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Analyzing ESG Barriers Using the Neutrosophic Delphi-Dematel Model

Phi-Hung Nguyen[1,*], Lan-Anh Thi Nguyen[1], Tra-Giang Vu[1], Le-Thi Ho[1], Phuong-Thao Thi Cao[1], Huong-Giang Le Hoang[1]

[1] Research Center of Applied Sciences, Faculty of Business, FPT University, Hanoi 100000, Vietnam; hungnp30@fe.edu.vn.

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Abstract

The growing global emphasis on Environmental, Social, and Governance (ESG) practices has placed increasing pressure on emerging economies, including Vietnam, to integrate sustainability into key industries such as logistics. However, ESG implementation in Vietnam's logistics sector faces numerous interrelated challenges. This study employs a two-staged Neutrosophic Delphi-DEMATEL (NS-Delphi and NS-DEMATEL) method to systematically identify and analyze the causal relationships among eight key barrier dimensions: Legal and Compliance, Institutional, Economic, Psychological and Behavioral, Environmental, Social, Governance, and Technological. The results reveal that Legal and Compliance, Institutional, Economic, Psychological, and Behavioral barriers serve as the core causal dimensions that significantly influence the remaining effect dimensions. Notably, weak legal enforcement, unclear regulatory mandates, institutional capacity limitations, financial constraints, and behavioral inertia were the most influential impediments to ESG adoption. In contrast, environmental degradation, poor stakeholder engagement, governance inefficiencies, and low technological uptake were identified as outcome variables shaped by upstream barriers. The study offers practical policy implications, including the need for mandatory ESG regulations, enforcement reforms, capacity building, and targeted green finance mechanisms. Managerial recommendations include conducting ESG audits, aligning sustainability strategies with business objectives, and enhancing ESG-related competencies across organizations. The study contributes to ESG literature by providing a causal framework tailored to emerging market contexts and highlights directions for future research, including comparative analysis and hybrid multi-criteria modeling.

Keywords: ESG, Sustainable logistics, Vietnam, Neutrosophic sets, NS-Delphi, NS-DEMATEL, Causal analysis.

1 | Introduction

1.1 | Research Background

In an era where sustainability has become a strategic imperative across industries, Environmental, Social, and Governance (ESG) factors have solidified their role as a cornerstone shaping the future of global logistics [1].

Corresponding Author: hungnp30@fe.edu.vn

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Within the logistics domain, ESG is conceptualized as the seamless integration of three pivotal dimensions: the environmental dimension, which focuses on mitigating carbon emissions, optimizing natural resource utilization, and enhancing waste management through innovative solutions such as renewable energy and recycling; the social dimension, which prioritizes ensuring safe working conditions, safeguarding labor rights, and fostering community welfare within supply chain operations; and the governance dimension, which emphasizes transparency in management, combating corruption, and adhering to legal regulations [2]. Leveraging modern trends like the circular economy and advanced technologies, ESG harnesses the potential of big data, Artificial Intelligence (AI), and the Internet of Things (IoT) to improve operational efficiency, enhance sustainable decision-making, and streamline material flows across supply chains [3]. In this context, ESG aims to minimize environmental harm and promote balanced economic, social, and Governance development, delivering long-term value to stakeholders. As businesses increasingly prioritize customer satisfaction, cost efficiency, and environmental accountability, ESG has become an indispensable element of contemporary supply chain management strategies. Effective ESG implementation enables firms to reduce resource wastage, meet stringent environmental standards, and cultivate a reputation for social responsibility [4]. The benefits of ESG are evident, encompassing reduced operational costs, enhanced performance, and strengthened trust among customers and partners. Although initially perceived as a costly investment, recent studies highlight its substantial potential to improve both financial and operational outcomes. For instance, a McKinsey and Company report [5] demonstrates that well-executed ESG strategies can significantly enhance a firm's financial performance. Specifically, energy reduction, supply chain optimization, and waste management initiatives lower operational expenses and boost operating profit margins (EBIT) by up to 60%. This underscores that ESG is not merely an ethical commitment but a financially viable and sustainable business strategy. Nevertheless, integrating ESG into practice presents complex challenges related to policy frameworks, funding constraints, and workforce capabilities, necessitating sophisticated analytical approaches to overcome these hurdles.

The Vietnamese logistics sector plays a vital role in the national economy, contributing approximately 16-20% to GDP and achieving an average annual growth rate of 14-16%, affirming its central position in economic development with an import-export turnover of 732.5 billion USD in 2022, driven by its facilitation of international trade and supply chain connectivity [6]. However, adopting ESG practices in Vietnam encounters distinct challenges, including outdated logistics infrastructure, limited awareness of sustainability standards, and insufficient financial resources to invest in green solutions [7]. These constraints hinder the transition to sustainable logistics, placing Vietnam at a disadvantage as a global market, such as the European Union, with its ESG certification requirements for imported goods starting in 2023, imposing increasingly rigorous standards [8]. The global emphasis on ESG demands swift adaptation to maintain Vietnam's competitive edge, yet these unique barriers require a deeper analytical approach to be addressed effectively. Empirical evidence reveals that Vietnam's logistics industry is constrained by a multifaceted array of ESG barriers, including an absence of supportive governmental policies to promote environmental initiatives, substantial initial investment costs for green infrastructure upgrades (the World Bank estimates Vietnam may require approximately 701 billion USD to address climate change and green transition challenges [9], and a workforce with inadequate skills, particularly in deploying sustainable technologies. Furthermore, limited intersectoral coordination between regulatory bodies and enterprises results in fragmented and inconsistent policy frameworks for advancing ESG adoption. These barriers precipitate severe consequences: according to the Ministry of Transport, the transportation sector currently accounts for about 18% of Vietnam's total Greenhouse Gas (GHG) emissions, a figure projected to rise to approximately 64.3 million tons of CO_2 by 2025 and reach 88.1 million tons by 2030 if no interventions are implemented [8], alongside labor rights violations due to deficient social standards and missed opportunities in international markets stemming from governance shortcomings.

Amid the remarkable growth of e-commerce and manufacturing in Vietnam, the logistics industry is pivotal in enhancing efficiency, reducing costs, and promoting sustainability through ESG practices. Logistics facilitates carbon emission management, resource optimization, labor rights protection, and regulatory compliance, contributing to a circular economy and bolstering Vietnam's position in global supply chains. As an essential component of supply chains, logistics systems ensure efficient transportation, warehousing, and distribution, maintaining product quality and supporting precise demand forecasting. Nevertheless, the Vietnamese logistics sector faces multifaceted ESG barriers, encompassing environmental challenges (carbon emissions, resource inefficiency, waste management), social obstacles (workforce issues, community engagement, labor rights), governance hurdles (regulatory compliance, transparency, ethical concerns), economic constraints (cost limitations, investment gaps, financial risks), technological impediments (digital adoption, IT infrastructure, cybersecurity risks), institutional shortcomings (policy deficiencies, weak frameworks), psychological and behavioral resistance (change aversion, cultural factors), and legal and compliance difficulties (ambiguous regulations, enforcement gaps). Given the robust expansion of Vietnam's logistics sector, particularly in transportation and supply chain management, there is an urgent need for a systematic and comprehensive causality analysis framework to tackle the barriers impeding ESG practice adoption. Existing studies highlight significant gaps in identifying and analyzing these ESG barriers, especially in rapidly developing economies like Vietnam. Current models frequently fail to capture the intricate interdependencies among these barriers, leaving critical relationships unexplored [10]. This necessitates a robust and nuanced causality analysis approach, employing Neutrosophic Sets (NS) to comprehensively assess ESG challenges while considering Vietnam's unique infrastructural and economic context, thereby delivering practical solutions to enhance the sustainability and global competitiveness of the logistics industry.

1.2 | Research Motivation

The motivation for this study arises from the pressing need to address ESG barriers within Vietnam's logistics sector, an industry experiencing robust growth propelled by the surge in e-commerce, industrial production, and supply chain modernization. Contributing approximately 16-20% to the national GDP and achieving an average annual growth rate of 14-16% in 2022 [6], the logistics sector nonetheless faces significant constraints in adopting ESG practices due to multifaceted barriers spanning environmental, social, governance, economic, technological, institutional, psychological and behavioral, and legal and compliance domains. These impediments undermine operational efficiency, cost-effectiveness, and sustainability. Current analytical frameworks frequently fail to capture the intricate interrelationships among ESG barriers adequately and are ill-equipped to handle the uncertainty and contradictions inherent in expert evaluations. This research aims to bridge these gaps by harnessing the capabilities of NS to develop a robust and adaptable decision-making framework, enabling the identification, analysis, and prioritization of ESG barriers within the Vietnamese logistics context. NS, an advanced extension of fuzzy set theory, provides a transformative approach to managing uncertain, incomplete, imprecise, and conflicting information in complex real-world scenarios [11]. Introduced by Smarandache [12], NS transcends the limitations of traditional fuzzy sets by integrating three independent membership functions: truth, indeterminacy, and falsity [13].

This triadic structure offers a flexible and detailed representation of uncertainty, effectively addressing the ambiguity and inconsistencies in expert assessments and decision-making processes. Integrating NS into Multi-Criteria Decision-Making (MCDM) methodologies offers substantial advantages in tackling ESG challenges within Vietnam's logistics sector. NS enables more precise analysis of expert inputs by converting linguistic terms into Neutrosophic values, facilitating computational analysis that captures the inherent uncertainty, imprecision, and variability in data [14]. This capability is particularly critical in the complex decision-making scenarios of logistics, where data reliability and accuracy often fluctuate due to the industry's dynamic nature. Compared to traditional fuzzy set theory and its extensions—such as Ordinary Fuzzy Sets (FS), Intuitionistic Fuzzy Sets (IFS), Pythagorean Fuzzy Sets (PFS), Picture Fuzzy Sets, and Spherical Fuzzy Sets—NS stand out due to their superior capacity to handle highly uncertain, imprecise, and contradictory situations through three independent membership functions. For instance, the FS model uncertainty uses a single membership degree representing truth, yet they struggle with scenarios involving hesitation or conflicting information due to their inability to explicitly denote non-membership or indeterminacy. IFS, introduced by Atanassov [15], extends FS by incorporating a non-membership degree. However, they still fall short in explicitly addressing indeterminacy, which is crucial in contexts with incomplete or opposing data [16]. PFS enhances flexibility by allowing the squared sum of membership and non-membership degrees to fall within [0,1]. Yet, they remain constrained by mathematical limitations, reducing their applicability in highly uncertain environments [17]. Picture Fuzzy Sets and Spherical Fuzzy Sets introduce a degree of hesitation and present uncertainty between membership and non-membership. Still, their components are bound by sum or squared conditions, limiting their ability to model diverse scenarios [18]. In contrast, NS overcomes these constraints by providing three independent membership functions—truth, indeterminacy, and falsity—enabling effective handling of incomplete, imprecise, and contradictory information. The independent variation of these components delivers unparalleled flexibility and a comprehensive depiction of uncertainty, making NS an ideal tool for addressing intricate real-world challenges such as ESG barriers in logistics [19].

