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Research On The Application Of Green Logistics Models In Supply Chain Management At Small And Medium-Sized Enterprises In Hanoi

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ABSTRACT
This study investigates the application of green logistics models in supply chain management at small and medium-sized enterprises (SMEs) in Hanoi, Viet Nam, within the context of sustainable development. The research addresses growing environmental challenges associated with logistics activities, such as energy inefficiency, emissions, and waste, while emphasizing the strategic role of green logistics in improving operational performance and competitiveness. Using a quantitative research approach, data were collected from 131 SMEs operating in the logistics sector in Hanoi through structured questionnaires. The data were analyzed using SPSS 26.0, applying reliability testing, exploratory factor analysis (EFA), correlation analysis, and multiple linear regression. The research model examines five independent factors affecting sustainable logistics performance: green technology in logistics, environmental protection regulations, sustainable supply chain management, internal business environment, and employee awareness and training. Reliability analysis shows strong internal consistency across all measurement scales, with Cronbach's Alpha coefficients ranging from 0.714 to 0.892, exceeding the acceptable threshold of 0.6. Exploratory factor analysis confirms the validity of the model, with a KMO value of 0.761, Bartlett's test significance of 0.000, and total variance explained of 64.335%, indicating robust factor structure. Regression analysis demonstrates that all five factors have a statistically significant positive impact on sustainable logistics performance (Sig. < 0.05). The adjusted R^2 value of 0.533 indicates that 53.3% of the variation in sustainable logistics performance is explained by the model. Among the factors, the internal business environment exerts the strongest influence ($\beta = 0.407$), followed by employee awareness and training ($\beta = 0.208$), green technology in logistics ($\beta = 0.184$), environmental protection regulations ($\beta = 0.151$), and sustainable supply chain management ($\beta = 0.150$). The findings confirm that effective green logistics adoption in SMEs requires not only technological investment and regulatory compliance but also strong internal organizational support and workforce engagement. The study provides empirical evidence to support policy development and managerial strategies aimed at promoting sustainable logistics practices in Viet Nam.
Keywords: green logistics, sustainable supply chain, SMEs, logistics performance, environmental regulations

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1. INTRODUCTION:

Research on the application of the green logistics model in supply chain management at small and medium-sized enterprises in Hanoi is becoming an urgent and important issue in the context of sustainable development. In recent years, Viet Nam has witnessed the strong development of the logistics sector, which plays a key role in connecting economic activities and promoting international trade. However, this sector also faces many challenges related to negative environmental impacts such as air pollution, inefficient energy consumption, and suboptimal waste management. Therefore, the adoption of green logistics not only meets environmental protection requirements but also contributes to improving supply chain management efficiency, bringing sustainable value to enterprises.

Green logistics is understood as activities within the supply chain aimed at minimizing negative environmental impacts while improving operational performance and reducing costs. According to Aldakhil et al. (2018), green logistics includes strategies such as route optimization, the use of environmentally friendly transportation vehicles, and the application of modern technologies to reduce emissions. These factors not only help reduce environmental burdens but also create competitive advantages for enterprises in a market that is increasingly concerned with sustainability issues.

In Viet Nam, the application of the green logistics model has gradually received more attention in the context of the country's commitment to achieving global sustainable development goals. Studies by Nguyễn Thùy Linh (2023) have indicated that factors such as government support policies, enterprises' awareness of environmental protection, and the application of advanced technologies are important determinants influencing the implementation of green logistics. In particular, the support of blockchain technology has opened new opportunities to enhance transparency and efficiency in supply chains, thereby promoting sustainability in logistics activities (Tran Thi Ngoc Lan et al., 2024).

In addition, small and medium-sized enterprises in Viet Nam are facing increasing pressure from increasingly stringent environmental regulations and changes in consumer behavior. According to Wong et al. (2020), the integration of green supply chains and green innovation has a positive impact on enterprises' environmental performance and costs. This requires small and medium- sized enterprises in Viet Nam to transform traditional operating models into green logistics in order to meet customer expectations and international market requirements. However, the adoption of the green logistics model in Viet Nam is not simple, especially in the context where most small and medium-sized enterprises in the logistics sector still face difficulties in investment capital, technology, and specialized human resources. Aytekin et al. (2024) have proposed fuzzy theory-based approaches to support enterprises in selecting appropriate green logistics strategies, helping to reduce risks and optimize resources. This highlights the importance of developing supportive policy frameworks from the government, along with training programs and awareness-raising initiatives on green logistics. In addition, studies in Viet Nam also emphasize the importance of assessing the impact of green logistics on enterprise performance. Hoang Thi Hong Le et al. (2024) analyzed the relationship between green supply chain management and operational performance in the construction industry, thereby confirming that the application of green principles not only helps reduce costs but also improves competitiveness. These findings can be widely applied in the logistics sector, where supply chain optimization plays a crucial role in meeting market demand.

