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DEVELOPING A MEASUREMENT SCALE FOR GREEN LOGISTICS PRACTICES: CASE STUDIES OF SERVICE ENTERPRISES IN CENTRAL VIETNAM

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Abstract. This study aims to develop and validate a Green Logistics Practices scale for logistics service enterprises. By combining qualitative research methods through expert interviews and quantitative methods with exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) on survey data from 178 logistics enterprises in Hue and Quang Tri, the study successfully built a scale of 25 observed variables. These variables are grouped into five main factors: Green packaging, Fuel efficiency, Route optimization, Carbon emission measurement, and Reverse green logistics. The study concludes that the developed Green Logistics Practices Scale is reliable, valid and applicable to assess green logistics practices in the context of logistics service enterprises in Vietnam, reflecting both theoretical value, and practical applicability.

Keywords: green logistics, green logistics practices, logistics service enterprises.

1. Introduction

Sustainable development has become a central global priority, motivating governments and industries to adopt a wide range of green and sustainable logistics initiatives aimed at reducing the negative environmental impacts of freight transportation. Logistics operations continue to generate significant externalities—including greenhouse gas emissions, congestion, noise, and waste—which pose substantial challenges for both economic systems and the natural environment [1, 2]. These impacts are particularly pronounced in developing economies where logistics systems rely on limited technology, fragmented infrastructure, and constrained managerial resources. As one of the countries most vulnerable to climate change, Vietnam has increasingly emphasized low-carbon development and environmental protection through national strategies and policy frameworks, particularly following its commitment at COP26. Many Vietnamese logistics enterprises have begun integrating green logistics activities into their business strategies, yet the transition remains difficult due to financial, informational, and infrastructural barriers.

Globally, the literature identifies multiple components associated with Green Logistics Practices (GLP), including eco-efficient packaging [3], fuel-efficient transportation [4, 5], route optimization [6], carbon emission measurement and reporting [7, 8], and reverse logistics [9, 10]. Although these studies offer valuable insights, most examine these practices in isolation or validate only limited subsets of indicators, resulting in fragmented evidence and the absence of an integrated and empirically tested scale. In emerging economies such as Vietnam, the literature remains even more limited: existing studies tend to provide conceptual or descriptive assessments rather than developing a unified, validated measurement framework tailored to local logistics service enterprises. Therefore, a clear research gap persists: no comprehensive, multidimensional, and empirically validated GLP measurement scale currently exists for the Vietnamese context, particularly for small and medium-sized logistics enterprises in Central Vietnam.

To address this gap, the present study develops and validates a measurement scale for Green Logistics Practices by synthesizing global theoretical foundations [3, 6, 9], conducting expert evaluations, and applying both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) to data collected from logistics enterprises in Hue, Quang Tri, and Quang Binh provinces. The study proposes and empirically confirms a five-factor structure consisting of Green Packaging, Fuel Efficiency, Route Optimization, Carbon Emissions Measurement, and Reverse Green Logistics. The research contributes theoretically by expanding global green logistics scholarship with evidence from an emerging economy and practically by providing a validated tool for logistics managers to assess and enhance the greening of their operations in Vietnam.

2. Literature review

Green logistics has become an increasingly important topic in both academic research and business practice as organizations seek to reduce environmental impacts while maintaining operational efficiency. Prior global studies have investigated various components of green logistics—such as eco-efficient packaging [3], fuel-efficient transportation [4, 5], route optimization [6], carbon emission management [7, 8], and reverse logistics [9, 10]. However, despite the breadth of this literature, most studies focus on individual elements in isolation or assess only a subset of practices, resulting in inconsistent conceptualizations of Green Logistics Practices (GLP). This fragmentation limits the development of a unified and multidimensional understanding of green logistics, and several scholars emphasize the need for more integrated empirical frameworks that capture GLP holistically across logistics activities.

In emerging markets, literature remains even more constrained. Existing research in Vietnam largely adopts a conceptual or descriptive orientation, addressing policy directions, general environmental benefits, or broad adoption challenges rather than operationalizing GLP into measurable constructs. Moreover, empirical studies in Vietnam often use adapted scales designed in foreign contexts, which may not accurately reflect local industry characteristics—especially among small and medium-sized logistics service enterprises, which constitute the majority of the sector. To date, no study has developed and validated a comprehensive GLP measurement scale tailored specifically to Vietnamese logistics enterprises.