Overall, the distinctive properties of NS position them as a superior choice over traditional fuzzy set extensions for resolving complex and uncertain scenarios. Their applications span diverse fields, including supply chain management, logistics, engineering, and sustainability [20]. NS significantly enhances decision-making processes by offering a flexible and holistic framework for modeling uncertainty, particularly in environments characterized by high indeterminacy and conflicting information. Thus, NS is a powerful instrument for advancing research and practice in dynamic, uncertain systems. This study proposes a multi-level MCDM framework tailored to the Vietnamese logistics context, integrating Neutrosophic Delphi (NS Delphi) and Neutrosophic DEMATEL (NS DEMATEL) to address specific objectives: 1) the NS-integrated Delphi method validates the significance and relevance of ESG barriers, analyzing expert feedback within a Neutrosophic framework to ensure consistency and reliability, 2) the NS DEMATEL method examines the interdependencies and causal relationships among identified barriers, highlighting key root causes to enable targeted interventions, and 3) it provides practical insights to overcome these barriers, ensuring that proposed solutions are feasible, actionable, and aligned with the specific challenges faced by stakeholders in Vietnam's logistics industry. This framework promises to deliver theoretical and practical contributions, fostering deeper integration of Vietnam's logistics sector into global sustainability trends.

1.3 | Research Questions

To address ESG barriers in the Vietnamese logistics industry, this study is guided by the following research questions:

I. What are the key ESG barriers in the Vietnamese logistics industry?

II. How do these barriers influence one another?

III. How can NS improve decision-making in addressing these barriers?

1.4 | Scope and Significance

This study focuses on mapping and analyzing barriers to integrating ESG principles within the Vietnamese logistics industry, emphasizing their multi-dimensional and interconnected nature. The scope includes a comprehensive assessment of challenges hindering ESG adoption, spanning environmental, social, governance, economic, technological, institutional, psychological, behavioral, and legal dimensions within Vietnam's context as an emerging economy critical to global supply chains yet constrained by sustainability demands.

Given these complex challenges, the significance of this research emerges from its targeted evaluation of ESG barriers in Vietnam's logistics sector, addressing a gap in the literature on ESG practices in emerging economies. This study delivers multiple key contributions, bridging theoretical advancements and practical applications. First, it identifies and analyzes the multi-dimensional ESG barriers impacting Vietnam's logistics industry, providing a structured understanding of their scope and interconnections. Second, it applies NS within a causality analysis framework to address the uncertainties inherent in evaluating these barriers, enhancing the robustness and reliability of the analytical process. Third, it offers actionable insights for stakeholders, equipping them with practical strategies to overcome ESG barriers and foster a sustainable logistics ecosystem in Vietnam. These advances in ESG understanding in logistics and decision-making deliver practical tools for Vietnam and emerging markets.

The subsequent sections of this paper are structured as follows: Section 2 synthesizes pertinent literature, Section 3 elucidates the methodological approach, Sections 4 and 5 present and interpret empirical results and discussion, and Section 6 offers concluding remarks, including implications, limitations, and avenues for future inquiry.

2 | Literature Review

2.1 | Literature Review on Barriers Adopted to ESG

The Vietnamese logistics industry stands as a cornerstone of the country's economic ascent, underpinning its emergence as a vital manufacturing and export hub in Southeast Asia. With an estimated annual value of $40 billion, the sector drives over 16% of Vietnam's GDP through its extensive network of freight transport, warehousing, and supply chain operations [21]. Nevertheless, this rapid growth has outstripped efforts to embed sustainable practices, exposing the industry to a web of ESG barriers. Intricately tied to Vietnam's evolving infrastructure, fragmented regulatory landscape, and unique socio-economic fabric, these challenges present a formidable obstacle to achieving a greener and more equitable logistics framework. This section delves into the complex array of barriers spanning environmental, social, governance, economic, technological, institutional, psychological, legal, and compliance dimensions, thoroughly exploring the impediments thwarting sustainability in Vietnam's logistics ecosystem. Through this analysis, the study seeks to illuminate pathways for overcoming these hurdles, fostering a logistics sector that balances economic vitality with long-term environmental and social responsibility.

Environmental barriers significantly impede ESG implementation in Vietnam's logistics industry. High carbon emissions from road freight transport contribute to urban pollution and climate change, yet decarbonization efforts remain limited [22]. The heavy reliance on fossil fuels for vehicles and insufficient integration of renewable energy sources into the logistics infrastructure significantly exacerbates the industry's carbon footprint [23]. Furthermore, the low level of awareness regarding environmental regulations, as well as limited enforcement of existing laws, creates an environment where unsustainable practices are often overlooked. In addition, waste management practices in logistics remain inadequate, with poor systems for recycling or reducing waste generated by packaging materials and transportation activities [24]. As the sector grows, air quality and noise pollution from logistics activities have further worsened in urban areas, directly affecting public health and the environment. The lack of green supply chain practices, which include reducing waste and increasing material reuse, further perpetuates the sector's environmental challenges [25]. Additionally, the impact of climate change, such as natural disasters disrupting logistics operations, adds another layer of complexity to sustainability efforts [26].

Social barriers present equally formidable challenges. Poor labor standards—manifested in long working hours, low wages, and occupational safety risks—are pervasive in the Vietnamese logistics sector, particularly in warehousing and transportation [27]. There is also a notable lack of ESG-related training programs to build workforce capacity, which results in a limited understanding of sustainability among employees and management. Up to 61% of companies that have yet to commit cite lack of knowledge as the key barrier [28]. Community resistance often arises in response to logistics infrastructure projects, particularly in urban and peri-urban areas, where expansion leads to land acquisition, noise, and traffic congestion. Health risks associated with logistics emissions affect workers and local communities. Compounding this is the low consumer demand for sustainable logistics services and the cultural inertia that resists adopting green practices. Stakeholder engagement—essential for socially responsible ESG implementation—is also weak, especially between logistics firms, local authorities, and civil society organizations [29].

Weak governance structures hinder ESG diffusion in logistics. The regulatory environment in Vietnam lacks clear, enforceable ESG guidelines tailored for the logistics sector [29]. ESG-related policies, when present, are often fragmented across ministries and inconsistently implemented at the provincial level. Corruption and administrative inefficiencies further reduce trust in the policy environment, discouraging compliance and investment in ESG initiatives [30]. ESG performance reporting remains voluntary and opaque, making it difficult for stakeholders to hold companies accountable [31]. Many logistics firms operate with short-term profit motives, deprioritizing long-term ESG goals. The absence of incentives—such as tax benefits or government subsidies—discourages proactive adoption of ESG standards, particularly among SMEs.

Economic constraints constitute a significant obstacle to ESG integration. Many logistics companies, particularly domestic SMEs, are deterred by the high upfront costs of investing in ESG-aligned technologies such as electric trucks, solar-powered warehouses, or carbon offsetting mechanisms [32]. These investments are perceived as low-yield or high-risk due to limited market incentives and low customer willingness to pay for green services. Moreover, eco-friendly packaging and materials tend to be more expensive, raising overall operational costs. Firms prioritize cost efficiency over sustainability in a sector characterized by thin profit margins and intense competition. Financial support mechanisms, such as green financing, grants, or public-private investment partnerships, remain underdeveloped in Vietnam, limiting the flow of capital toward ESG transformation.

Technological limitations also act as a bottleneck. The logistics industry lacks digital infrastructure for ESG data collection, analysis, and reporting. Many firms rely on manual systems or outdated software that cannot track real-time emissions, resource consumption, or compliance metrics [33]. Technologies that can facilitate ESG adoption—such as IoT sensors for route optimization, AI for predictive maintenance, or blockchain for supply chain transparency—are not widely adopted due to high costs and lack of technical expertise [34]. Further, clean technologies like electric vehicles or energy-efficient cooling systems for temperature-sensitive cargo face infrastructural and technical limitations, including an underdeveloped EV charging network [35]. Moreover, cybersecurity concerns and a lack of interoperability between systems further limit the digitization of ESG efforts [36].

Institutional capacity is another limiting factor. Many regulatory bodies in Vietnam lack the resources, technical expertise, and inter-agency coordination required to develop and enforce ESG standards in the logistics industry [37]. Policies are frequently updated or delayed, creating uncertainty and discouraging long-term ESG investments. There is also a lack of harmonization between sector-specific standards and broader ESG frameworks, resulting in compliance ambiguities. Collaboration between public institutions, industry associations, and research organizations remains limited, leading to fragmented efforts and missed knowledge-sharing opportunities and joint initiatives.

Behavioral factors contribute to ESG resistance at the organizational and individual levels. Many logistics firms exhibit a strong status quo bias, favoring traditional methods over innovative, sustainable practices. ESG is often perceived as a regulatory burden rather than a strategic opportunity, especially in firms where leadership lacks awareness of long-term ESG benefits [38]. There is also a general underestimation of the urgency of ESG adoption, driven by a belief that sustainability is only relevant for large multinational corporations, not local logistics firms. This leads to passive attitudes and weak internal motivation to change. Complemented by insufficient internal communication and leadership commitment, organizational resistance to change further undermines ESG integration efforts.

Legal uncertainties further undermine ESG adoption. Vietnam lacks standardized frameworks for ESG reporting specific to logistics, creating inconsistency in disclosure practices and making benchmarking difficult [39]. The penalties for non-compliance with environmental or labor regulations are often minimal or unenforced, reducing the perceived risk of violating ESG principles. Moreover, ESG regulations often fail to align with international standards such as the Global Reporting Initiative (GRI) or ISO 26000, complicating compliance for firms involved in international logistics. The overlapping mandates of different regulatory authorities also result in jurisdictional confusion and delays in project approval or monitoring. Importantly, whistleblower protections related to ESG violations are weak or non-existent, discouraging internal reporting and perpetuating governance issues.

Table 1. Barriers to ESG adoption in Vietnam's logistics industry.