The Vietnamese government is also making efforts to promote the development of green logistics through the issuance of specific policies and strategies to support enterprises in transitioning toward sustainable operating models. Policies encouraging investment in environmentally friendly technologies and the development of modern logistics infrastructure are being implemented, creating favorable conditions for enterprises to adopt green logistics. Kim et al. (2024) emphasized the role of government support policies in promoting the financial performance of small and medium-sized enterprises through the adoption of green practices. However, many challenges still need to be addressed to promote green logistics in Viet Nam. One of the biggest obstacles is the lack of synchronization in the logistics infrastructure system and legal regulations. In addition, the level of awareness and commitment of enterprises to environmental protection remains limited. These constraints require close coordination among stakeholders, including the government, enterprises, and research organizations, to develop effective solutions. Therefore, the author has chosen the topic ***"Research on the application of green logistics models in supply chain management at small and medium-sized enterprises in Hanoi"*** as the subject of this study.

2. THEORETICAL FRAMEWORK

2.1. Green green logistics in supply chain management

Green logistics is a sustainable development trend in the field of supply chain management, focusing on minimizing negative environmental impacts while maintaining business operational efficiency. According to Vasiliauskas (2013), green logistics is the integration of sustainable operational strategies and management tools aimed at reducing emissions, optimizing resources, and enhancing corporate social responsibility. Green-oriented supply chain management not only includes transportation and warehousing activities but also integrates recycling solutions, reductions in raw material usage, and the development of environmentally friendly products. This trend contributes to building brand value, reducing operating costs, and simultaneously meeting increasingly stringent requirements from legal regulations and customers regarding sustainable development (Garg, A., & Vemaraju, S., 2024)..

2.2. Factors affecting the green logistics model in supply chain management at small and medium-sized enterprises

Green technology in logistics

Green technology plays an important role in optimizing green logistics activities. According to Tran Thi Ngoc Lan, Nguyen Thi Hoai Thu and Cao Thi Hoai (2024), blockchain technology applied in green supply chains helps improve transparency, enhance traceability, and reduce waste. In addition, modern technologies such as energy management systems, electric vehicles, and IoT solutions also contribute to reducing emissions and increasing operational efficiency (Wong, Wong, & Boon-itt, 2020).

Environmental protection regulations

Government policies and regulations are important factors influencing the level of green logistics adoption. Nguyen Thuy Linh (2023) points out that small and medium-sized enterprises are often required to strictly comply with regulations on emissions, waste management, and the use of renewable energy to ensure legal compliance. These policies not only create pressure but also encourage enterprises to innovate in order to achieve sustainable development goals.

Sustainable supply chain management

Sustainable supply chain management involves optimizing processes, reducing resource consumption, and integrating environmentally friendly activities into the overall strategy. According to Hoang Thi Hong Le, Do Thi Huyen, and Pham Thi Thanh Nhan (2024), green supply chain management brings high efficiency to enterprises, especially in the construction industry. Activities such as reducing transportation costs, using recycled materials, and optimizing distribution systems are all important factors driving sustainability.

Internal business environment

The internal environment includes organizational structure, corporate culture, and sustainable development strategies. Gazi (2024) indicates that coordination among departments and leadership commitment play a decisive role in the implementation of green logistics. When the internal environment supports green initiatives, enterprises can achieve better outcomes in supply chain management.

Employee awareness and training

Employee awareness of the importance of green logistics and training programs plays a significant supporting role in the implementation process. Nguyen Thuy Linh (2023) emphasizes that enhancing human resource capacity through training and communication helps employees clearly understand the value of environmentally friendly activities, thereby promoting proactiveness at work. At the same time, Vienažindienė, Tamulienė, and Zaleckienė (2021) affirm that employees who are adequately equipped with knowledge tend to cooperate more effectively in implementing green initiatives, contributing to improving the overall performance of the supply chain.

