H2, H4, H6) and indirect cognitive influences (H1, H3, H5 -> H7), **Perceived Economic and Environmental Usefulness (PEEU)** is positioned as a **partial mediator**. This partial mediation structure implies that while technical capability, leadership willpower, and institutional demands can directly compel an enterprise to adopt green logistics, their total effects are significantly channeled through and amplified by the extent to which the organization explicitly perceives the economic and ecological dividends of the innovation (Lin & Ho, 2011; Chu et al., 2019).

H8: *Perceived economic and environmental usefulness partially mediates the relationship between (a) technological readiness, (b) top management commitment, (c) stakeholder pressure, and green logistics adoption intention.*

Based on the integration of the classical TOE framework and strategic cognition perspective, the proposed conceptual model and its corresponding hypotheses are visually formalized and presented in Figure 1.

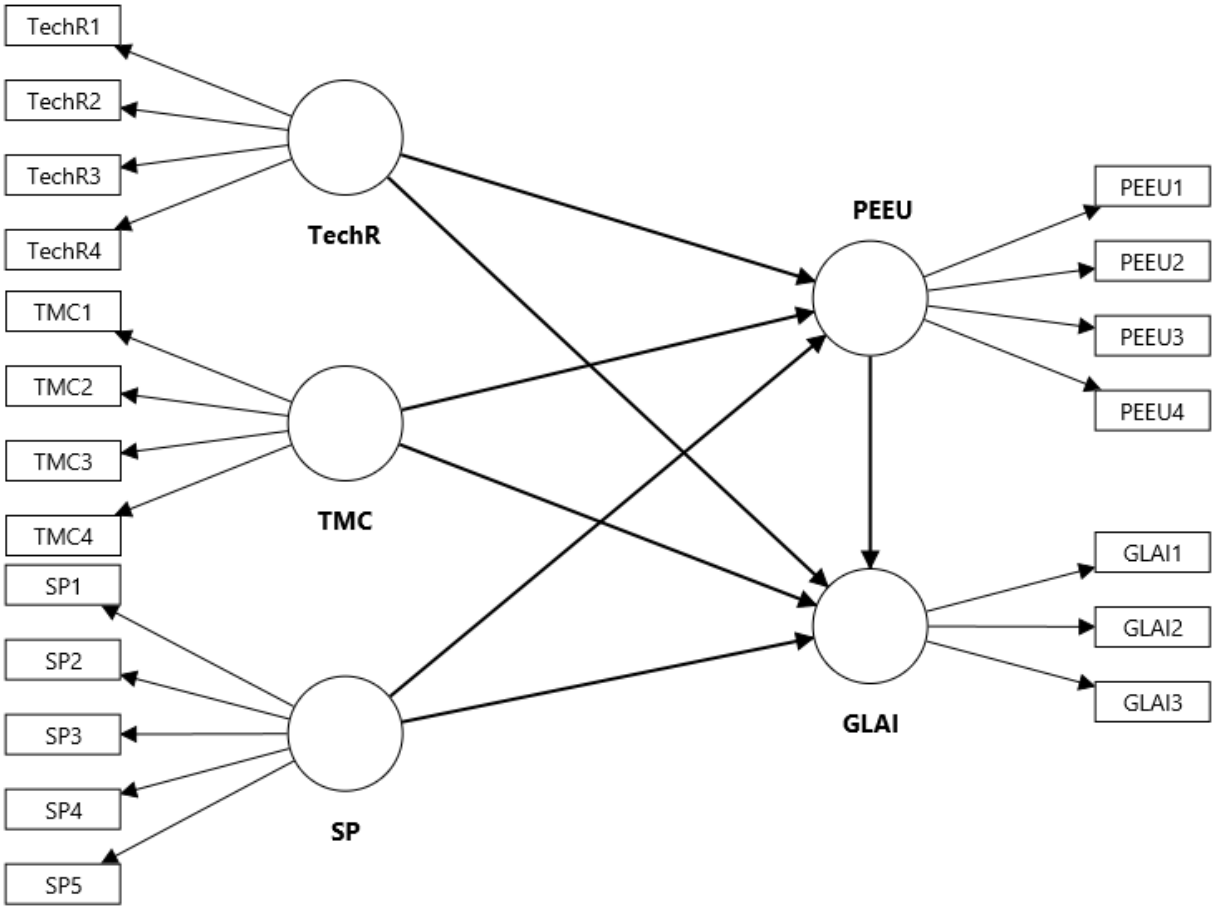

Figure 1: Conceptual Framework

III. Research Methodology

3.1 Research Design and Sample Procedure

To empirically test the proposed conceptual model, this study utilizes a quantitative, deductive research design based on a cross-sectional survey. The target population consists of owners, senior executives, operations managers, or logistics directors of Small and Medium Enterprises (SMEs) operating in Vietnam. These respondents are selected because they serve as key corporate decision-makers who possess comprehensive knowledge of their firm's technological capabilities, strategic orientation, and logistics operations.

The sampling frame is restricted to firms meeting the official national criteria for SMEs (i.e., fewer than 200 employees). Data will be collected through a self-administered questionnaire distributed via a hybrid approach (online via email/Google Forms and physical drop-off). To mitigate potential Common Method Bias (CMB) resulting from a single informant, the questionnaire instructions explicitly assure respondents of complete anonymity and emphasize that there are no right or wrong answers (Podsakoff et al., 2003).

Regarding sample size requirements for Partial Least Squares Structural Equation Modeling (PLS-SEM), the minimum sample size must satisfy the "10-times rule" (Hair et al., 2011) or the minimum sample size recommendations from power analysis tables (Hair et al., 2022). Given that the maximum number of arrows pointing to a construct in our structural model is three, a target sample size of $N \geq 150$ valid responses is statistically sufficient to achieve a statistical power of 80% at a 5% significance level.

3.2 Measurement Scales and Operationalization

All construct measurements are adapted from validated scales published in established international peer-reviewed journals. To fit the unique socio-economic context of Vietnamese SMEs and green logistics operations, minor linguistic adaptations were made. A double-translation protocol (English-to-Vietnamese and Vietnamese-back-to-