Dimensions	Code	Driver	Explanation	References
Environment barriers	EN1	High carbon emissions from transportation	High carbon emissions from transport accelerate climate change and hinder ESG goals.	[40]
	EN2	Lack of environmental law awareness	Fossil fuel dependence in logistics drives greenhouse gas emissions	[40]
	EN3	Overdependence on fossil fuels	The lack of circular economy practices causes resource waste and inefficiencies.	[41]
	EN4	Lack of renewable energy integration	Poor waste systems increase pollution and reduce sustainability	[42], [43]
	EN5	Poor waste management systems	Green supply chain practices are limited, especially in packaging	[43]
	EN6	Air quality degradation due to logistics emissions	Renewable energy is not integrated, raising the carbon footprint and costs	[44]
	EN7	Noise pollution due to logistics emissions	Logistics emissions worsen air quality, especially from road transport	[45]
	EN8	Limited implementation of green supply chain practices	Logistics noise pollution harms health and urban living conditions	[46]
	EN9	Low adoption of circular economy principles (e.g., reuse/recycling)	Climate change disrupts logistics through extreme weather events	[47]
	EN10	Climate change impacts (e.g., natural disasters disrupting logistics operations)	Infrastructure growth causes deforestation and environmental harm	[48]
	EN11	Deforestation and environmental damage due to infrastructure expansion	Lack of awareness of environmental laws weakens ESG compliance	[49], [50], [49]
Social barriers	SO1	Poor labor standards and unsafe working conditions	Work conditions lack safety measures, causing accidents and poor well-being	[51]
	SO2	Health and safety risks for workers and communities	Exposure to hazards threatens the health of workers and nearby communities	[52], [53]
	SO3	Skill gaps in ESG knowledge and workforce training	Limited ESG skills prevent effective, sustainable logistics practices	[54]
	SO4	Urban congestion caused by logistics operations	Traffic from logistics causes delays and higher emissions in cities	[55]
	SO5	Gender and income inequality in employment opportunities	Gender and income gaps reduce equity and diversity in logistics jobs	[56]

Table 1. Continued.

Dimensions	Code	Driver	Explanation	References
Social barriers	SO6	Community resistance to logistics projects	Public resistance delays ESG logistics due to unclear community benefits	[57]
	SO7	Social unrest or displacement due to infrastructure development	Infrastructure projects displace people, disrupting lives and social systems	[58]
	SO8	Low consumer demand for sustainable logistics services	Consumers show low interest in eco-friendly logistics options	[54]
	SO9	Lack of community engagement in ESG planning	Lack of public input weakens ESG planning and supply chain efforts	[59]
	SO10	Weak stakeholder engagement in ESG initiatives	Stakeholders are not engaged, slowing long-term ESG progress	[60]
	SO11	Cultural resistance to adopting sustainable practices	Cultural habits resist change, blocking sustainability in logistics	[41]
Government barriers	GO1	Inadequate monitoring and evaluation mechanisms	Lack of ESG monitoring leads to poor tracking and weak accountability	[51]
	GO2	Lack of transparency in ESG performance reporting	Transparency gaps in ESG reporting reduce trust and hinder adoption	[52]
	GO3	Short-term focus of businesses over long-term ESG goals	Short-term business focus conflicts with long-term ESG goals	[53]
	GO4	Limited incentives for companies adopting ESG practices	Few incentives discourage companies from adopting ESG practices	[54]
	GO5	Insufficient enforcement of ESG-related policies	Weak policy enforcement allows greenwashing and reduces accountability	[51]
	GO6	Fragmented policy implementation across regions	Inconsistent regional policies create legal and operational barriers	[55]
	GO7	Weak regulatory frameworks for ESG	Weak ESG regulations slow the adoption of sustainable logistics	[43]
	GO8	High compliance costs for meeting ESG standards	High ESG compliance costs burden, especially small businesses	[46]
	GO9	Insufficient public-private collaboration for ESG improvements	Poor collaboration limits innovation and ESG progress	[57]
	GO10	Corruption and bureaucratic inefficiencies	Corruption and bureaucracy delay ESG implementation and reduce the impact	[58]

Table 1. Continued.

Dimensions	Code	Driver	Explanation	References
Economic barriers	EC1	Perceived low ROI on sustainable investments	Low expected ROI discourages sustainable investment	[43]
	EC2	Lack of knowledge of economic benefits	Limited awareness of green practices' economic benefits	[54]
	EC3	High operational costs of green logistics practices	Green logistics raises operating costs and hinders adoption	[54]
	EC4	High initial investment costs for ESG technologies	High upfront costs slow ESG tech implementation	[59]
	EC5	Economic volatility in global and domestic supply chains	Market volatility reduces confidence in eco-innovation	[57]
	EC6	Lack of financial incentives like grants or subsidies	Lack of subsidies weakens motivation for green practices	[60]
	EC7	Limited funding for ESG-related R&D	Limited R&D funding restricts green solution development	[54]
	EC8	Expensive eco-friendly packaging and materials	Eco-friendly packaging is costly and reduces profitability	[61]
Technology barriers	TE1	Limited access to clean technologies (e.g., electric trucks)	Limited tech availability delays green logistics adoption	[62]
	TE2	Technical challenges in implementing renewable energy solutions	Complex energy systems slow renewable implementation	[43]
	TE3	Low adoption of IoT, AI, and blockchain for ESG tracking	Low use of smart tech weakens ESG tracking	[43], [62]
	TE4	Lack of advanced technology	Lack of green tech slows manufacturing innovation	[54]
	TE5	Cybersecurity risks associated with digital transformation	Cybersecurity gaps risk ESG data and system safety	[59]
	TE6	Poor digital infrastructure for ESG reporting and monitoring	Weak digital systems limit ESG reporting capabilities	[51]
	TE7	Lack of expertise in applying ESG-related technologies	Limited skills hinder green tech application	[59]
	TE8	Inadequate infrastructure for charging electric vehicles (EVs)	Insufficient EV charging hinders fleet sustainability	[63]

Table 1. Continued.

Dimensions	Code	Driver	Explanation	References
Institutional barriers	IN1	Weak institutional capacity in regulatory bodies	Weak regulators cause fragmented ESG enforcement	[51]
	IN2	Policy uncertainty discouraging ESG investments	Uncertain policies deter green investments	[64]
	IN3	Inconsistent ESG standards across logistics sectors	Inconsistent ESG standards slow eco-innovation	[57]
	IN4	Limited awareness campaigns for promoting ESG practices	Low awareness campaigns reduce ESG adoption	[56]
	IN5	Weak partnerships between the public and private sectors	Weak public-private ties limit green progress	[65]
	IN6	Limited ESG knowledge among decision-makers	Leaders lack ESG knowledge for informed decisions	[65]
	IN7	Fragmented coordination among stakeholders	Poor stakeholder coordination disrupts ESG efforts	[54]
Psychological and behavioral barriers	PS1	Resistance to organizational change	Internal resistance delays ESG adoption	[53]
	PS2	Cognitive bias favoring traditional over sustainable practices	Bias for old ways slows the green transition	[43]
	PS3	Risk aversion toward ESG innovation and investment	Fear of loss blocks ESG innovation	[57]
	PS4	Lack of intrinsic motivation for ESG adoption	No internal drive weakens ESG efforts	[54]
	PS5	Perceived low urgency for addressing ESG issues	Low urgency perception hinders the green shift	[43]
	PS6	Cultural habits promoting unsustainable resource use	Cultural norms support unsustainable habits	[66]
Legal and compliance barriers	LE1	Complicated or unclear taxation policies for ESG initiatives	Unclear taxes complicate ESG action plans	[67]
	LE2	Overlapping regulatory authorities causing inefficiencies	Regulatory overlap slows ESG progress across sectors	[14]
	LE3	Weak penalties for non-compliance with ESG regulations	Weak penalties reduce ESG pressure on firms	[57]
	LE4	Misalignment with global ESG standards (e.g., ISO, GRI)	No global alignment blocks compliance efforts	[54]

Table 1. Continued.

Dimensions	Code	Driver	Explanation	References
Legal and compliance barriers	LE5	Lack of standardized ESG reporting frameworks	Lack of standards fuels ESG greenwashing risks	[68]
	LE6	Inadequate legal protection for ESG-related whistleblowers	Poor whistleblower protection stifles ESG truth-telling	[67]

The implementation of ESG practices in the Vietnamese logistics industry is hindered by a complex and interrelated set of barriers spanning environmental, social, governance, technological, economic, legal, institutional, and behavioral dimensions. These barriers do not operate in isolation; they are often intertwined and mutually reinforcing, creating systemic obstacles that challenge both public and private actors striving to align with global ESG standards.

Addressing these challenges requires a multi-pronged, systemic approach. This includes improving regulatory clarity and enforcement, promoting stakeholder awareness and training, providing financial and technological incentives, enhancing digital readiness, and fostering cross-sector partnerships. As Vietnam seeks deeper integration into global value chains and aims to fulfill its commitments under the UN Sustainable Development Goals (SDGs), tackling ESG barriers in logistics is not only a necessity but also a strategic imperative. Building a resilient, sustainable logistics sector can serve as a foundation for broader ESG alignment across industries, positioning Vietnam as a competitive and responsible player in the global economy.

2.2 | Literature Review on NS DEMATEL

Causality analysis is pivotal in ESG research within the logistics sector, shedding light on the complex interrelationships among various barriers. One of the key methodologies employed to uncover these cause-and-effect dynamics is the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method, which is widely used to map and evaluate the influence of different factors, helping prioritize and effectively address ESG challenges.

Table 2. Related work.

Domain	Methods	Authors
Identifying barriers in reverse logistics, focusing on regulatory constraints and stakeholder coordination issues.	Fuzzy Delphi, DEMATEL	Bouzon et al. [69]
Examining ESG barriers in Vietnam's logistics sector highlights fragmented policies and inter-ministerial coordination gaps.	DEMATEL	Le et al. [70]
Evaluation of challenges in smart supply chains within the Industry 4.0 context, emphasizing complex interdependencies.	Neutrosophic DEMATEL	Tripathi and Gupta [19]
Analysis of reverse logistics barriers, identifying a lack of top management commitment as a key causal factor.	DEMATEL, IF-EDAS	U-Dominic et al. [71]
Prioritization of solutions to mitigate reverse logistics barriers, focusing on regulatory deficiencies and financial support gaps.	SWARA, WASPAS, DEMATEL	Prajapati et al. [72]

The advantages of DEMATEL include its capacity to structure intricate systems, prioritize influential factors, and provide actionable insights for decision-making. However, traditional DEMATEL struggles with uncertainty, particularly subjective expert inputs prevalent in ESG contexts, as noted by Abdel-Basset et al. [14]. Fuzzy DEMATEL partially addresses vagueness, yet it often fails to capture indeterminacy and conflicting data, as seen in scenarios involving diverse stakeholder perspectives in Vietnam's logistics industry. Lee et al. [68] highlighted that traditional DEMATEL may encounter feasibility issues when handling heterogeneous data, necessitating enhancements such as integration with fuzzy theory or NS. Incorporating NS into DEMATEL overcomes these limitations by independently modeling truth, indeterminacy, and falsity. Abdullah et al. [61] applied NS DEMATEL for subcontractor selection, demonstrating its robustness in segregating criteria under uncertainty. Liu et al. [73] utilized NS DEMATEL to evaluate transport service providers, showcasing its superiority in handling vague and conflicting data. Within ESG research, NS DEMATEL is particularly apt for Vietnam's logistics sector, where fragmented policies, inadequate infrastructure, and diverse stakeholder perspectives generate indeterminate data. This justifies the adoption of NS DEMATEL in this study to map ESG barriers effectively.