3. Research methodology

The study was conducted using a quantitative research method to examine the application of the green logistics model in supply chain management at small and medium-sized enterprises in Hanoi. Data were collected through a survey questionnaire with quantitative questions, designed based on previous studies by Kim, Na, and Ha (2024) and Nguyen Thuy Linh (2023). The survey subjects included managers and employees working in the logistics sector in Viet Nam.The sampling method applied was convenience sampling, with a sample size of 131 enterprises, ensuring representativeness. Data were analyzed using SPSS 26.0 software.

Research model

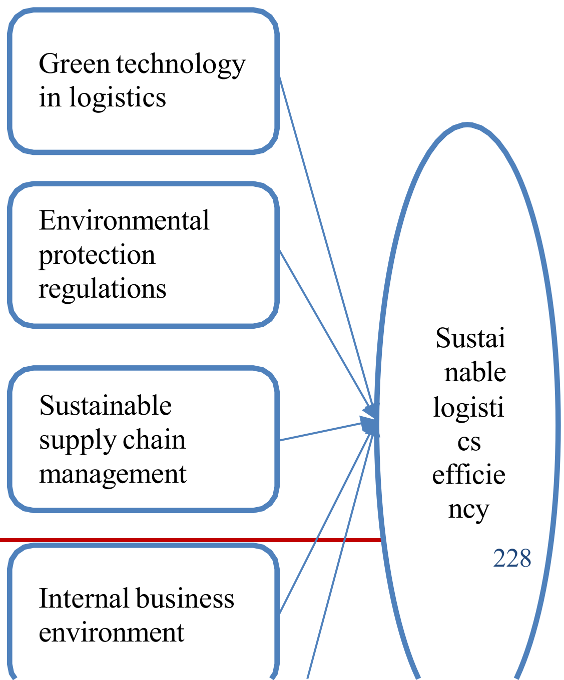

Figure 1. Author's research model

(Source: Author's proposal)Giả thuyết nghiên cứu

H1: Green technology in logistics has a positive impact on sustainable logistics efficiency.

H2: Environmental protection regulations have a positive impact on sustainable logistics efficiency.

H3: Sustainable supply chain management has a positive impact on sustainable logistics efficiency.

H4: The internal environment of the enterprise has a positive impact on sustainable logistics efficiency.

H5: Employee awareness and training have a positive impact on sustainable logistics efficiency.

4. Research Results and Discussion

The study, based on 131 surveys of small and medium-sized enterprises (SMEs) in Hanoi, on the application of green logistics models in supply chain management in SMEs in Hanoi, shows the following:

Cronbach's Alpha Reliability

The reliability of the scale is tested through the Cronbach's Alpha coefficient to eliminate variables with a variable-total correlation coefficient less than 0.3. The criterion for selecting a scale is that it has a Cronbach's Alpha reliability ≥ 0.6. Scales with a Cronbach's Alpha reliability ≥ 0.6 are also selected when used for the first time (Nunnally & Burnstein, 1994). Theoretically, the higher the Cronbach's Alpha, the better (the more reliable the scale). The Cronbach's Alpha of the component scales is presented in the tables below:

Table 1. Results of Cronbach's Alpha test for the scales.

Observed variable	**Scale mean if item deleted**	**Scale variance if item deleted**	**Corrected item–total correlation**	**Cronbach's Alpha if item deleted**
The scale "Green technology in logistics" has Cronbach's alpha = 0.845				
CNX1	11,77	3,470	0,725	0,785
CNX2	11,85	3,617	0,666	0,811
CNX3	11,76	3,613	0,682	0,804
CNX4	11,76	3,505	0,657	0,816
The scale "Environmental protection regulations" has Cronbach's alpha = 0.856				
HDV1	10,72	7,773	0,683	0,823
HDV2	10,59	8,090	0,650	0,832
HDV3	10,59	7,598	0,712	0,816
HDV4	10,71	7,838	0,657	0,830
HDV5	10,59	7,598	0,653	0,832
The scale "Sustainable supply chain management" has Cronbach's alpha = 0.798				
QLC1	9,47	3,851	0,649	0,726
QLC2	9,44	4,418	0,548	0,776
QLC3	9,44	3,926	0,616	0,744
QLC4	9,43	3,908	0,626	0,738
The scale "Internal business environment" has Cronbach's alpha = 0.714				
CKL1	15,66	4,579	0,442	0,678
CKL2	15,93	3,988	0,524	0,645
CKL3	15,95	4,082	0,482	0,664
CKL4	15,83	4,695	0,405	0,692
CKL5	15,68	4,327	0,514	0,651
The scale "Employee awareness and training" has Cronbach's alpha =				
NTD1	11,77	3,839	0,733	0,846
NTD2	11,64	3,863	0,734	0,846
NTD3	11,62	3,822	0,709	0,856
NTD4	11,60	3,612	0,776	0,829
The scale "Sustainable logistics performance" has Cronbach's alpha = 0.892				
HQ1	9,92	5,539	0,757	0,863
HQ2	9,82	4,930	0,790	0,850
HQ3	9,73	5,309	0,757	0,862
HQ4	9,88	5,370	0,746	0,866