English) was conducted by bilingual academic experts to ensure translation equivalence and face validity. All items are measured using a standard 5-point Likert scale, ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree").

The operationalized measurement items and their respective literature sources are detailed in the table below:

Table 2: Detailed Operationalization of Measurement Scales

Construct	Code	Measurement Items	Sourced References
Technological Readiness	**TechR**	**TechR1:** Our firm possesses the necessary IT hardware and digital infrastructure to support advanced logistics applications. **TechR2:** Our employees have the specific technical skills and competence required to operate eco-efficient logistics software/tools. **TechR3:** It is technically straightforward for us to integrate green practices (e.g., alternative fuel vehicles, route-optimization systems) into our current workflow. **TechR4:** Our enterprise has reliable access to ongoing technical support and information regarding green logistics innovations.	Lin & Ho (2011); Centobelli et al. (2020)
Top Management Commitment	**TMC**	**TMC1:** Top management considers green logistics practices to be a critical strategic priority for the firm's long-term survival. **TMC2:** Top management allocates sufficient financial budget and human resources specifically dedicated to supporting green logistics initiatives. **TMC3:** Top management actively encourages and rewards employees who initiate or implement eco-friendly processes in daily operations. **TMC4:** Top management is willing to assume the financial risks associated with investing in sustainable logistics technologies.	Zailani et al. (2015); El-Kassar & Singh (2019)
Stakeholder Pressure	**SP**	**SP1:** Current government environmental regulations and environmental laws push our firm to adopt green logistics. **SP2:** Our major domestic and international B2B clients demand that we provide certified eco-friendly logistics options. **SP3:** Our primary competitors have already started adopting green logistics, threatening our market position if we fail to follow suit. **SP4:** Environmental non-governmental organizations (NGOs) and the local community expect our logistics operations to be ecologically clean. **SP5:** Our supply chain partners prefer working with firms that demonstrate active green logistics implementation.	Huang et al. (2024); Chu et al. (2019)
Perceived Economic & Environmental Usefulness	**PEEU**	**PEEU1:** Adopting green logistics will help our firm optimize resource consumption and significantly reduce energy/fuel costs over time. **PEEU2:** Adopting green logistics will significantly minimize our firm's negative impacts on the environment (e.g., lower carbon emissions, less physical waste). **PEEU3:** Implementing sustainable logistics will improve our corporate image and enhance brand reputation in the market. **PEEU4:** Green logistics adoption will enable our firm to secure a sustainable long-term competitive advantage.	Lin & Ho (2011); Huang et al. (2024)