2.3 | Literature Review on NS Delphi

NS in Decision-Making NS, introduced by Smarandache [76], extends fuzzy set theory by incorporating three independent membership functions—truth, indeterminacy, and falsity—offering a robust framework for decision-making under uncertainty. Unlike traditional fuzzy sets, which rely on a single membership degree, NS provides a more nuanced representation of uncertainty by addressing hesitation and contradiction. The components of NS can independently range from 0 to 1, with their sum spanning 0 to 3, providing superior flexibility compared to other fuzzy extensions such as IFS or PFS. This adaptability renders NS an ideal tool for complex systems like logistics, where incomplete, conflicting, and uncertain information is prevalent. NS has been extensively applied in logistics to manage uncertainty and complexity. Mishra and Rani [74] employed a Single-Valued Neutrosophic Set (SVNS) framework with COCOSO to prioritize sustainable third-party reverse logistics providers, effectively handling conflicting criteria and integrating ESG considerations. Ji et al. [75] applied NS Bonferroni operators for third-party logistics selection, enhancing decision reliability under uncertainty. In the Vietnamese context, Le et al. [70] utilized NS Delphi to validate barriers in smart reverse logistics, demonstrating its capacity to achieve expert consensus amidst indeterminate inputs. The NS Delphi method iteratively aggregates expert opinions, minimizing bias, as evidenced by Kumar et al. [76], who used it to identify barriers in textile supply chains. Zakeri et al. [77] applied NS cognitive maps for PESTEL analysis in logistics, illustrating NS's ability to handle indeterminate stakeholder data.

Furthermore, Yazdani et al. [78] employed NS for sustainable supplier selection, showcasing its capability to address complex ESG-related criteria. Görçün et al. [79] utilized bipolar NS to evaluate fresh food suppliers in green supply chains, emphasizing NS's versatility in sustainability contexts. Nguyen et al. [16] also applied NS to develop a green-resilient model for smartphone closed-loop supply chains, further highlighting its applicability in sustainable logistics.

Table 3. Related work.

Domain	Methods	Authors
Development of supplier selection criteria, managing imprecise and conflicting expert judgments.	NS, DEMATEL	Abdel-Basset et al. [14]
Prioritization of sustainable third-party reverse logistics providers, addressing ESG criteria.	SVNS, COCOSO	Mishra and Rani [74]
Multi-attribute decision-making, aggregating diverse opinions in complex systems.	NS, Multi-Attribute Decision-Making	Ye [80]
Validation of barriers in smart reverse logistics in Vietnam, achieving expert consensus under uncertainty.	NS Delphi	Le et al. [70]
Optimization of inventory policies for seasonal items, handling demand uncertainty.	NS	Mondal et al. [81]
Emergency logistics decision-making, managing incomplete data in time-sensitive scenarios.	SVNS	Lu and Luo [82]
Sustainable industry evaluation in transportation, addressing uncertainty with sine trigonometric operators.	Neutrosophic Z-Rough Set	Kamran et al. [83]

Integrating NS Delphi and NS DEMATEL in this study provides a comprehensive framework for causality analysis and decision-making in the ESG context. NS Delphi ensures reliable consensus among stakeholders, while NS DEMATEL facilitates the analysis of complex causal relationships, addressing the uncertainty and contradictions inherent in Vietnam's logistics industry, where stakeholder perspectives often diverge and data is incomplete.

3 | Literature Review

3.1 | Research Process

This research employs a two-phase Neutrosophic set approach to analyze ESG barriers in Vietnam's logistics sector, as presented in **Figure 1**. Phase 1 identifies potential barriers through a literature review, with expert evaluation using NS-Delphi to determine significance against a threshold value. Phase 2 applies NS-DEMATEL to establish cause-and-effect relationships among validated factors and determine their relative influence weights. This methodology ensures robust identification of key ESG barriers, creating a foundation for strategic interventions [84].

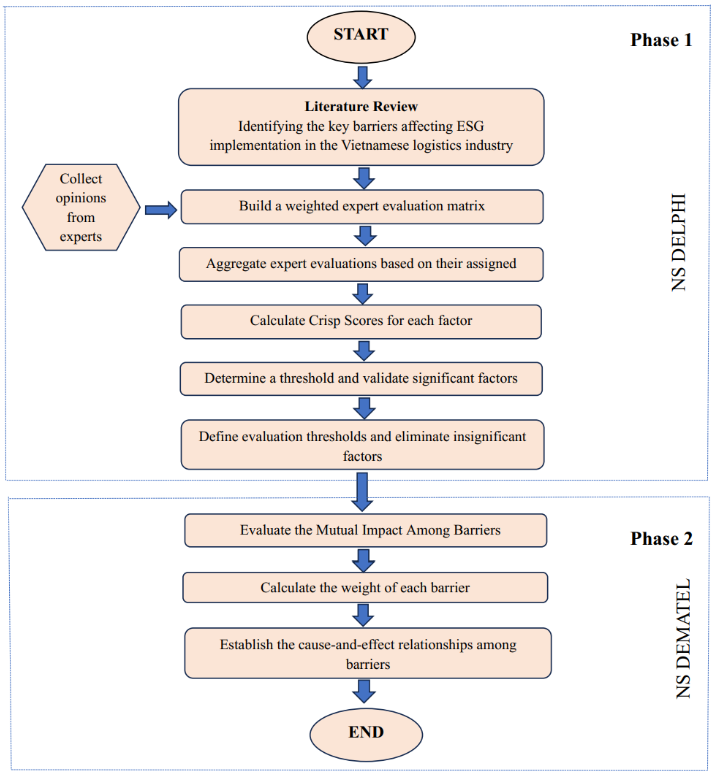

Fig. 1. Research flowchart.

3.2 | Neutrosophic Sets

NS goes beyond IFS by using Truth (T), Falsity (F), and Indeterminacy (I) degrees to represent uncertainty, unlike IFS's dual membership approach [84]. This flexibility makes NS better at modeling vague, inconsistent, and incomplete information, especially for complex decision-making like evaluating ESG barriers.

Definition 1. Let X be a space of points with elements $x \in X$. A Neutrosophic set A in X is characterized by three membership functions: truth-membership $T_A(x)$, indeterminacy-membership $I_A(x)$, and falsity-membership $F_A(x)$, each mapping X to $X \to]0-,1+[$. Unlike traditional fuzzy sets, NS have no restriction that these values must sum to 1. Instead, only the sum of their supreme values must satisfy: $0^- \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$. This structure provides greater flexibility for representing uncertain information in complex systems [84].

Example 1. Consider an expert evaluating the ESG barrier "Limited green technology adoption" in logistics companies. Using Neutrosophic representation, the expert might assign values. $T_A(x)$= 0.7(degree of truth that this is a significant barrier), $I_A(x)$ = 0.4 (degree of uncertainty about its impact), and $F_A(x)$ = 0.2 (degree of falsity that this is a significant barrier). The sum (0.7 + 0.4 + 0.2 = 1.3) falls within the allowed range [0,3], reflecting the expert's complex perception, including partial agreement, some uncertainty, and minimal disagreement about this barrier's significance.

Definition 2 (Single-valued Neutrosophic set). Let X be a set of objects, each denoted as x. A SVNS is defined as [84]:

$$\widetilde{A} = \{(x, T_{\widetilde{A}}(x), I_{\widetilde{A}}(x), F_{\widetilde{A}}(x)) : x \in X\} \tag{1}$$

Where:

$T_{\widetilde{A}}(x)$ indicates the truth membership function, reflecting the extent to which the object x belongs to the set.

$I_{\widetilde{A}}(x)$ represents the indeterminacy membership function, capturing the uncertainty regarding x's membership in the set.

$F_{\widetilde{A}}(x)$ denotes the falsity membership function, measuring how much x does not belong to the set.

Each of these functions produces values in the range $[0,1]$. The sum of these three membership values for any object x follows the inequality: $0 \leq T_{\widetilde{A}}(x), I_{\widetilde{A}}(x), F_{\widetilde{A}}(x) \leq 3$.

When we refer to an object x within the SVNS $\widetilde{A}$, we can call it a Single-Valued Neutrosophic Number (SVNN). For convenience, we can write this as: $x = (T_{\widetilde{A}}(x), I_{\widetilde{A}}(x), F_{\widetilde{A}}(x))$.

Example 2. Suppose X is a set of companies evaluated for their ability to overcome ESG barriers (e.g., adopting sustainable practices). Take a company x_1, a manufacturing firm assessed for its efforts to reduce carbon emissions:

$T_{\widetilde{A}}(x_1)$ = 0.7 (70% evidence it is succeeding, based on reduced emissions data).

$I_{\widetilde{A}}(x_1)$ = 0.4 (40% uncertainty, as experts disagree on whether its efforts are consistent or just temporary PR moves).

$F_{\widetilde{A}}(x_1)$= 0.2 (20% evidence it fails due to occasional non-compliance reports).

Thus, x_1 = (0.7,0.4,0.2), with a sum of 0.7 + 0.4 + 0.2 = 1.3 ≤ 3.

This SVNS approach captures the complexity of ESG barriers—where success, doubt, and failure coexist independently—unlike simpler models that might force a yes/no answer.

Definition 3 (Properties of SVNN operations). These properties govern how SVNNs behave under the defined operations, ensuring consistency and predictability in calculations. They establish rules for combining, comparing, and transforming SVNNs, making them reliable for modeling complex systems like decision-making or uncertainty analysis [84].

Commutativity:

$$\begin{aligned} &a \oplus b = b \oplus a, \\ &a \otimes b = b \otimes a, \\ &a \cup b = b \cup a, \\ &a \cap b = b \cap a, \end{aligned} \tag{2}$$

Order does not matter for addition, multiplication, union, or intersection.
Associativity:

$$(a \oplus b) \oplus c = a \oplus (b \oplus c),$$
$$(a \otimes b) \otimes c = a \otimes (b \otimes c), \tag{3}$$

Grouping does not affect the result for addition or multiplication.
Distributivity (Partial):

$$a \otimes (b \oplus c) \approx (a \otimes b) \oplus (a \otimes c), \tag{4}$$

Multiplication is partially distributed over addition, but exact equality may not hold due to SVNN's complex formulas.

Identity Elements:

Additive Identity: (0,1,1), since $a \oplus (0,1,1) = a$.

Multiplicative Identity: (1,0,0), since $a \otimes (1,0,0) = a$. **(5)**

These are "neutral" SVNNs that do not change when combined.

Idempotency:

$$a \cup a = a.$$
$$a \cap a = a. \tag{6}$$

Union or intersection of an SVNN with itself yields itself.

Complement Law:

$$(a^c)^c = a. \tag{7}$$

Double complement returns the original SVNN.

Example 3. Let us use two SVNNs, a = (0.8,0.2,0.1) (Company A) and b = (0.6,0.3,0.2) (Company B), and introduce c = (0.5,0.4,0.3) (Company C) where needed.