Taken together, the literature highlights three major gaps: (1) the absence of an integrated and empirically validated multidimensional scale for GLP; (2) limited empirical evidence from developing economies where institutional, resource, and technological constraints differ significantly from developed countries; and (3) a lack of measurement tools designed for the context of logistics service enterprises in Central Vietnam. Addressing these gaps is essential to advancing the theoretical foundation of green logistics and providing practitioners with reliable tools to evaluate and enhance environmentally responsible logistics practices. The present study responds to these gaps by synthesizing prior research, incorporating expert insights, and validating a five-factor GLP scale through EFA and CFA.

3. Methodology

3.1. Research Design

This study followed a multi-stage scale development procedure combining qualitative exploration and quantitative validation, consistent with established guidelines for measurement scale development [11]. The process included (1) theoretical synthesis, (2) expert evaluation, (3) exploratory factor analysis (EFA), and (4) confirmatory factor analysis (CFA).

3.2. Conceptual Framework

Based on the global literature and synthesized theoretical foundations, the study proposes that Green Logistics Practices consist of five core components: Green Packaging, Fuel Efficiency, Route Optimization, Carbon Emissions Measurement, and Reverse Green Logistics.

These components form the conceptual basis for developing the measurement scale. Figure 1 illustrates the conceptual structure of GLP adopted in this study.

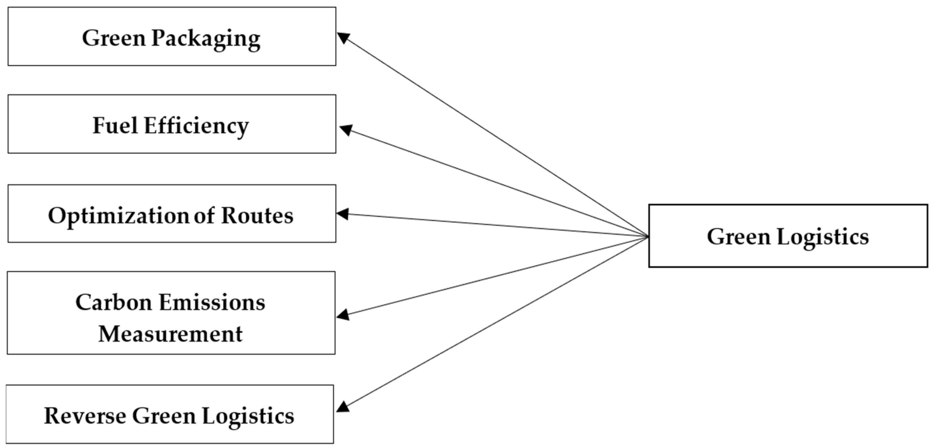

Figure 1. Model of Green Logistics Practice Components of Logistics Enterprises

Source: Proposed by the Authors

3.3. Developing the GLP Measurement Scale

Following the conceptual framework, the study developed an initial pool of measurement items based on prior research and definitions from global literature. Items were synthesized from established studies on eco-packaging [3], fuel efficiency practices [4, 5], route optimization [6], carbon emission management [7, 8], and reverse logistics [9, 10].

The initial list consisted of 25 observed variables grouped into five categories corresponding to the conceptual framework. Table 1 presents the complete set of measurement items used for expert validation and subsequent statistical testing.

Table 1. The scale of Green Logistics Practices

Code	Green Logistics Practice	Source
	I. Green Packaging (GP)	
GP1	Our business employs recyclable materials (bioplastic, paperboard, and cardboard) when packaging for suppliers.	[12]
GP2	Our company packages natural materials such as dye-free paper, which	