Green Logistics Adoption Intention	**GLAI**	**GLAI1:** Our firm intends to adopt green logistics practices (e.g., green packaging, eco-driving) within the next 12 to 24 months. **GLAI2:** Our firm will actively search for opportunities and technologies to implement eco-friendly transportation and warehousing operations. **GLAI3:** Our firm plans to prioritize collaboration with business partners and vendors who offer sustainable and certified logistics solutions.	Piprani et al. (2024); Chu et al. (2019)

3.3 Data Analysis Strategy

The conceptual model will be empirically validated using Partial Least Squares Structural Equation Modeling (PLS-SEM) via **SmartPLS 4** software. PLS-SEM is chosen over covariance-based SEM (CB-SEM) because it offers superior statistical power for small-to-medium sample sizes typical of SME research, handles non-normal data distributions robustly, and is highly optimized for complex predictive models with mediation pathways (Hair et al., 2022).

Following the standard two-step approach by Hair et al. (2022), the analysis will be executed as follows:

Step 1: Evaluation of the Measurement Model: Internal consistency reliability will be verified using Cronbach's Alpha (α) and Composite Reliability (CR) (threshold > 0.70). Indicator reliability requires factor loadings > 0.70. Convergent validity will be established via Average Variance Extracted (AVE > 0.50), while discriminant validity will be strictly cross-checked using the Heterotrait-Monotrait Ratio (HTMT < 0.85).

Step 2: Collinearity and Structural Model Assessment: Prior to path estimation, lateral collinearity will be ruled out using the inner Variance Inflation Factor (VIF < 3.0). Hypotheses H1 to H7 will then be tested via a non-parametric bootstrapping procedure (5,000 subsamples, 95% confidence intervals) to compute path coefficients (β) and p-values. The model's explanatory power will be evaluated using the coefficient of determination (R^2).

Mediation Analysis (H8): The specific indirect effects will be assessed via SmartPLS 4's bias-corrected bootstrap confidence intervals to determine whether the mediation mechanism is full or partial.

IV. Results

4.1 Measurement Model Assessment

To evaluate the measurement model, internal consistency reliability, indicator reliability, convergent validity, and discriminant validity were assessed according to the guidelines suggested by Hair et al. (2022) .

As presented in Table 3, all indicator loadings exceeded the recommended threshold of 0.70 (ranging from 0.831 to 0.895), confirming robust indicator reliability. Internal consistency reliability was well-established, as Cronbach's alpha (α) values ranged from 0.840 to 0.919 , and Composite Reliability values (rho_a and rho_c) were all significantly higher than the 0.70 benchmark. Furthermore, the Average Variance Extracted (AVE) values for all constructs surpassed the 0.50 threshold (ranging from 0.731 to 0.758), demonstrating strong convergent validity.

Table 3: Measurement Model Evaluation Results

Construct	Item	Outer Loading	Cronbach's Alpha (α)	Composite Reliability (rhoa)	Composite Reliability (rhoc)	Average Variance Extracted (AVE)
Green Logistics Adoption Intention (GLAI)	GLAI1 GLAI2 GLAI3	0.895 0.861 0.855	0.840	0.846	0.904	0.758
Perceived Econ. & Environ. Usefulness (PEEU)	PEEU1 PEEU2 PEEU3 PEEU4	0.864 0.861 0.831 0.865	0.878	0.880	0.916	0.731
Stakeholder Pressure (SP)	SP1 SP2 SP3 SP4 SP5	0.877 0.862 0.872 0.880 0.857	0.919	0.921	0.939	0.756

Top Management Commitment (TMC)	TMC1 TMC2 TMC3 TMC4	0.855 0.878 0.853 0.891	0.893	0.914	0.925	0.756
Technological Readiness (TechR)	TechR1 TechR2 TechR3 TechR4	0.882 0.849 0.847 0.873	0.886	0.891	0.921	0.744

Discriminant validity was evaluated using two rigorous approaches: the Fornell-Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio. According to the Fornell-Larcker criterion shown in Table 4, the square root of the AVE for each construct (diagonally listed in bold) was consistently higher than its highest correlation with any other latent variable. Additionally, all HTMT values (presented below the diagonal in parentheses) were strictly below the conservative threshold of 0.85 , confirming that the constructs are conceptually distinct and discriminant validity is fully supported.

