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Sustainability practices as predictors of competitiveness in the freight transport industry

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Abstract
This paper develops a conceptual model proposing sustainability practices as key predictors of competitiveness in the freight transport industry. Grounded in the resource-based view, the natural resource-based view and dynamic capabilities theory, the model positions sustainability not only as compliance or cost reduction but as a strategic resource that can strengthen firms' competitive positions. Sustainability practices are conceptualised across four dimensions: environmental management, green logistics operations, digital technologies for sustainability and green supply chain collaboration. Competitiveness is framed through cost efficiency, service quality, innovation capability and market differentiation.
A structured synthesis of literature on sustainability, logistics and strategic management is used to refine construct definitions, clarify mechanisms and specify contextual influences relevant to freight transport. The model argues that innovation capability acts as the central mechanism linking sustainability practices to competitive outcomes, while digital adoption and environmental uncertainty operate as boundary conditions that may strengthen or weaken these effects. The contribution of this paper lies in offering an integrated, theory-driven framework for understanding how sustainability can become a source of competitive advantage in freight transport, especially in emerging markets.

Keywords: Sustainability practices, freight transport industry, competitiveness, resource-based view, green logistics, innovation capability

1. Introduction
Freight transport plays a central role in global trade but is also a major source of greenhouse gas emissions and environmental impacts (ITF-OECD, 2024; McKinnon, 2018) [7, 14]. Road freight generates most freight-related CO_2 emissions, while maritime transport contributes significantly to global energy-related emissions (IMO, 2023; UNCTAD, 2023) [6, 25]. These pressures have increased interest in how sustainability practices relate to the competitive position of freight transport firms (Kumar & Anbanandam, 2022) [10].
Sustainability practices in the sector encompass carbon reduction, energy efficiency, green logistics operations, digital technologies and green supply chain management (Green *et al.*, 2012; Tan *et al.*, 2015) [3, 21]. At the same time, competitiveness depends on cost efficiency, service quality, innovation capability and differentiation (Poliak *et al.*, 2021; Sivaslioğlu *et al.*, 2021) [17, 31]. While research has linked sustainability to firm performance in broader logistics contexts, studies focused specifically on freight transport remain limited, particularly in emerging markets (Hermundsdottir & Aspelund, 2021; Le, 2024) [5, 12].
Existing work also lacks conceptual clarity. Many studies rely on narrow sustainability indicators and simplified performance measures, which limits understanding of the multidimensional nature of both constructs (Saunila *et al.*, 2024) [20]. Research rarely explains how internal capabilities translate sustainability efforts into competitive outcomes, despite insights from the resource-based view, the natural resource-based view and dynamic capabilities theory (Barney, 1991; Hart, 1995; Teece, 2007) [1, 4, 22].
The purpose of this paper is to propose an integrated conceptual model that positions sustainability practices as predictors of competitiveness in the freight transport industry. The model identifies innovation capability as a central mechanism that connects sustainability efforts with competitive advantage and considers digital adoption and environmental uncertainty as important contextual influences. Sustainability practices are conceptualised as a multidimensional resource base, and competitiveness is defined across cost efficiency, service quality, innovation capability and market differentiation.

2. Literature Review

2.1 Sustainability Practices in Freight Transport

Sustainability practices in freight transport include environmental measures, green logistics operations, digital technologies and green supply chain management. Environmental practices focus on carbon management, fuel efficiency and emissions reduction, which are critical because freight transport represents a substantial share of global CO_2 emissions (IMO, 2023; ITF-OECD, 2024) [6, 7]. Green logistics operations, such as route optimisation, modal shift, load consolidation and energy-efficient transport modes, aim to reduce environmental impact while improving operational efficiency (Yang *et al.*, 2024; Tan *et al.*, 2015) [32, 21].

Digitalisation is increasingly recognised as a core sustainability driver. Technologies such as IoT, transport management systems, AI-based routing and supply chain visibility tools help firms optimise asset use and reduce emissions (Al-Shboul *et al.*, 2024; Petersen, 2022) [33, 34]. Green supply chain management extends sustainability beyond firm boundaries through green purchasing, supplier collaboration and reverse logistics (Green *et al.*, 2012) [3].

Across these dimensions, sustainability practices are conceptualised as strategic resources that enhance efficiency, reduce risk and improve stakeholder relations, which aligns with the resource-based view and the natural resource-based view (Hart, 1995; Russo & Fouts, 1997) [4, 19]. Recent studies also emphasise the role of dynamic capabilities in enabling firms to adapt and reconfigure sustainability-related resources (Teece, 2007) [22].

2.2 Competitiveness in the Freight Transport Industry

Competitiveness in freight transport is multidimensional. Cost efficiency remains central because transportation costs directly influence supply chain performance and customer satisfaction (Poliak *et al.*, 2021) [17]. Service quality, defined by reliability, timeliness and transparency, is increasingly important for logistics clients (Sivaslioğlu *et al.*, 2021) [31]. Innovation capability supports new service models, process improvements and technology integration, all of which strengthen a firm's competitive position (Lookman *et al.*, 2023) [13]. Market differentiation involves offering unique value through sustainability, digital integration or specialised services (Fikru, 2021) [35].