I. Commutativity

Addition

$a \oplus b = (0.8+0.6-0.8\cdot0.6, 0.2\cdot0.3, 0.1\cdot0.2) = (0.92, 0.06, 0.02)$.

$b \oplus a = (0.6+0.8-0.6\cdot0.8, 0.3\cdot0.2, 0.2\cdot0.1) = (0.92, 0.06, 0.02)$.

Result: Equal (combining A and B's ESG efforts works the same either way).

Union

$a \cup b = (\max(0.8,0.6), \min(0.2,0.3), \min(0.1,0.2)) = (0.8, 0.2, 0.1)$.

$b \cup a = (0.8, 0.2, 0.1)$.

Result: Equal (best ESG aspects are identical regardless of order).

II. Associativity

Addition

$a \oplus b = (0.92, 0.06, 0.02)$.

$(a \oplus b) \oplus c = (0.92+0.5-0.92\cdot0.5, 0.06\cdot0.4, 0.02\cdot0.3) = (0.96, 0.024, 0.006)$.

b ⊕ c = (0.6+0.5−0.6·0.5,0.3·0.4,0.2·0.3) = (0.8,0.12,0.06).

a ⊕ (b ⊕ c) = (0.8+0.8−0.8·0.8,0.2·0.12,0.1·0.06) = (0.96,0.024,0.006).

Result: Equal (grouping A, B, and C's ESG efforts does not change the outcome).

Multiplication

a ⊗ b = (0.8·0.6,0.2+0.3−0.2·0.3,0.1+0.2−0.1·0.2) = (0.48,0.44,0.28).

(a ⊗ b) ⊗ c = (0.48·0.5,0.44+0.4−0.44·0.4,0.28+0.3−0.28·0.3) = (0.24,0.664,0.496).

b ⊗ c = (0.6·0.5,0.3+0.4−0.3·0.4,0.2+0.3−0.2·0.3) = (0.3,0.58,0.44).

a ⊗ (b ⊗ c) = (0.8·0.3,0.2+0.58−0.2·0.58,0.1+0.44−0.1·0.44) = (0.24,0.664,0.496).

Result: Equal.

III. Distributivity (Partial)

b ⊕ c=(0.8,0.12,0.06).

a ⊗(b ⊕ c) = (0.8·0.8,0.2+0.12−0.2·0.12,0.1+0.06−0.1·0.06) = (0.64,0.296,0.154).

a ⊗ b = (0.48,0.44,0.28).

a ⊗ c = (0.8·0.5,0.2+0.4−0.2·0.4,0.1+0.3−0.1·0.3) = (0.4,0.52,0.37).

(a ⊗ b) ⊕ (a ⊗ c) = (0.48+0.4−0.48·0.4,0.44·0.52,0.28·0.37) = (0.688,0.2288,0.1036).

Result: Approximate (0.64 vs. 0.688, etc.)—close but not exact due to SVNN complexity in ESG joint efforts.

IV. Identity Elements

Additive

a ⊕ (0,1,1) = (0.8+0−0.8·0,0.2·1,0.1·1) = (0.8,0.2,0.1) = a.

(Adding a "zero-effort" ESG case leaves A unchanged.).

Multiplicative

a ⊗ (1,0,0) = (0.8·1,0.2+0−0.2·0,0.1+0−0.1·0) = (0.8,0.2,0.1) = a.

(Multiplying by "perfect ESG" keeps A's values.).

V. Idempotency

Union

a ∪ a = (max(0.8,0.8), min(0.2,0.2), min(0.1,0.1)) = (0.8,0.2,0.1) = a.

(Best of A with A is still A's ESG performance).

Intersection

a ∩ a = (min(0.8,0.8), max(0.2,0.2), max(0.1,0.1)) = (0.8,0.2,0.1) = a.

(Worst of A with A remains A).

I. **Complement Law**

ac = (Fa, 1−Ia, Ta) = (0.1, 1−0.2, 0.8) = (0.1, 0.8, 0.8).

(ac) c = (0.8, 1−0.8, 0.1) = (0.8, 0.2, 0.1) = a,

(Reversing A's ESG failure back to success restores A).

Definition 4 (Operations on single-valued Neutrosophic numbers (SVNNs)). Let $a = (T_a, I_a, F_a)$ and $b = (T_b, I_b, F_b)$ be two SVNNs, where T, I, and F represent truth, indeterminacy, and falsity degrees, respectively, in [0, 1]. Let k > 0 be a positive constant [84]. The following operations are defined [85], [86].

Subset (a⊇b):

$$a \supseteq b \text{ if } T_a \geq T_b, I_a \leq I_b, F_a \leq F_b, \tag{8}$$

(Meaning a is "at least as good as" b b b: more true, less uncertain, less false).

Equality (a = b): **(9)**

$$a = b \text{ if } a \supseteq b \text{ and } b \supseteq a,$$

(Both must match perfectly in all three components).

Union (a∪b): **(10)**

$$a \cup b = \langle T_a \vee T_a, I_a \wedge I_b, F_a \wedge F_b \rangle$$

$$= \langle \max(T_a, T_b), \min(I_a, I_b), \min(F_a, F_b) \rangle,$$

(Takes the best truth and the least uncertainty/falsity).

Intersection (a∩b): **(11)**

$$a \cap b = \langle T_a \wedge T_a, I_a \vee I_b, F_a \vee F_b \rangle$$

$$= \langle \min(T_a, T_b), \max(I_a, I_b), \max(F_a, F_b) \rangle,$$

(Takes the worst truth and the highest uncertainty/falsity).

Complement (a^c): **(12)**

$a^c = \langle F_a, 1 - I_a, T_a \rangle$ (Complement of a),

(Swaps truth with falsity and flips indeterminacy).

Addition (a ⊕ b): **(13)**

$$a \oplus b = (T_a + T_b - T_a T_b, I_a I_b, F_a F_b),$$

Truth: Combines T_a and T_b, subtracting overlap to avoid exceeding 1.

Indeterminacy & Falsity: Multiplies I and F, reflecting joint uncertainty and failure

Multiplication (a ⊗ b): **(14)**

$$a \otimes b = (T_a T_b, I_a + I_b - I_a I_b, F_a + F_b - F_a F_b),$$

Truth: Multiplies T_a and T_b (joint success).

Indeterminacy & Falsity: Adds I and F, subtracting overlap to stay within [0,1].

Scaling by a constant (ka): **(15)**

$$ka = (1 - (1 - T_a)^k, I_a^k, F_a^k),$$

Truth: Increases toward 1 based on k.

Indeterminacy & Falsity: Raises I and F to k, scaling their intensity

Exponentiation (a^k): **(16)**

$$a^k = (T_a^k, 1 - (1 - I_a)^k, 1 - (1 - F_a)^k),$$

Truth: Raises T_a to k.

Indeterminacy & Falsity: Adjusts I and F toward 1 based on k

Subtraction (a⊖b): **(17)**

$a \ominus b = \langle \max(0, T_a - T_b), \min(1, I_a + I_b), \min(1, F_a + F_b) \rangle,$

Models the "difference" between two SVNNs, capping values at 0 or 1.

Truth decreases if a exceeds b b b, while indeterminacy and falsity increase to reflect uncertainty or failure gaps.

Division (a⊘b): **(18)**

$a \oslash b = \langle \min(1, T_a/T_b), \max(1, I_a - I_b), \max(0, F_a - F_b) \rangle$ (assuming $T_a \neq 0$),

Compares relative performance, adjusting for division by zero risks.

Truth is scaled, and indeterminacy/falsity differences reflect reduced uncertainty or failure

Scalar Subtraction (a ⊖ k): **(19)**

$a \ominus k = \langle \max(0, T_a - k), \min(1, I_a + k), \min(1, F_a + k) \rangle$

Reduces truth by a constant while increasing uncertainty/failure

Max Operator (max (a,b)): **(20)**

$\max(a,b) = (\max(T_a, T_b), \min(I_a, I_b), \min(F_a, F_b))$

Picks the "better" SVNN (higher truth, lower indeterminacy/falsity).

Min Operator (min(a,b)): **(21)**

$\min(a,b) = (\min(T_a, T_b), \max(I_a, I_b), \max(F_a, F_b))$

Identifies the "worse" SVNN (lower truth, higher indeterminacy/falsity).

Single-Valued Neutrosophic Weighted Aggregation Arithmetic (SVNWAA) operator:

$$\mathrm{SVNWAA}\left(\tilde{A}_1, \tilde{A}_2, \dots, \tilde{A}_n\right) = \sum_{j=1}^{n} w_j \tilde{A}_j = \left[1 - \prod_{j=1}^{n} \left(1 - T_{\tilde{A}_j}\right)^{w_j}, \prod_{j=1}^{n} \left(I_{\tilde{A}_j}\right)^{w_j}, \prod_{j=1}^{n} \left(F_{\tilde{A}_j}\right)^{w_j}\right], \quad (22)$$

Suppose we have n $\tilde{A}_j = \left(T_{\tilde{A}_j}, I_{\tilde{A}_j}, F_{\tilde{A}_j}\right)$, where $j = 1,2, \dots . n.$ and each has a weight w_j represents the weight for each SVNN $\tilde{A}_j$, and the weights satisfy $w_j > 0$ and $\sum w_{j}{}_{j=1}^{n} = 1.$

Truth: Combines T values, adjusting for overlap.

Indeterminacy and Falsity: Takes weighted geometric means of I and F

Single-Valued Neutrosophic Weighted Aggregation Geometric (SVNWAG):

$$\mathrm{SVNWAG}\left(\tilde{A}_1, \tilde{A}_2, \dots, \tilde{A}_n\right) = \prod_{j=1}^{n} \left(\tilde{A}_j\right)^{w_j} = \left[\prod_{j=1}^{n} \left(T_{\tilde{A}_j}\right)^{w_j}, 1 - \prod_{j=1}^{n} \left(1 - I_{\tilde{A}_j}\right)^{w_j}, 1 - \prod_{j=1}^{n} \left(1 - F_{\tilde{A}_j}\right)^{w_j}\right] \quad (23)$$

Suppose we have n $\widetilde{A}_j = \left(T_{\widetilde{A}_j}, I_{\widetilde{A}_j}, F_{\widetilde{A}_j}\right)$, where $j = 1,2, \ldots . n$, and each has a weight w_j represents the weight for each SVNN $\widetilde{A}_j$, and the weights satisfy $w_j > 0$ and $\sum w_{j_{j=1}}^{n} = 1$.

Truth: Multiplies T values with weights.

Indeterminacy & Falsity: Adjusts I and F toward 1 based on weights

De-Neutrosophication: This simplifies an SVNN into a single real number for easier comparison. Given an SVNN, $\widetilde{A} = \{ (x, T_{\widetilde{A}}(x), I_{\widetilde{A}}(x), F_{\widetilde{A}}(x)) : x \in X \}$:

$$E(\widetilde{A}) = \frac{3 + T_{\widetilde{A}} - 2I_{\widetilde{A}} - F_{\widetilde{A}}}{4} \tag{24}$$

Example 4. Evaluate companies' efforts to overcome ESG barriers (e.g., reducing waste).