Table 4: Discriminant Validity Results (Fornell-Larcker Criterion and HTMT Ratio)

Construct	GLAI	PEEU	SP	TMC	TechR
GLAI	**0.870**				
PEEU	0.523 *(0.604)*	**0.855**			
SP	0.295 *(0.334)*	0.283 *(0.315)*	**0.869**		
TMC	0.245 *(0.278)*	0.208 *(0.228)*	0.022 *(0.045)*	**0.869**	
TechR	0.373 *(0.424)*	0.440 *(0.497)*	0.092 *(0.101)*	-0.118 *(0.139)*	**0.863**

Note: Values on the diagonal in **bold** represent the square root of the AVE. Values outside the parentheses are latent variable correlations (Fornell-Larcker). Values inside the parentheses and italicized are HTMT ratios.

4.2. Structural Model Assessment

Before assessing the structural pathways, lateral collinearity was examined via the inner Variance Inflation Factor (VIF). The VIF values for all indicators were well below the 3.0 threshold (ranging from 1.877 to 2.862) , ensuring that multicollinearity does not pose an issue for structural estimation.

A non-parametric bootstrapping procedure with 5,000 subsamples was performed to evaluate the statistical significance of the hypothesized direct relationships (H1 to H7). The explanatory power of the model was evaluated through the coefficient of determination (R^2). The model accounts for 31.7% of the variance in Perceived Economic and Environmental Usefulness (R^2 = 0.317, Adjusted R^2= 0.310) and 36.0% of the variance in Green Logistics Adoption Intention (R^2 = 0.360, Adjusted R^2 = 0.351), indicating an acceptable level of predictive capability in social science and organizational research.

Table 5: Structural Path Coefficients and Hypothesis Testing

Hypothesis	Direct Path	Path Coefficient (β)	T Statistics	P Values	Effect Size (f2)	Result
H1	TechR -> PEEU	0.449	10.805	0.000	0.288	**Supported**
H2	TechR -> GLAI	0.236	5.096	0.000	0.066	**Supported**
H3	TMC -> PEEU	0.255	5.036	0.000	0.094	**Supported**
H4	TMC -> GLAI	0.201	3.468	0.001	0.057	**Supported**
H5	SP -> PEEU	0.235	4.701	0.000	0.080	**Supported**
H6	SP -> GLAI	0.176	3.606	0.000	0.044	**Supported**
H7	PEEU -> GLAI	0.328	5.728	0.000	0.115	**Supported**

As summarized in Table 5, all direct hypotheses received strong empirical validation:

Technological Readiness exerted a highly significant positive effect on both PEEU (β = 0.449, t = 10.805, p < 0.001) and GLAI (β = 0.236, t = 5.096, p < 0.001), confirming H1 and H2. The effect size of TechR on PEEU was substantial (f^2 = 0.288).

Top Management Commitment demonstrated positive and significant impacts on PEEU (β = 0.255, t = 5.036, p < 0.001) and GLAI (β = 0.201, t = 3.468, p = 0.001), validating H3 and H4.

Stakeholder Pressure similarly proved to be a critical external catalyst, significantly predicting PEEU (β = 0.235, t = 4.701, p < 0.001) and GLAI (β = 0.176, t = 3.606, p < 0.001), thus supporting H5 and H6.

Finally, Perceived Economic and Environmental Usefulness (PEEU) significantly driven Green Logistics Adoption Intention (β = 0.328, t = 5.728, p < 0.001) , providing solid empirical support for H7 with a medium effect size (f^2= 0.115).

4.3. Mediation Analysis (Hypothesis 8)

To address the mediating role of Perceived Economic and Environmental Usefulness (H8), specific indirect effects were estimated using bias-corrected bootstrapping confidence intervals.

Table 6: Specific Indirect and Mediation Structure Results

Hypothesis	Indirect Relationship Path	Indirect Effect (β)	T Statistics	P Values	Direct Effect	Mediation Type	Result
H8a	TechR -> PEEU -> GLAI	0.147	5.103	0.000	0.236***	**Partial Mediation**	**Supported**
H8b	TMC -> PEEU -> GLAI	0.084	3.693	0.000	0.201***	**Partial Mediation**	**Supported**
H8c	SP -> PEEU -> GLAI	0.077	3.463	0.001	0.176***	**Partial Mediation**	**Supported**

*Note: *** Significant at p < 0.001.*

As shown in Table 6, all proposed indirect pathways were statistically significant:

The indirect path from **Technological Readiness** to GLAI mediated by PEEU was positive and highly significant (β = 0.147, t = 5.103, p < 0.001). Given that the direct effect of TechR on GLAI remained significant (β = 0.236, p < 0.001) , PEEU functions as a **partial mediator**, supporting **H8a**.