The logistics performance of a region or firm is also shaped by infrastructure, regulatory quality and the availability of advanced digital systems (OECD, 2021) [15]. These factors influence both operational efficiency and competitive positioning.

2.3 Linking sustainability practices and competitiveness

Most empirical studies report a positive association between sustainability practices and firm-level outcomes, although results vary across sectors. Findings show that environmental and green logistics practices often contribute to cost savings, risk reduction and improved reputational value (Hermundsdottir & Aspelund, 2021; Thomas & Gupta, 2023) [5, 23]. Digitalisation enhances both sustainability and competitiveness by enabling real-time optimisation, increased visibility and faster decision-making (Al-Shboul *et al.*, 2024) [33].

Innovation capability is frequently identified as a channel through which sustainability practices generate competitive advantage. Firms that invest in sustainability tend to develop stronger capabilities in green product and process innovation, which in turn improve performance (Widyantoro *et al.*, 2025) [26]. This aligns with dynamic capabilities theory, which suggests that the ability to reconfigure and integrate resources determines long-term competitiveness (Teece, 2007) [22].

Although existing studies support the potential of sustainability to enhance competitiveness, the evidence for freight transport specifically remains fragmented and context dependent.

2.4 Research Gap

This review highlights four major gaps that justify the development of an integrated conceptual model.

Many studies use narrow sustainability constructs such as emissions metrics or isolated environmental actions. This approach overlooks the multidimensional nature of sustainability practices, which span environmental measures, green operations, digital technologies and supply chain integration (Saunila *et al.*, 2024) [20]. Competitiveness is also often reduced to financial indicators, which limits understanding of performance dimensions relevant to freight transport, including service quality, innovation capability and differentiation.

Existing research rarely explains how sustainability practices create competitive outcomes. Few studies examine capability-based mechanisms, even though the resource-based view, natural resource-based view and dynamic capabilities theory point to internal capabilities, particularly innovation capability, as the core process through which sustainability investments translate into competitive advantage (Hart, 1995; Teece, 2007) [4, 22].

Similarly, limited attention has been paid to contextual conditions that influence this relationship. Digital adoption and environmental uncertainty are likely to shape how sustainability practices affect organisational capabilities and outcomes, but these influences remain underexplored.

Most evidence comes from manufacturing or general logistics sectors in developed economies. Research specific to freight transport, especially in emerging markets such as ASEAN, is scarce (OECD, 2021; Le, 2024) [15, 12]. Given the structural differences in infrastructure, regulatory environments and digital readiness, findings from developed contexts may not generalise to emerging freight markets.

3. Methodology

3.1 Research Approach

The paper follows a theory-building approach grounded in three established perspectives: the resource-based view, the natural resource-based view and dynamic capabilities theory (Barney, 1991; Hart, 1995; Teece, 2007) [1, 4, 22]. These theories provide the basis for identifying the mechanisms through which sustainability practices may influence competitiveness. The approach involves analysing how these theories conceptualise organisational resources, environmental capabilities and adaptive processes relevant to freight transport.

3.2 Literature Identification and Selection

A structured review of the academic and professional literature was conducted to identify the main constructs, dimensions and relationships relevant to sustainability, freight transport and competitiveness. Sources included peer-reviewed journals, industry reports and institutional

publications. Database searches were performed using keywords such as sustainability practices, green logistics, freight transport, competitiveness, digitalisation and innovation capability. Studies were included if they addressed sustainability in logistics or transport, analysed firm competitiveness or identified mechanisms relevant to capability development.

The review synthesised findings across environmental management, logistics management, digital transformation and supply chain studies. The goal was to organise the literature into thematic categories that inform the structure of the conceptual model.

3.3 Model Development Procedure

The conceptual model was developed through three steps.

First, multidimensional definitions of sustainability practices and competitiveness were derived from recurring themes in the literature. This step allowed the construction of comprehensive constructs aligned with freight transport characteristics.

Second, potential mechanisms linking sustainability practices to competitiveness were identified, with innovation capability emerging as a central integrative capability supported by past research.

Third, relevant contextual conditions were examined. Based on consistent findings on digital transformation and environmental turbulence, digital adoption and environmental uncertainty were incorporated as boundary conditions that may shape the sustainability and competitiveness relationship.

3.4 Validation of Conceptual Reasoning

The model was refined through theoretical triangulation. Constructs and proposed linkages were compared with insights from multiple theoretical perspectives to ensure coherence and logical consistency. Consistency with prior empirical trends was also assessed to confirm that the proposed framework aligns with documented patterns in freight transport sustainability and organisational performance.