(Source: Survey results and SPSS analysis)

The Green Technology in Logistics scale is measured by 4 observed variables. The reliability analysis results show a Cronbach's Alpha coefficient of 0.845 > 0.6. The item-total correlation coefficients are all higher than 0.3. The Cronbach's Alpha coefficients, if removed, are lower than the overall reliability level. Therefore, all 4 observed variables are retained for EFA analysis.

The Environmental Protection Regulations scale is measured by 5 observed variables. The reliability analysis results show a Cronbach's Alpha coefficient of 0.856 > 0.6. Furthermore, all 5 observed variables have item-total correlation coefficients greater than 0.3, indicating correlation between the variables. No observed variable has a Cronbach's Alpha coefficient lower than the overall reliability level if removed, thus ensuring the scale's reliability.

The Sustainable Supply Chain Management scale is measured by 4 observed variables. The reliability analysis results show a Cronbach's Alpha coefficient of 0.798 > 0.6. Furthermore, all 4 observed variables have a variable-total correlation greater than 0.3, and the Cronbach Alpha coefficients (if excluded) of the observed variables are all smaller than the overall Cronbach Alpha. Therefore, the service capability scale meets reliability standards.

The Internal Business Environment scale is measured by 5 observed variables. The reliability analysis results show a Cronbach's Alpha coefficient of 0.714 > 0.6. All 5 observed variables have a variable-total correlation greater than 0.3, indicating correlation between the observed variables, and no observed variable has a Cronbach Alpha (if excluded) greater than the overall Cronbach Alpha. Therefore, this scale achieves high reliability for use in subsequent validation steps.

The Employee Perception and Training scale is measured by 4 observed variables. The results show that the Cronbach's alpha coefficient is 0.874 > 0.6, and the Corrected Item-Total Correlation coefficients of the variables are all greater than 0.3. The Cronbach Alpha coefficients (if excluded) of the observed variables are all smaller than the overall Cronbach Alpha, ensuring that the observed variables are correlated with each other.

The Sustainable Logistics Performance scale is measured by 5 observed variables. The reliability analysis results show that the Cronbach's Alpha coefficient is 0.892 > 0.6. Furthermore, all 5 observed variables have a Corrected Item-Total Correlation coefficient > 0.3, and the Cronbach Alpha coefficients (if excluded) of the observed variables are all smaller than the overall Cronbach Alpha. Therefore, the "Sustainable Logistics Performance" scale has high reliability and can be included in the next validation steps.

After validating the scales using Cronbach's Alpha coefficient, all scales met the reliability requirements and were moved to the next step for Exploratory Factor Analysis (EFA) to assess the convergent and discriminant validity of the scales.

Exploratory Factor Analysis (EFA)

The results obtained showed a KMO coefficient of 0.761 > 0.5 and a Barlett's test with a Chi-square value of 1293.637 and a significance level of Sig = 0.000 < 0.05, indicating that the observed variables belonging to the same factor are strongly correlated. Simultaneously, the total extracted variance is 64.335% > 50%, showing that these 5 newly extracted factors explain 64.335% of the variability in the dataset, and the Eigenvalue = 1.348 > 1, meeting the criteria for factor analysis.

Table 2. Results of factor analysis of independent variables

Rotated Component Matrix[a]					
	Component				
	1	2	3	4	5
HDV3	0,790				
HDV4	0,779				
HDV2	0,775				
HDV5	0,729				
HDV1	0,695				
NTD4		0,846			
NTD1		0,844			
NTD2		0,840			
NTD3		0,790			
CNX1			0,809		
CNX2			0,803		
CNX3			0,789		
CNX4			0,738		
QLC1				0,787	
QLC3				0,745	
QLC4				0,727	
QLC2				0,721	
CKL1					0,703
CKL2					0,682
CKL5					0,678
CKL4					0,635
CKL3					0,570

(Source: Survey results and SPSS analysis)

Based on Table 2, which is a rotated matrix created using the Varimax rotation method and the Principal Component data extraction method, we see that the observed variables meet the following conditions:

Convergent validity: The observed variables are grouped together with factor loading coefficients in the same column within the same scale as initially proposed. Discriminant validity: The other observed variables all have only one factor loading coefficient and are all greater than 0.5, indicating that the observed variables have practical significance and can be used in subsequent tests.