The indirect path from **Top Management Commitment** to GLAI via PEEU was statistically verified (β = 0.084, t = 3.693, p < 0.001). Since the direct effect was also significant (β = 0.201, p = 0.001), **H8b** is supported under a **partial mediation** structure.

Lastly, PEEU significantly mediated the relationship between **Stakeholder Pressure** and GLAI (β = 0.077, t = 3.463, p = 0.001). Combined with a significant direct relationship (β = 0.176, p < 0.001) , PEEU acts as a **partial mediator** for this environmental construct as well, supporting **H8c**.

In summary, the partial mediation structure is robustly established across all three dimensions of the extended TOE framework. This confirms that while technological infrastructure, executive drive, and external pressures directly influence Vietnamese SMEs' intentions to adopt green logistics , their total impacts are significantly channeled through and reinforced by shifting managerial cognitive perceptions regarding the dual economic and ecological value of sustainable innovations.

V. Discussion

The empirical results of this study provide robust support for the proposed extended TOE framework, explaining 31.7% of the variance in PEEU and 36.0% of the variance in green logistics adoption intention among Vietnamese SMEs. By integrating Perceived Economic and Environmental Usefulness (PEEU) as a mediating cognitive mechanism, this research offers a granular understanding of how technological, organizational, and environmental antecedents shape strategic green orientations in a transition economy.

The highly significant positive influence of technological readiness on both PEEU (β = 0.449, p < 0.001) and GLAI (β = 0.236, p < 0.001) underscores that infrastructure availability and digital capability are absolute prerequisites for sustainability transitions. When SMEs possess adequate technological literacy and compatible digital platforms (such as IoT-enabled tracking or route optimization software), their managers can readily recognize the tangible economic and environmental returns of green logistics. This finding strongly aligns with the foundational assertions of the TOE framework (Tornatzky & Fleischer, 1990) and resonates with recent empirical evidence from Lin and Ho (2011) and Piprani et al. (2024), who argued that technical compatibility mitigates the perceived risks of green supply chain innovations. In the context of Vietnam, where the logistics infrastructure is still undergoing rapid modernization, this result implies that technical competence acts as an internal confidence booster. SMEs are not merely driven by ecological altruism; rather, their willingness to adopt green practices is heavily contingent upon whether their existing technical architecture can absorb new green procedures without causing operational disruption.

On the organizational front, the significant impact of top management commitment on PEEU (β = 0.255, p < 0.001) and GLAI (β = 0.201, p = 0.001) shifts the analytical focus toward strategic leadership and cognitive framing. As resource allocation in small-to-medium firms is typically centralized, the ecological posture of the firm is a direct reflection of its

leadership's vision. This outcome corroborates the findings of El-Kassar & Singh (2019) and Tapia Morán et al. (2025), emphasizing that proactive executive leadership is vital for overcoming the institutional inertia that frequently stalls green initiatives. However, by illuminating the partial mediating role of PEEU ($\beta = 0.084$, $p < 0.001$), this study uncovers a deeper nuance: top management commitment does not blindly force green adoption. Instead, visionary leaders first reshape the organizational value system by actively interpreting green logistics not as a pure cost center, but as a dual-benefit strategy that yields long-term cost efficiency (via fuel reduction) and market differentiation. For Vietnamese SME owners, this signals that migrating toward sustainable logistics demands a fundamental transition from a reactive "compliance mindset" to a proactive "value-creation mindset."