	are less harmful to the environment.	
GP3	Our company produces packaging boxes to conserve products and make space during the process of delivery	
GP4	Our organization is continuously working to identify new reusable materials for packaging.	
GP5	Our company works with suppliers to utilize life cycle assessments to analyze the environmental effect of packaging during design and standardized packaging.	
	II. Fuel Efficiency (FE)	
FE1	We train drivers to practice driving techniques which are fuel efficient.	
FE2	We ensure correct tires maintenance to enhance fuel efficiency.	
FE3	We use fuel efficient vehicles.	
FE4	We are implementing a continuous preventive maintenance program for our vehicles.	
FE5	We leverage technology (i.e., taking advantage of on-board diagnostics systems and new telematics) that aids in analyzing fuel purchases and vehicle performance.	[4, 5]
FE6	We are integrating real-time visibility of inventory into the warehouses aimed at reducing unnecessary trips.	
FE7	We organize supplier consignments to consolidate freight costs and leverage multiple modes of transport (e.g., railway lines) to enhance efficiency.	
	III. Optimization of Routes (OR)	
OR1	Our firm directs drivers by automatically providing driving directions based on running sheet data to the trucks at the next stop.	
OR2	Our company provides a graphical view of the calls to a driver. re-calculating automatically the route when a driver selects a manual stop which is out-of-sequence.	[4, 13]
OR3	Our organization has statistics on drivers and fleets to offer an enhanced	

	level of understanding of fleets operational efficiency and help in pinpointing areas where costs can be reduced or improve productivity like in regrouping of goods.	
	IV. Carbon Emissions Measurement (CEM)	
CEM1	Our company obtain from vehicle manufacturers a Life Cycle Assessment [14] showing the complete carbon emission from the vehicle assembly to its usage and its disposal.	
CEM2	Our company has purchased carbon offsets to compensate for all carbon emissions caused by our vehicles, i.e., tree planting.	
CEM3	Our firm often replaces older vehicles with newer ones which emit less to the environment.	[15-18]
CEM4	Our firm's carbon emission report has all the information needed for decision making by both the external and internal users.	
CEM5	Our firm's carbon emission information is reported in a coherent, neutral and factual manner based on audit trail which is clear.	
	V. Reverse Green Logistics (RGL)	
RGL1	Our company offers and notifies product vendors the product recall or packaging return or take-back service	
RGL2	Our firm provides logistics service for on-site disposition	
RGL3	Our company provides product suppliers with rework or liquidation services for their returned products.	[9, 10, 19-21]
RGL4	Our company provides suitable guidance to clients on the environmental aspects of handling usage and disposal of the vendor's products.	
RGL5	Our firm returns used packaging and products to suppliers for recycling or reuse.	

Source: Authors' compilation

3.4. Expert Evaluation (Content Validity)

The content validity of the initial Green Logistics Practices (GLP) measurement scale was assessed through expert evaluation based on the Content Validity Ratio (CVR). A panel of 18 experts participated, including three university lecturers specializing in supply chain and logistics management, along with 5 directors, 3 deputy directors, and 7 department heads from logistics enterprises located in Hue, Quang Tri, and Quang Binh. These experts reviewed the conceptual definitions, assessed the relevance and clarity of each observed variable, and evaluated the comprehensiveness of the proposed scale.

Each expert rated whether an item was "essential" to the construct. CVR values were then computed using the formula:

$$\mathrm{CVR} = \frac{n_e - (N/2)}{N/2}$$

where N = 18 (total experts) and n_e is the number of experts identifying the item as essential. Based on Lawshe's threshold (CVR > 0.49), all items meeting the required value were retained for subsequent analysis. This expert validation step ensured that the GLP scale was theoretically grounded, conceptually consistent, and contextually appropriate for logistics service enterprises in Central Vietnam.

3.5. Data Collection and Sample

Following expert validation, the study administered a structured survey to logistics service enterprises in Hue city, Quang Tri, and Quang Binh provinces. A minimum sample size of 125 was required based on the rule of at least five observations per variable [11], given the 25 measurement items. To enhance reliability and account for potential non-response, 180 questionnaires were distributed through both online platforms and direct contact. A total of 178 valid responses were obtained, including 60 online and 118 face-to-face surveys.