Company a = (0.8,0.3,0.1): 80% effective (truth), 30% uncertain (indeterminacy), 10% ineffective (falsity).

Company b = (0.6,0.4,0.2): 60% effective, 40% uncertain, 20% ineffective.

Subset: a ⊇ b because 0.8 ≥ 0.6, 0.3≤ 0.4, 0.1 ≤ 0.2 (Company a outperforms b).

Equality: a ≠ b since b ⊉ a (they are not identical).

Union: a ∪ b = ⟨max(0.8,0.6), min(0.3,0.4), min(0.1,0.2)⟩ = (0.8,0.3,0.1) (best-case scenario).

Intersection: a ∩ b = ⟨min(0.8,0.6), max(0.3,0.4), max(0.1,0.2)⟩ = (0.6,0.4,0.2) (worst-case overlap).

Complement: a^c = ⟨0.1,1−0.3,0.8⟩ = (0.1,0.7,0.8) (reverses a's success to failure).

Addition (a ⊕ b): Combining their efforts (e.g., a joint sustainability project):

T = 0.8 + 0.6 − 0.8 × 0.6 = 0.92; I = 0.3 × 0.4 = 0.12; F = 0.1 × 0.2 = 0.02;

a ⊕ b = (0.92,0.12,0.02) (High success, low uncertainty/failure due to teamwork.)

Multiplication (a ⊗ b): Joint impact of both efforts (e.g., overlapping policies):

T = 0.8 × 0.6 = 0.48; I = 0.3 + 0.4−0.3 × 0.4 = 0.58; F = 0.1 + 0.2 − 0.1 × 0.2 = 0.28;

a ⊗ b = (0.48,0.58,0.28) (Moderate success, higher uncertainty due to overlap.)

Scaling (2a): Doubling Company A's effort (e.g., doubling investment):

T = 1− $(1 - 0.8)^2$ = 1−0.04 = 0.96; I = 0.3^2=0.09; F = 0.1^2=0.01;

2a = (0.96,0.09,0.01) (Much higher success, less doubt/failure.)

Exponentiation (a^2): Intensifying Company A's effort (e.g., squared commitment):

T = 0.8^2 = 0.64; I = 1−$(1 - 0.3)^2$ = 1−0.49 = 0.51; F = 1−$(1 - 0.1)^2$ = 1−0.81=0.19;

a^2 = (0.64,0.51,0.19) (Lower success, increased uncertainty.)

Example 5. Suppose we evaluate three companies' ESG efforts (reducing emissions) with SVNNs and weights based on their market size:

A_1= (0.8,0.2,0.1), weight $W_1 = 0.5$ (big company).

A_2= (0.6,0.4,0.3), weight $W_2 = 0.3$ (medium company).

A_3= 0.5,0.5,0.4), weight $W_2 = 0.2$ (small company).

SVNWAA calculation

T = $1-(1-0.8)^{0.5} \times (1-0.6)^{0.3} \times (1-0.5)^{0.2}$ = 1−0.447 × 0.725 × 0.870 = 0.718.

I = $0.2^{0.5} \times 0.4^{0.3} \times 0.5^{0.2}$ = 0.447 × 0.725 × 0.870 = 0.282.

F = $0.1^{0.5} \times 0.3^{0.3} \times 0.4^{0.2}$ = 0.316 × 0.617 × 0.758 = 0.148.

Result: (0.718,0.282,0.148) (weighted average ESG performance).

SVNWAG calculation

T = $0.8^{0.5} \times 0.6^{0.3} \times 0.5^{0.2}$ = 0.894 × 0.851× 0.870 = 0.662.

I = $1-(1-0.2)^{0.5} \times (1-0.4)^{0.3} \times (1-0.5)^{0.2}$ = 1− 0.894 × 0.851 × 0.870 = 0.338.

F = $1-(1-0.1)^{0.5} \times (1-0.3)^{0.3} \times (1-0.4)^{0.2}$ = 1− 0.949 × 0.812 × 0.758 = 0.416.

Result: (0.662,0.338,0.416) (geometric weighted ESG performance).

DeNeutrosophication (SVNWAA result)

$E(\widetilde{A}) = \frac{3+0.718-2\times0.282-0.148}{4}$ = 0.752.

(A score of 0.752 reflects solid ESG effort with some uncertainty).

3.3 | NS-Delphi Model

The NS-Delphi model combines expert judgment with NS to evaluate the importance of multiple factors [70]. It involves three main steps:

Step 1. Expert weighting

Each q expert is assigned a weight based on their education and professional experience. These qualifications are converted into NS numbers using a linguistic scale (e.g., Extremely High, High). For example, a doctoral-level expert with 5–10 years of experience may receive NS scores of (0.8, 0.15, 0.2) and (0.5, 0.65, 0), respectively. These are aggregated using an NS aggregation equation, *Eq. (2)*, then defuzzified, *Eq. (13)*, into a crisp value (e.g., 0.8913). Each expert's final weight is normalized using *Eq. (25)*:

$$sw_a = \frac{sq_a}{\sum_{a=1}^{q} sq_a}. \quad (25)$$

Step 2. Weighted evaluation matrix

Experts evaluate the significance of nnn factors using linguistic terms translated into NS numbers (*Table 5*). The result is a matrix $\otimes$ FM = $[f_{ia}]_{n\times q}$, where f_{ia} is expert a's score for factor iii. The weighted matrix is then calculated using *Eq. (26)*:

$$fw_{ia} = fw_{ia} \otimes sw_a \quad (26)$$

Table 4. Neutrosophic linguistic importance scales.

NS-Delphi Linguistic Scales	NS-Delphi Code	Membership Function			NS-DEMATEL Linguistic Scales	NS-DEMATEL Linguistic Scales
		T	I	F		
Extremely High	EH	0.8	0.15	0.2	AI	Absolute influence
High	H	0.6	0.35	0.4	SI	Strong influence
Medium	M	0.4	0.65	0.6	FI	Fair influence
Low	L	0.2	0.85	0.8	WI	Weak influence
Extremely Low	EL	0	1	1	NI	No influence

Step 3. Threshold and factor validation

Each factor's aggregated score is calculated by combining all expert evaluations and converting them into crisp values. A threshold γ is calculated as the average of these scores using *Eq. (27)*:

$$\gamma = \frac{\sum_{i=1}^{n} av_i}{n}. \tag{27}$$

Factors with $av_i \geq \gamma$ are accepted; otherwise, they are excluded from further analysis.

3.4 | N-DEMATEL Model

The NS-DEMATEL method is used to analyze the causal relationships among multiple factors, integrating expert judgments expressed in NS [86], [87], [88]. Suppose k experts assess the mutual influence of n factors, each weighted by ew_t. Expert evaluations are first expressed using linguistic terms and then transformed into NS values using a standardized scale.

Step 1. Constructing the direct influence matrix

Each expert's influence score for factor i on factor j denoted v_{ij}^{k} , is weighted and aggregated using *Eq. (28)*:

$$v = \text{SVNWA}\left(v_{ij}^{1}, v_{ij}^{2}, \dots, p_{ij}^{k}\right) = \sum_{t=1}^{k} ew_t v_{ij}^{k}. \tag{28}$$

The resulting matrix $\otimes V = [\otimes v_{ij}]_{n\times n}$ is the direct influence matrix, where $\otimes v_{ij} = (v_{ij}^{\alpha}, v_{ij}^{\beta}, v_{ij}^{\gamma})$. Diagonal elements are zero.

Step 2. Normalizing the matrix

Normalize $\otimes V$ to obtain the matrix $\otimes U$ using *Eqs. (29)-(31)*:

$$\otimes U = [\otimes u_{ij}]_{n\times n} = \begin{bmatrix} \otimes \theta \cdot v_{11} & \otimes \theta \cdot v_{12} & \cdots & \otimes \theta \cdot v_{1j} & \cdots & \otimes \theta \cdot v_{1n} \\ \otimes \theta \cdot v_{21} & \otimes \theta \cdot v_{22} & \cdots & \otimes \theta \cdot v_{2j} & \cdots & \otimes \theta \cdot v_{2n} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ \otimes \theta \cdot v_{i1} & \otimes \theta \cdot v_{i2} & \cdots & \otimes \theta \cdot v_{ij} & \cdots & \otimes \theta \cdot v_{in} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ \otimes \theta \cdot v_{n1} & \otimes \theta \cdot v_{n2} & \cdots & \otimes \theta \cdot v_{nj} & \cdots & \otimes \theta \cdot v_{nn} \end{bmatrix}_{n\times n}. \tag{29}$$

$$\otimes u_{ij} = \theta . v_{ij} = \left(\theta v_{ij}^{\alpha}, \theta v_{ij}^{\beta}, \theta v_{ij}^{\gamma}\right). \tag{30}$$

where $\otimes u_{ij} = (u_{ij}^{\alpha}, u_{ij}^{\beta}, u_{ij}^{\gamma})$.

$$\theta = \max\left\{\frac{1}{\sum_{j=1}^{n} v_{ij}^{\alpha}}; \frac{1}{\sum_{i=1}^{n} v_{ij}^{\beta}}; \frac{1}{\sum_{i=1}^{n} v_{ij}^{\gamma}}\right\}. \tag{31}$$

Step 3. Computing the total influence matrix

The total influence matrix $\otimes T$ includes both direct and indirect effects using Equation (32):

$$\otimes T = [\otimes t_{ij}]_{n\times n} = \begin{bmatrix} \otimes t_{11} & \otimes t_{12} & \cdots & \otimes t_{1j} & \cdots & \otimes t_{1n} \\ \otimes t_{21} & \otimes t_{22} & \cdots & \otimes t_{2j} & \cdots & \otimes t_{2n} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ \otimes t_{i1} & \otimes t_{i2} & \cdots & \otimes t_{ij} & \cdots & \otimes t_{in} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ \otimes t_{n1} & \otimes t_{n2} & \cdots & \otimes t_{nj} & \cdots & \otimes t_{nn} \end{bmatrix}_{nxn}. \tag{32}$$

$i = j = 1, 2, \dots n,$

where $\otimes t_{ij} = (t_{ij}^{\alpha}, t_{ij}^{\beta}, t_{ij}^{\gamma})$.