Regarding institutional drivers, stakeholder pressure emerged as a critical external catalyst, significantly predicting PEEU ($\beta = 0.235$, $p < 0.001$) and GLAI ($\beta = 0.176$, $p < 0.001$). This confirms that coercive, mimetic, and normative pressures from regulatory bodies, demanding international buyers, and eco-conscious consumers are actively penetrating the Vietnamese business landscape. This alignment with Institutional Theory (DiMaggio & Powell, 1983) and green logistics studies in emerging markets (e.g., Chu et al., 2019; Centobelli et al., 2020) indicates that SMEs are highly sensitive to market legitimacy. Interestingly, the validation of hypothesis H8c ($\beta = 0.077$, $p = 0.001$) suggests that market-driven and regulatory pressures successfully alter managers' internal utility evaluations. When government mandates or foreign partners impose strict carbon footprint requirements, SME managers do not just passively obey; they actively recalibrate their strategic outlook, recognizing that eco-efficiency is vital for retaining lucrative export contracts and maintaining competitive survival.

Ultimately, the pivotal role of PEEU in driving GLAI ($\beta = 0.328$, $p < 0.001$) and its robust performance as a partial mediator across all dimensions bridge the traditional gap between macro-level contextual factors and micro-level behavioral intentions. By inserting this cognitive layer, this study extends the classic TOE framework, moving beyond the traditional descriptive stance ("what factors drive adoption") to a more explanatory position ("how and why these factors drive adoption"). The empirical evidence clearly demonstrates that contextual drivers (TOE) achieve their maximum efficacy when they are successfully filtered through a positive managerial evaluation of dual economic-ecological utility. For policy-making bodies in Vietnam and similar developing nations, this integrated mechanism suggests that purely coercive regulatory pressure or passive technical training may yield sub-optimal results. To accelerate the greening of the SME sector - a critical requirement for fulfilling Vietnam's COP26 net-zero commitments - interventions must be designed to explicitly highlight the economic viability of green logistics. Subsidizing energy-efficient fleet upgrades, granting green tax incentives, and showcasing successful local case studies can effectively raise the PEEU, thereby systematically converting contextual pressures into concrete organizational intentions.

VI. Conclusion

6.1. Concluding Remarks

This study successfully extended the traditional Technology-Organization-Environment (TOE) framework by integrating Perceived Economic and Environmental Usefulness (PEEU) as a core mediating cognitive mechanism to investigate the determinants of green logistics adoption intentions among SMEs in Vietnam. Utilizing structural equation modeling (PLS-SEM) via SmartPLS 4, all eight hypothesized relationships were empirically validated. The findings demonstrate that technological readiness, top management commitment, and stakeholder pressure serve as crucial drivers that not only directly foster green logistics intentions but also significantly shape managers' cognitive perceptions of ecological and economic usefulness. Notably, PEEU acts as a vital conduit, confirming that the structural transition toward sustainable logistics in an emerging economy is heavily reliant on a strategic calculus that balances commercial viability with environmental stewardship.

6.2. Theoretical and Managerial Implications

Theoretically, this research contributes to the sustainable supply chain literature by shifting the analytical boundary from a purely contextual perspective to a cognitive-contextual integration. By demonstrating the robust partial mediation of PEEU, the predictive power of the TOE framework has been enriched, providing a clearer psychological and strategic rationale for how external and internal factors are processed within small-to-medium corporate structures. Furthermore, this study responds to calls for more empirical research on green logistics within transition economies, offering a validated model tailored to the specific institutional and resource-constrained environments of Southeast Asian SMEs.

Managerially, the results offer actionable insights for both corporate leaders and policy makers. For SME executives, the study highlights that green logistics should not be feared as an unprofitable financial burden; rather, investing in technological competence and digital infrastructure can unlock substantial operational efficiencies and market goodwill. For government authorities and industry associations, the findings suggest a pivot in policy design. To

successfully drive the national green agenda, regulatory frameworks should be balanced with market-based incentives (such as green credits or technical support programs) that directly enhance the perceived economic utility of sustainable practices, thereby turning mandatory compliance into voluntary, strategic adoption.

5.3. Limitations and Future Research Directions

Despite its substantial contributions, this study is subject to certain limitations that open avenues for future investigation. First, the empirical data were collected cross-sectionally within Vietnam, which may limit the generalization of the findings to countries with different institutional or economic fabrics. Future research could employ longitudinal designs or cross-national comparative analyses to track the evolution of green logistics adoption across different stages of economic development. Second, while the extended model explained a satisfactory portion of variance, future studies could integrate additional boundary conditions, such as green dynamic capabilities, financial constraints, or the moderating role of government subsidies, to capture an even more comprehensive picture of the complex ecosystem driving green logistics implementation.

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