The sample collected reflects the key characteristics of the regional logistics sector. The sample distribution by service type was led by transportation service providers, accounting for 34.2% (61 firms), followed by warehousing at 29.6% (53 firms), delivery services at 21.0% (37 firms), and specialized logistics providers comprising 15.2% (27 firms). Small and medium-sized enterprises (SMEs) dominated the size profile: 42.0% employed 100–200 workers and 39.5% employed fewer than 100 employees, with only 18.5% classified as large enterprises. Furthermore, the industry is relatively young, with 45.0% of firms operating 2–5 years and 36.6% operating 6–10 years, and just 4.8% having more than 10 years of experience. These collective characteristics demonstrate the sample's representativeness for the logistics sector in Central Vietnam.

3.6. Data Analysis Procedures

The study employed a two-stage analytical approach using SPSS and AMOS to validate the GLP measurement model.

Step 1: Reliability testing and Exploratory Factor Analysis (EFA)

All 25 items were first assessed using Cronbach's Alpha to determine internal consistency. Items with item–total correlations below 0.30 or scales with alpha values below 0.60 were removed. Results indicated that all five dimensions achieved acceptable reliability (α ranging from 0.712 to 0.900). EFA with Varimax rotation was then conducted. The Kaiser–Meyer–Olkin (KMO) value reached 0.836 and Bartlett's Test of Sphericity was statistically significant ($p < .001$), indicating suitability for factor analysis. EFA extracted five factors with Eigenvalues > 1 and a cumulative variance of 62.14%. All loadings exceeded 0.50, confirming factor structure clarity.

Step 2: Confirmatory Factor Analysis (CFA)

CFA was conducted using AMOS 24 to validate the measurement model. Model fit indices indicated strong fit: CMIN/df = 1.015, GFI = 0.897, TLI = 0.997, CFI = 0.998, RMSEA = 0.009, PCLOSE = 0.423. Convergent validity was established as Composite Reliability (CR > 0.70) and Average Variance Extracted (AVE > 0.50) thresholds were met across all factors. Discriminant validity was confirmed using Fornell–Larcker criteria, in which the square roots of AVE values exceeded inter-construct correlations. Bootstrap analysis with 5,000 samples further verified the stability of parameter estimates, with no confidence intervals containing the value 1.

These analytical steps collectively confirmed the reliability, validity, and robustness of the developed GLP measurement scale.

4. Empirical results

4.1. Reliability Analysis

Before conducting factor extraction, the reliability of the initial 25 observed variables was examined using Cronbach's Alpha. All five constructs demonstrated acceptable internal consistency, with Alpha coefficients ranging from 0.712 (Route Optimization) to 0.900 (Green Packaging). Item–total correlations were all above 0.30, and no items were removed. These results confirmed that the observed variables were suitable for further factor analysis.

4.2. *Exploratory Factor Analysis (EFA)*

The Kaiser–Meyer–Olkin (KMO) value of 0.836 and the significant Bartlett's test of sphericity ($p < .001$) confirmed that the dataset was appropriate for factor analysis. Using Principal Component Analysis with Varimax rotation, five factors with eigenvalues above 1 were extracted, explaining 62.14% of the cumulative variance. All observed variables had factor loadings above the recommended threshold of 0.50, and the extracted factors corresponded clearly to the conceptual structure of Green Packaging, Fuel Efficiency, Route Optimization, Carbon Emissions Measurement, and Reverse Green Logistics.

Table 2. Results of exploration factor analysis EFA of Green Logistics practice scale

Observation variable	Factors				
	GP	FE	OR	CEM	RGL
GP2	0.929				
GP4	0.831				
GP5	0.790				
GP3	0.773				
GP1	0.700				
FE5		0.809			
FE7		0.734			
FE1		0.721			
FE4		0.684			
FE2		0.639			
FE3		0.631			
OR1			0.806		
OR3			0.720		
OR2			0.574		
CEM1				0.753	
CEM5				0.747	

CEM4				0.729	
CEM3				0.695	
CEM2				0.605	
RGL4					0.721
RGL5					0.716
RGL2					0.716
RGL1					0.658
RGL3					0.614
Cronbach's Alpha	0.900	0.862	0.712	0.828	0.813
Eigen Value	5.800	2.845	2.828	2.277	1.786
Variance	23.199	11.378	11.313	9.108	7.145
Cumulative Variance	23.199	34.577	45.890	54.998	62.142

Source: Processing survey data in 2025

4.3 Confirmatory Factor Analysis (CFA)

To validate the measurement model, CFA was conducted using AMOS 24. The results demonstrate an excellent model fit: CMIN/df = 1.015; GFI = 0.897; TLI = 0.997; CFI = 0.998; RMSEA = 0.009; PCLOSE = 0.423. These values all met or exceeded recommended thresholds, indicating strong model adequacy.