Each element $\otimes t_{ij}$ is defuzzified into crisp values t_{ij}^* using a defuzzification formula (e.g., *Eq. (13)*), resulting in the matrix $\otimes T^* = [t_{ij}^*]_{n\times n}$.

$$\begin{aligned}\otimes T &= \otimes U + \otimes U^2 + \cdots + \otimes U^{\infty} \\ &= \otimes U(I + \otimes U + \otimes U^2 + \cdots + \otimes U^{\infty-1}) \\ &= \otimes U(I - \otimes U^{\infty})(I - \otimes U)^{-1} = \otimes U(I - \otimes U)^{-1}\end{aligned} \tag{33}$$

where $\otimes U^{\infty} = [0]_{n\times n}$ and I is the identity matrix

Step 4. Calculating influence degrees

From $\otimes T^*$, compute the row sums $\otimes r_i = (r_i^{\alpha}, r_i^{\beta}, r_i^{\gamma})$ and column sums $\otimes c_i = (c_i^{\alpha}, c_i^{\beta}, c_i^{\gamma})$ using *Eqs. (34)-(37)*:

$$\otimes r = [\otimes r_i]_{n\times 1} = (\otimes r_1, \otimes r_2, \dots, \otimes r_{i,} \dots, \otimes r_n), \tag{34}$$

$$[\otimes r_i]_{n\times 1} = \left[\sum_{j=1}^{n} \otimes t_{ij}^*\right]_{n\times 1}, \tag{35}$$

$$\otimes c = [\otimes c_i]_{1\times n} = (\otimes c_1, \otimes c_2, \dots, \otimes c_{j,} \dots, \otimes c_n)^T, \tag{36}$$

$$[\otimes c_j]_{1\times n} = \left[\sum_{i=1}^{n} \otimes t_{ij}^*\right]_{1\times n} = [\otimes c_i]_{n\times 1}^T, \tag{37}$$

Total influence (given + received) of factor iii: $\otimes r_i + \otimes c_i$,

: $\otimes r_i - \otimes c_i$Net influence (positive = cause; negative = effect).

Step 5. Determining influence weights

Finally, each factor's normalized impact weight σ_i is computed using *Eq. (38)*:

$$\sigma_i = \frac{(r_i + c_i)}{\sum_{i=1}^{n}(r_i + c_i)}. \tag{38}$$

4 | Result and Discussion

4.1 | Result of NS-Delphi Model

The NS-Delphi technique evaluated 67 ESG factors in Vietnam's logistics sector, identified via a literature review, using linguistic scales. Each factor's significance was assessed against a threshold (γ = 0.5451). Of these, 19 factors below the threshold were excluded, spanning Environmental (EN2, EN7, EN8, EN10), Social (SO4, SO5, SO7), Governance (GO3, GO4, GO6, GO9), Economic (EC8), Technological (TE1, TE7, TE8), Institutional (IN4), Psychological and Behavioral (PS3, PS4, PS6), and Legal and Compliance (LE6) dimensions, as shown in *Table 5*.

Table 5. NS-Delphi results.

Factor	Aggregate	Score	Results
EN1	(0.624, 0.357, 0.376)	0.6335	O
EN2	(0, 0.605, 0.552)	0.3095	X
EN3	(0.546, 0.448, 0.454)	0.5490	O
EN4	(0.574, 0.422, 0.426)	0.5760	O
EN5	(0.611, 0.36, 0.389)	0.6255	O
EN6	(0.573, 0.419, 0.427)	0.5770	O
EN7	(0, 0.626, 0.574)	0.2935	X
EN8	(0, 0.599, 0.545)	0.3143	X
EN9	(0,64; 0,335; 0,36)	0.6525	O
EN10	(0, 0.644, 0.588)	0.2810	X
EN11	(0.56, 0.444, 0.44)	0.5580	O
SO1	(0.659, 0.318, 0.341)	0.6705	O
SO2	(0.648, 0.319, 0.352)	0.6645	O
SO3	(0.588, 0.405, 0.412)	0.5915	O
SO4	(0, 0.608, 0.553)	0.3078	X
SO5	(0.539, 0.458, 0.461)	0.5405	X
SO6	(0,603; 0,379; 0,397)	0.6120	O
SO7	(0, 0.627, 0.572)	0.2935	X
SO8	(0.601, 0.385, 0.399)	0.6080	O
SO9	(0.6, 0.384, 0.4)	0.6080	O
SO10	(0.558, 0.447, 0.442)	0.5555	O
SO11	(0.596, 0.394, 0.404)	0.6010	O
GO1	(0.576, 0.409, 0.424)	0.5835	O
GO2	(0.58, 0.415, 0.42)	0.5825	O
GO3	(0.543, 0.465, 0.457)	0.5390	X
GO4	(0.517, 0.49, 0.483)	0.5135	X
GO5	(0.618, 0.351, 0.382)	0.6335	O
GO6	(0, 0.622, 0.571)	0.2963	X
GO7	(0.63, 0.345, 0.37)	0.6425	O

Table 5. Continued.

Factor	Aggregate	Score	Results
GO8	(0, 0.248, 0.281)	0.5558	O
GO9	(0, 0.409, 0.417)	0.4413	X
GO10	(0.553, 0.44, 0.447)	0.5565	O
EC1	(0.63, 0.344, 0.37)	0.6430	O
EC2	(0.636, 0.321, 0.364)	0.6575	O
EC3	(0.608, 0.377, 0,392)	0.6155	O
EC4	(0.583, 0.407, 0.417)	0.5880	O
EC5	(0.668, 0.288, 0.332)	0.6900	O
EC6	(0.572, 0.422, 0.428)	0.5750	O
EC7	(0.581, 0.399, 0.419)	0.5910	O
EC8	(0.475, 0.536, 0.525)	0.4695	X
TE1	(0, 0.466, 0.412)	0.4140	X
TE2	(0.664, 0.288, 0.336)	0.6880	O
TE3	(0.589, 0.406, 0.411)	0.5915	O
TE4	(0.584, 0.405, 0.416)	0.5895	O
TE5	(0.654, 0.323, 0.346)	0.6655	O
TE6	(0.574, 0.408, 0.426)	0.5830	O
TE7	(0.535, 0.468, 0.465)	0.5335	X
TE8	(0; 0,461; 0,454)	0.4060	X
IN1	(0.547, 0.449, 0.453)	0.5490	O
IN2	(0.675, 0.292, 0.325)	0.6915	O
IN3	(0.608, 0.383, 0.392)	0.6125	O
IN4	(0, 0.485, 0.431)	0.3998	X
IN5	(0.682, 0.289, 0.318)	0.6965	O
IN6	(0.614, 0.355, 0.386)	0.6295	O
IN7	(0.645, 0.325, 0.355)	0.6600	O
PS1	(0.556, 0.436, 0.444)	0.5600	O
PS2	(0.602, 0.386, 0.398)	0.6080	O
PS3	(0.524, 0.482, 0.476)	0.5210	X

Table 5. Continued.

Factor	Aggregate	Score	Results
PS4	(0.533, 0.478, 0.467)	0.5275	X
PS5	(0.558, 0.435, 0.442)	0.5615	O
PS6	(0, 0.614, 0.559)	0.3033	X
LE1	(0.627, 0.357, 0.373)	0.6350	O
LE2	(0.555, 0.453, 0.445)	0.5510	O
LE3	(0.574, 0.423, 0.426)	0.5755	O
LE4	(0.584, 0.414, 0.416)	0.5850	O
LE5	(0.565, 0.431, 0.435)	0.5670	O
LE6	(0, 0.726, 0.673)	0.2188	X

Threshold (V_c) 0.5451
Note: X: Rejected Factor; O: Accepted Factor

Fig. 2. Multi-dimensional evaluation.

Fig. 2 highlights key ESG barriers in Vietnam's logistics sector, validated via NS-Delphi. In the Environmental dimension, 'Climate change impacts' (EN9 - 0.6525) and 'High carbon emissions from transportation' (EN1 - 0.6335) emerged as the most significant barriers, while factors like 'Overdependence on fossil fuels' (EN2) and 'Deforestation due to infrastructure expansion' (EN10) were rejected. The Social dimension validated 'Poor labor standards and unsafe working conditions' (SO1 - 0.6705) as the dominant barrier while excluding factors related to urban management and social inequality. In governance, factors GO5 (0.6335) and GO7 (0.6425) were strongly validated, while those related to business behavior and policy implementation were rejected. The Economic dimension retained all factors except EC8, with 'Economic volatility in supply chains' (EC5 - 0.6900) ranking highest. For Technology, factors related to digital infrastructure (TE2 - 0.6880) and innovative solutions (TE5 - 0.6655) were accepted, while factors perceived as less critical technological issues were excluded. The Institutional dimension retained all factors except IN4 (0.3998), which was considered a communication issue rather than an institutional barrier. In the Psychological and Behavioral dimension, 'Resistance to organizational change' (PS2 - 0.6080) was strongly validated, while secondary factors with less direct impact were rejected. Finally, the Legal and Compliance dimension accepted all factors except LE6 (0.2188), which related more to financial policy than legal regulations. This consensus evaluation ensured that only the 48 most relevant and impactful factors were retained for Phase 2 analysis, enhancing the methodological robustness and validity of the study's findings regarding ESG barriers in Vietnam's logistics sector.

4.2 | Result of NS-DEMATEL Model

The NS-DEMATEL model comprehensively explains the interrelationships among the main dimensions influencing barriers to ESG implementation in the Vietnamese logistics sector, as detailed in *Table 6* and visualized in *Fig. 3*.

Table 6. The NS DEMATEL results of the main dimensions.

	Ri	Ci	Ri + Ci	Ri – Ci	Relations
EN	3.5528	4.5655	8.1183	-1.0128	Effect
SO	4.0228	4.5340	8.5568	-0.5113	Effect
GO	4.1198	4.6298	8.7495	-0.5100	Effect
EC	4.7950	4.3093	9.1043	0.4857	Cause
TE	3.7830	4.3283	8.1113	-0.5453	Effect
IN	5.0068	4.3900	9.3968	0.6168	Cause
PS	4.7650	4.2258	8.9908	0.5393	Cause
LE	5.1700	4.2325	9.4025	0.9375	Cause

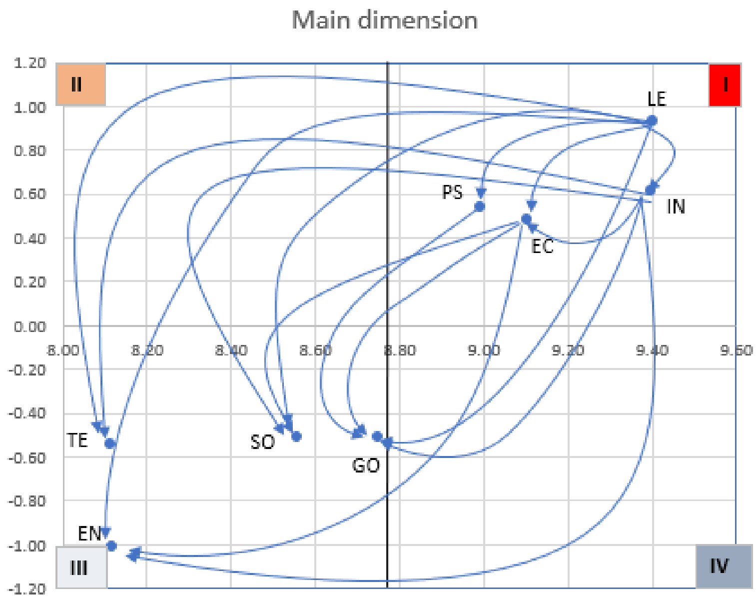

Fig. 3. IRM diagram of main dimension.