Table 3. Results of factor analysis of dependent variables

	Component
	1
HQ2	0,888
HQ1	0,866
HQ3	0,866
HQ4	0,858

(Source: Survey results and SPSS analysis)

Furthermore, the other observed variables all show only one factor loading coefficient, and that coefficient is greater than 0.5, indicating that the observed variables have convergent validity and practical significance, so they can be used in subsequent tests.

Hypothesis Testing – Correlation and Regression Analysis

+ Correlation Analysis

Before conducting multiple linear regression analysis, the linear correlation between variables needs to be considered. The Pearson correlation coefficient is used to quantify the strength of the linear relationship between two quantitative variables.

Table 4. Correlation Matrix

Observed variable		HQ	CNX	HDV	QLC	CKL	NTD
HQ	Pearson Correlation	1	.404**	.455**	.596**	.403**	.418**
	Sig. (2-tailed)		0,000	0,000	0,000	0,000	0,000
	N	131	131	131	131	131	131
CNX	Pearson Correlation	.404**	1	.397**	0,139	0,171	.372**
	Sig. (2-tailed)	0,000		0,000	0,112	0,050	0,000
	N	131	131	131	131	131	131
HDV	Pearson Correlation	.455**	.397**	1	.387**	.191*	.216*
	Sig. (2-tailed)	0,000	0,000		0,000	0,029	0,013
	N	131	131	131	131	131	131
QLC	Pearson Correlation	.596**	0,139	.387**	1	.400**	.215*
	Sig. (2-tailed)	0,000	0,112	0,000		0,000	0,014
	N	131	131	131	131	131	131
CKL	Pearson Correlation	.403**	0,171	.191*	.400**	1	0,142
	Sig. (2-tailed)	0,000	0,050	0,029	0,000		0,106
	N	131	131	131	131	131	131
NTD	Pearson Correlation	.418**	.372**	.216*	.215*	0,142	1
	Sig. (2-tailed)	0,000	0,000	0,013	0,014	0,106	
	N	131	131	131	131	131	131

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

(Source: Survey results and SPSS analysis)

+ Regression Analysis

Evaluating and Testing the Model's Fit

Using the F-Test: It is necessary to accurately assess the model's fit through hypothesis testing. To test the fit of the regression model, we set the hypothesis H0: R2 = 0. The F-test is used to test this hypothesis. Test results:

• Sig < 0.05: Reject the null hypothesis H0, meaning R2 ≠ 0 statistically significantly, the regression model is fit.

• Sig > 0.05: Accept the null hypothesis H0, meaning R2 = 0 statistically significantly, the regression model is not fit.

The results in Table 5 show that the F-statistic value is 75.594 at a very small significance level (sig = 0.000 < 0.05). Therefore, we can conclude that if R2 ≠ 0 is statistically significant, the regression model is appropriate.

Table 5. ANOVA Table

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	39,279	5	7,856	28,524	.000[b]
	Residual	34,426	125	0,275		
	Total	73,705	130			

(Source: Survey results and SPSS analysis)

Using the t-test: Testing the linear relationship between an independent variable and the dependent variable.

- Hypothesis H0: There is no linear relationship between the dependent variable and each independent variable

- Hypothesis H1: There is a linear relationship between the dependent variable and each independent variable

- Reject H0 when sig. < 0.05

From Table 6, it can be seen that the regression coefficients tested by the t-test all have significance levels of sig. < 0.05. Therefore, H0 is rejected. Thus, there is a linear relationship between each independent variable and the dependent variable, meaning that all independent variables included in the model explain the variation of the dependent variable.