Table 3. Model fit testing

Index	**CMIN/df**	**GFI**	**TLI**	**CFI**	**RMSEA**	**PCLOSE**
Value	1.015	0.897	0.997	0.998	0.009	0.423
Reference standards	<3	≥ 0,8	≥ 0,9	≥ 0,9	≤ 0,08	≥ 0,05

Source: Processing survey data in 2025

Convergent validity was confirmed, with Composite Reliability (CR) values ranging from 0.814 to 0.903 and Average Variance Extracted (AVE) values ranging from 0.568 to 0.653.

Table 4. Testing the convergent validity of the model

Factors	Composite reliability (CR)	Total extracted variance (AVE)
Green Packaging	0.903	0.653
Fuel efficiency	0.865	0.580
Optimization of Routes	0.741	0.592
Carbon emissions measurement	0.831	0.592
Reverse Green logistics	0.814	0.568

Source: Processing survey data in 2025

The standardized CFA model confirmed strong factor loadings and inter-factor relationships consistent with theoretical expectations.

Table 5. Test of discriminant validity of the model

	GP	FE	OR	CEM	RGL
GP	**0.808**				
FE	0.415	**0.761**			
OR	0.259	0.227	**0.769**		
CEM	0.243	0.175	0.146	**0.769**	
RGL	0.118	0.108	0.116	0.048	**0.753**

Source: Processing survey data in 2025

4.4. Summary of Measurement Model Validation

The combined results of Cronbach's Alpha, EFA, and CFA confirm that the newly developed GLP measurement scale is reliable, valid, and structurally sound. The findings empirically support a five-factor structure representing Green Packaging, Fuel Efficiency, Route Optimization, Carbon Emissions Measurement, and Reverse Green Logistics. The validated scale is suitable for assessing green logistics practices among logistics service enterprises in Central Vietnam and provides a robust foundation for future theoretical and empirical research in the field.

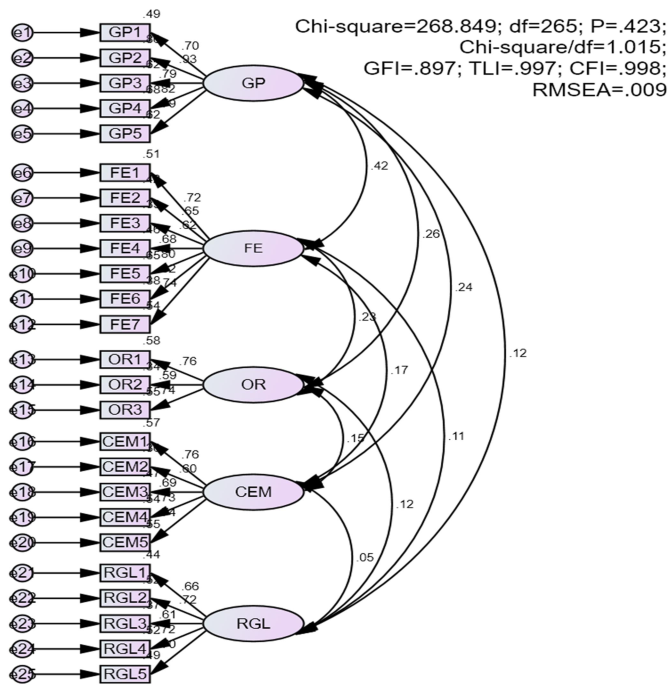

Figure 2. Results of CFA analysis of the factors constituting Green Logistics practices of logistics service enterprises

Source: Processing survey data in 2025

4.5 Discussion

The objective of this study was to develop and validate a multidimensional measurement scale for Green Logistics Practices (GLP) in the context of logistics service enterprises in Central Vietnam. Unlike the earlier sections of this paper, which focused on conceptualization and empirical validation, this Discussion section elaborates on the theoretical significance of the findings, compares them with prior studies, and provides insights into the variables that were excluded during the analysis—an aspect emphasized by the reviewer as particularly important.