Fig. 3 IRM diagram identifies Legal and Compliance Barriers (LE) as the top causal factor in Vietnam's logistics ESG system, with a prominence score of 9.4025 and net influence of 0.9375 (Quadrant I), driving sustainable practices. Institutional Barriers (IN) follow, with a prominence of 9.3968 and a net effect of 0.6168, impacting six dimensions: EN, SO, GO, EC, TE, and itself. Economic Barriers (EC) (prominence = 9.1043, net effect = 0.4857) and Psychological and Behavioral Barriers (PS) (prominence = 8.9908, net effect = 0.5393) also rank as causal, influencing EN, SO, GO, and PS/GO, respectively. Conversely, Governance (GO) (net effect = −0.5100), Social (SO) (−0.5113), Environmental (EN) (−1.0128), and Technology (TE) (−0.5453) fall in Quadrant III as effect dimensions, with GO notably shaped by LE, IN, EC, and PS. Strengthening LE, IN, EC, and PS is key to boosting ESG performance across the sector.

4.3 | Discussion

This study utilized the integrated NS-Delphi and NS-DEMATEL methods to explore interdependencies among key ESG implementation barriers in Vietnam's logistics sector. The key results provide a structured view of how legal, institutional, economic, psychological, environmental, social, governance, and technological dimensions interact, with four primary domains—Legal and Compliance (LE), Institutional (IN), Economic (EC), and Psychological and Behavioral (PS)—emerging as dominant causal factors. These findings align with the complex, multi-level challenges reported in ESG adoption literature, particularly within emerging economies like Vietnam [87], [88], [89], [90]. Duff & Phelps, a Kroll Business [91], a leading governance, risk, and transparency authority, found that 45% of valuation experts view a standardized ESG measurement system as the greatest obstacle to effective disclosures. In Vietnam's logistics sector, which relies on road transport and is hampered by fragmented regulation, this lack of standardization intensifies enforcement difficulties. To counter this, stakeholders should focus on creating a unified ESG reporting framework aligned with global standards like the Global Reporting Initiative (GRI) while introducing tougher penalties for non-compliance and fostering international cooperation to align standards.

Legal and compliance factors, particularly LE5 (Inadequate enforcement of environmental laws) and LE2 (Lack of mandatory ESG regulations), are ranked as the top causal dimensions [92]. These results reinforce evidence from regulatory studies, which note that despite recent policy efforts, Vietnam's legal landscape for ESG remains fragmented, reactive, and inconsistent across jurisdictions [93]. LE5, with the highest causal impact, reflects issues raised by JICA and UNDP reports, which include weak implementation capacity, inconsistent inspections, and limited legal penalties for non-compliance. Moreover, LE2 points to the voluntary nature of most ESG guidelines in Vietnam, lacking the statutory weight to compel firm-level action, which was echoed in ASEAN ESG gap assessments [94].

The effects of legal ambiguity (LE1) and limited legal incentives (LE3) further support the argument that the absence of clear, enforceable ESG mandates fosters uncertainty, especially among logistics SMEs [95]. These firms often do not understand how compliance applies to their operations and lack clarity on penalties or rewards for ESG performance [96]. This aligns with OECD studies calling for better legal harmonization between domestic policies and international ESG frameworks like GRI or SASB [97].

Institutional limitations, particularly IN7 (Weak institutional capacity in regulatory bodies) and IN2 (Policy uncertainty), play a significant role in shaping ESG outcomes. These findings are corroborated by World Bank governance indicators, which consistently rank Vietnam low on regulatory quality and enforcement capacity [98]. The study also confirms that policy instability and bureaucratic delays reduce investor confidence and disincentivize ESG adoption—a trend supported by comparative FDI research in ASEAN markets [95]. Additionally, IN6 (Limited ESG knowledge among decision-makers) and IN3 (Inconsistent ESG standards across sectors) reflect findings in managerial and public sector literature indicating that ESG knowledge is often siloed, inconsistently applied, or absent at the local level [87], [88], [99].

Effect variables such as IN1 (Fragmented stakeholder coordination) and IN5 (Weak public-private partnerships) result from these deeper institutional flaws. Similar conclusions are drawn by IFC assessments of Vietnam's ESG ecosystem, emphasizing the lack of inter-ministerial collaboration and underutilization of industry associations in ESG planning [100].

On the economic front, EC4 (High initial investment costs for ESG technologies) emerges as a key constraint, consistent with findings that ESG-aligned infrastructure—such as clean fleets, emission tracking, or energy-efficient warehousing—requires significant upfront capital [89], [98], [101]. Many logistics firms in Vietnam, particularly SMEs, operate on thin margins and lack access to affordable long-term financing, reinforcing EC6 (Lack of financial incentives) and EC7 (Limited ESG-related R&D funding) as additional causal barriers. This is echoed in studies by the ADB and UNESCAP, which call for targeted green finance instruments, such as ESG-linked loans or tax credits, to bridge these financial gaps [102], [103], [104].

Effect factors such as EC1 (Limited access to green investment) and EC2 (Unclear ROI on ESG) are thus not primary barriers but are symptoms of the lack of systemic economic support mechanisms. Several studies emphasize that, in the absence of clear ROI evidence or state-backed incentives, ESG remains a discretionary rather than strategic priority [88], [90], [102].

Psychological inertia plays a notable causal role, particularly PS2 (Cognitive bias favoring traditional practices) and PS1 (Resistance to organizational change). These findings echo behavioral economists who argue that status quo bias and loss aversion often deter firms from embracing unfamiliar sustainability models. This is particularly true in sectors like logistics, where operational continuity and cost-minimization dominate management priorities [105], [106].

PS5 (Perceived low urgency) is identified as an effect factor shaped by these internal resistances. This dynamic supports prior studies suggesting that unless firms experience external pressures—such as customer demand, regulatory fines, or investor scrutiny—they often undervalue ESG risks [107], [108].

Environmental barriers—particularly EN1 (High carbon emissions) and EN5 (Lack of green practices)—are shown to be influenced by legal, institutional, and economic constraints [92]. These outcomes mirror sectoral life-cycle assessments showing that Vietnam's freight sector is among Southeast Asia's highest GHG contributors per ton-km [28]. Similarly, limited renewable integration (EN6) and poor waste systems (EN4) stem more from policy failures than technical infeasibility [89], [109].

In the social dimension, SO11 (Cultural resistance) and SO3 (ESG skill gaps) emerge as major effect variables, reinforcing the argument that societal and workforce-level ESG adoption lags behind policy development. Educational reforms and public awareness campaigns, as proposed in recent sustainability education studies, are needed to address these soft barriers [88], [93], [110].

Governance-related effect variables like GO8 (High ESG compliance costs) and GO10 (Corruption risks) reflect underlying legal and institutional failures, not isolated inefficiencies. These findings are aligned with anti-corruption reports that link weak enforcement with inflated ESG reporting costs and fraudulent sustainability claims [111], [112].

Finally, while not deeply explored in this paper, technology (TE) was an effective factor across most dimensions, indicating that digital or green logistics technologies are underutilized not due to technical limits but due to economic and governance constraints—a trend echoed by Vietnam's digital transformation roadmap and IoT adoption lag in the logistics sector [113], [114].

5 | Conclusion

This study applied the Neutrosophic DEMATEL method to identify and analyze the causal relationships among barriers affecting ESG implementation in Vietnam's logistics sector. The results highlight that Legal and Compliance (LE), Institutional (IN), Economic (EC), and Psychological and Behavioral (PS) barriers are the primary causal dimensions exerting influence over Environmental (EN), Social (SO), Governance (GO), and Technology (TE) domains. Legal enforcement inconsistencies, institutional capacity gaps, economic disincentives, and behavioral resistance emerged as foundational drivers shaping ESG integration's effectiveness. Conversely, environmental emissions, governance inefficiencies, limited stakeholder engagement, and low technological uptake were identified as effect dimensions largely dependent on upstream interventions. This interconnected structure emphasizes the need for holistic strategies to overcome ESG barriers in Vietnam's logistics industry.

5.1 | Policy implications

The study offers several policy-level insights. First, regulatory bodies should establish mandatory ESG compliance frameworks and consistent enforcement mechanisms across provinces to reduce ambiguity and ensure alignment with international standards. Second, capacity-building programs should be implemented for both regulators and private actors, with ESG training integrated into civil service and logistics industry development curricula. Third, targeted financial instruments—such as tax incentives, green credit lines, and ESG-linked bonds—should be introduced and scaled to stimulate investment. Lastly, a multi-stakeholder ESG task force involving government, industry associations, academia, and civil society could help harmonize ESG guidelines, reporting standards, and incentive schemes nationwide.

5.2|Managerial Recommendations

For logistics firms and industry leaders, several managerial interventions are critical. Firms should conduct internal ESG readiness audits to identify gaps across environmental impact, labor standards, governance structures, and compliance obligations. Managers should champion organizational change initiatives, including ESG-focused workshops, sustainability KPIs, and integration of ESG into strategic planning. Adopting a data-driven approach by leveraging ESG management software, emissions tracking systems, and supplier sustainability scorecards is also recommended. Firms can collaborate with educational institutions and startups to build ESG competencies and co-develop green logistics solutions. Furthermore, logistics managers should proactively engage with ESG investors and certification bodies to strengthen credibility and access new funding channels.

5.3| Limitations and Future Research Directions

While this study provides significant contributions, it is subject to certain limitations. First, the analysis is based on expert judgment using the NS-DEMATEL approach, which may involve subjective biases despite validation. Second, the study focuses exclusively on Vietnam's logistics sector, limiting the generalizability of findings to other sectors or countries. Third, while comprehensive, the dimensional framework may omit certain emergent ESG variables, such as circular economy practices or biodiversity impacts, which are gaining prominence globally. Lastly, while causality was assessed among barriers, the model did not evaluate logistics firms' temporal dynamics or sectoral maturity differences.

Future studies could extend this research by incorporating longitudinal data to examine how ESG barrier dynamics evolve in response to policy and market interventions. Additionally, integrating quantitative performance indicators (e.g., CO_2 reduction metrics, ESG scores, cost savings) could help link ESG adoption with business outcomes. Comparative studies across ASEAN countries or logistics sub-sectors (e.g., maritime, road freight, last-mile delivery) would provide cross-contextual insights. Moreover, combining NS-DEMATEL with hybrid MCDM models (e.g., Neutrosophic AHP, Fuzzy TOPSIS) could offer a more robust prioritization of policy or investment strategies. Lastly, integrating stakeholder-specific perspectives—from employees, consumers, or investors—would enrich the behavioral dimensions of ESG research.

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