Table 6. Results of linear regression coefficients

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t value**	**Sig.**	**Multicollinearity**	
		B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
1	Constant	-1,388	0,465		-2,986	0,003		
	CNX	0,226	0,087	0,184	2,595	0,011	0,745	1,343
	HDV	0,166	0,079	0,151	2,114	0,037	0,730	1,369
	QLC	0,473	0,084	0,407	5,661	0,000	0,723	1,383
	CKL	0,225	0,101	0,150	2,232	0,027	0,826	1,211
	NTD	0,246	0,079	0,208	3,109	0,002	0,834	1,199

(Source: Survey results and SPSS analysis)

Testing multicollinearity: From Table 6, the variance inflation factor (VIF) values of all variables are less than 2; therefore, multicollinearity does not occur. Thus, the relationships among the independent variables do not affect the explanation of the multiple linear regression model.

Testing the goodness of fit of the model: When additional independent variables are included in regression analysis, R^2 tends to increase. This leads to some cases in which the goodness of fit of the regression model is overstated when independent variables that explain the dependent variable very weakly or do not explain it are included. In SPSS, in addition to the R^2 index, there is also the adjusted R^2 index. The adjusted R^2 does not necessarily increase when more independent variables are added to the regression; therefore, the adjusted R^2 reflects the goodness of fit of the model more accurately than the R^2 coefficient.

From Table 7, the adjusted R^2 is 0.533, meaning that the constructed linear regression model is appropriate, and the independent variables in the model explain 53.30% (>50%) of the variation of the dependent variable. This means that 50.14% of the variation of the dependent variable is explained by variables not included in the model and by random error.

Table 7. Criteria for evaluating model fit.

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Durbin–Watson
1	.730[a]	0,533	0,514	0,52479	1,707

(Source: Survey results and SPSS analysis)

Thus, based on the test results above, we see that the regression model is appropriate and statistically significant. The regression equation is:

HL = -1,388 + 0.184*CNX+0.151*HDV+0.407*QLC+0.150*CKL+0.208*NTD

However, the above equation uses unstandardized regression coefficients, which are only mathematically meaningful. To examine the degree of impact or the order of influence of independent variables on the dependent variable, we must rely on standardized regression coefficients. These coefficients indicate which independent variable has a strong or weak influence on the dependent variable; the larger the coefficient, the greater the importance of that independent variable to the dependent variable.

Management Implications

The environmental protection regulatory factor (Beta = 0.184) emphasizes the role of the legal and policy framework in promoting the adoption of green logistics by businesses. Managers need to focus on strictly complying with regulations on emission reduction, waste treatment, and energy optimization. Continuously updating and flexibly applying international environmental standards not only helps businesses ensure legal compliance but also enhances their reputation in the market.

Sustainable supply chain management (Beta = 0.151) plays a crucial role in optimizing the overall efficiency of the supply chain. Managers need to establish long-term collaborative relationships with suppliers, customers, and partners to ensure that all parties in the supply chain participate in implementing measures to mitigate environmental impacts. Furthermore, the application of advanced supply chain management technologies such as blockchain or artificial intelligence will create a competitive advantage while enhancing operational transparency.

The internal business environment (Beta = 0.407) is identified as the biggest factor influencing the success of green logistics. Businesses need to build an organizational culture that focuses on sustainable development and encourages employee participation in green initiatives. Investing in environmentally friendly infrastructure and technology, along with designing efficient operational processes, will help create a solid foundation for implementing green logistics.

The factor of employee awareness and training (Beta = 0.150) emphasizes the importance of improving understanding of green logistics among the workforce. In-depth training programs, along with integrating environmental protection content into daily operations, will help strengthen employee commitment to sustainability goals. Therefore, implementing green logistics requires a close combination of management elements, with the internal business environment and training programs at the heart of it, supported by appropriate policies and collaborative relationships within the supply chain.

5. Conclusion

The study of applying green logistics models in supply chain management at small and medium-sized enterprises (SMEs) in Hanoi is not only a trend but also an essential requirement in the context of sustainable development. This model offers many important benefits, including minimizing negative impacts on the environment, optimizing resources, and improving business efficiency. Integrating green logistics practices not only helps improve economic performance but also contributes to building brand image and meeting international environmental protection standards. However, the current situation in Vietnam shows that businesses still face many challenges such as inconsistent infrastructure, limited awareness of green logistics, and a lack of specific support policies from regulatory agencies. Therefore, to effectively implement green logistics, synchronized coordination between businesses, the government, and stakeholders is needed. The application of modern technologies such as blockchain and artificial intelligence will help increase transparency and efficiency in the green supply chain. With its clear benefits and immense potential, green logistics is not only a strategic solution but also a driving force for small and medium-sized enterprises in Vietnam to move towards sustainable development and global competitiveness....

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