Comparative insights with previous studies

The validated five-factor GLP structure supports the notion that environmental logistics practices are inherently multidimensional; however, the configuration observed in this study reveals several noteworthy differences compared with prior international research. For example, while [3, 4] emphasized packaging and fuel efficiency as separate strategic domains, this study finds that Vietnamese logistics enterprises perceive these dimensions more operationally rather than strategically. The strong factor loadings for Fuel Efficiency and Route Optimization, compared with moderate loadings for Carbon Emissions Measurement, suggest that firms prioritize cost-saving and operational efficiency over long-term environmental reporting-contrasting with findings from more developed markets such as those in[6, 7].

Similarly, the significance of Reverse Green Logistics in this study extends the work of [10], who observed that reverse logistics is often underdeveloped in emerging economies. The Vietnamese context demonstrates a more proactive approach toward product returns, recycling, and recovery processes due to increasing pressure from customers and regulatory bodies. This finding suggests that reverse logistics may be evolving from a peripheral activity to a core component of green logistics within transition economies.

Insights on excluded variables

A unique contribution of this study is the examination of variables excluded during scale refinement—a topic often overlooked in GLP literature. During EFA and CFA, several measurement items exhibited weak loadings or cross-loadings, leading to their removal. Notably, some indicators related to detailed carbon auditing and long-term carbon reduction planning were excluded due to low reliability. This aligns with global studies (i.e., [8], which note that carbon accounting practices are underdeveloped in many logistics enterprises, especially SMEs lacking technological capability or standardized reporting procedures.

Additionally, certain items under Green Packaging were excluded because they focused on advanced eco-design or supplier–collaboration mechanisms, which may not yet be widely practiced in Central Vietnam. The exclusion of these items indicates that although firms recognize the importance of green packaging, implementation remains at a basic level—primarily involving material reduction rather than systemic or strategic innovation. This finding reinforces insights from [5], who observed similar gaps in developing economies where green logistics is still at an emergent stage.

The removal of several items thus provides valuable guidance for future research: (1) Scholars should examine barriers to the adoption of advanced green practices; (2) Additional qualitative inquiry may uncover firm-level constraints that influence item performance; and (3) Future scale refinement could reintroduce these items when industry maturity improves.

Theoretical implications

The study advances theoretical understanding of GLP by demonstrating that its multidimensional structure is stable even in developing contexts, but that the operational emphasis differs from developed economies. This suggests that GLP adoption pathways are context-dependent, shaped by institutional pressures, technological readiness, and resource availability. The exclusion of advanced items further indicates that GLP concepts must be adapted carefully across regions rather than assumed to generalize universally.

Practical implications

The validated scale enables logistics managers to assess their current level of green practice adoption and identify specific dimensions needing improvement. Moreover, the excluded variables highlight areas where Vietnam's logistics industry could enhance capacity—particularly carbon auditing, supplier collaboration, and eco-design. Policymakers can use these insights to design targeted interventions that address capability gaps.

5. Conclusion

This study develops and validates a five-factor measurement scale for Green Logistics Practices (GLP) appropriate for logistics service enterprises in Central Vietnam. The findings confirm that GLP is a multidimensional construction and provides an integrated measurement tool that addresses the fragmentation in previous studies. The exclusion of several advanced items—particularly those related to carbon auditing and eco-design—reflects the early stage of green logistics development in Vietnam, where many firms still lack technological readiness, financial capability, and standardized reporting systems. In the Vietnamese context, the validated scale offers practical value by helping enterprises evaluate their current practices and identify areas needing improvement, especially in carbon management, fuel efficiency, and reverse logistics. The results also highlight the need for stronger policy support, targeted training, and incentive mechanisms to encourage wider adoption of GLP across the logistics sector. Overall, this study contributes a concise, reliable, and context-sensitive measurement tool that supports Vietnam's transition toward sustainable logistics and enriches the international understanding of GLP development in emerging economies.

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