3.5 Intended Contribution of the Methodology

The methodology provides a systematic foundation for proposing a model that integrates multiple dimensions of sustainability practices, identifies innovation capability as a key mechanism and acknowledges important contextual influences. This approach supports future empirical research by offering clear conceptual definitions, theoretically grounded relationships and a structured basis for hypothesis development.

4. Proposed Conceptual Model

The model is grounded in the resource-based view, the natural resource-based view and dynamic capabilities theory. Sustainability practices are conceptualised across four dimensions: environmental practices, green logistics operations, digital technologies and green supply chain management. Competitiveness is defined across cost efficiency, service quality, innovation capability and market differentiation.

Innovation capability is proposed as the mechanism through which sustainability practices are transformed into competitive advantage. Digital adoption and environmental uncertainty are included as contextual variables because they influence how effectively firms leverage sustainability-related resources.

4.1 Direct Effects

H1. Sustainability Practices Have A Positive Effect on Competitiveness in The Freight Transport Industry.

RBV argues that valuable, rare and inimitable resources improve firm competitiveness (Barney, 1991) [1]. NRBV extends this by identifying environmental practices as strategic resources that enhance efficiency and stakeholder legitimacy (Hart, 1995) [4].

Studies across logistics and supply chain contexts show that sustainability initiatives reduce operational costs, enhance market reputation and improve service reliability (Hermundsdottir & Aspelund, 2021; Thomas & Gupta, 2023) [5, 23]. Green logistics practices contribute to better performance outcomes such as service quality, environmental efficiency and financial stability (Yingfei *et al.*, 2021) [36]. In freight operations, lower emissions, route optimisation and energy-efficient transport modes can simultaneously reduce costs and improve competitive positioning.

Sustainability practices provide strategic and operational benefits that enhance firm competitiveness.

H2. Sustainability Practices Have a Positive Effect on Innovation Capability: Dynamic capabilities theory states that environmental pressures stimulate firms to reconfigure processes and adopt new technologies (Teece, 2007) [22]. Sustainability initiatives often require new designs, green technologies and cleaner operations, which activate learning and innovation.

Sustainability-oriented firms exhibit higher levels of green product and process innovation (Feng *et al.*, 2022; Widyantoro *et al.*, 2025) [37, 26]. Environmental regulations and stakeholder pressures encourage freight and logistics firms to adopt advanced fuel-efficient vehicles, digital monitoring tools and green packaging solutions, all of which require innovation capabilities. Green supply chain management also fosters collaborative innovation across suppliers and transport operators (Green *et al.*, 2012) [3].

Sustainability practices act as catalysts for innovation capability development.

H3. Innovation Capability Has a Positive Effect on Competitiveness: RBV positions innovation capability as a strategic resource that helps firms create differentiated offerings and respond effectively to market demands (Barney, 1991) [1]. Dynamic capabilities theory emphasises innovation as a key mechanism enabling firms to adjust to environmental changes (Teece, 2007) [22].

Innovation capability is linked to improved service quality, cost efficiency and market differentiation in logistics and transport firms (Lookman *et al.*, 2023) [13]. Studies show that firms with strong innovation capabilities outperform competitors by developing superior logistics technologies, greener services and data-driven operations (Sivaslioğlu *et al.*, 2021) [31].

Firms with stronger innovation capabilities are better positioned to achieve competitive advantage.

4.2 Mediation Effect

H4. Innovation Capability Mediates the Relationship Between Sustainability Practices and Competitiveness.

NRBV suggests that environmental strategies enhance organisational capabilities, which then improve performance outcomes (Hart, 1995) [4]. Sustainability practices strengthen innovation routines and technological capabilities that firms use to achieve competitive advantage.

Evidence shows that sustainability initiatives stimulate innovation, which subsequently contributes to cost savings, higher service reliability and stronger differentiation (Hermundsdottir & Aspelund, 2021) [5]. Widyantoro *et al.* (2025) [26] demonstrate that sustainability pressures lead to capability development, which then improves financial outcomes. Studies in logistics confirm that green innovation mediates the effect of environmental practices on performance (Tan *et al.*, 2015) [21].

Sustainability practices influence competitiveness both directly and indirectly by enhancing innovation capability.

4.3 Moderation Effects

H5. Digital Adoption Positively Moderates the Relationship between Sustainability Practices and Innovation Capability

Digital tools enhance visibility, data accuracy and asset utilisation, thereby strengthening the effectiveness of sustainability practices. Digitalisation also accelerates firms' ability to learn, prototype and scale new green solutions.

Digital transformation enables logistics and freight firms to optimise routing, reduce idle time and improve energy efficiency, all of which intensify the innovation potential of sustainability initiatives (Al-Shboul *et al.*, 2024; Petersen, 2022) [33, 34]. Industry studies show that sustainability benefits are larger in firms with advanced digital systems such as IoT tracking, real-time analytics and AI-supported decision systems.

When digital adoption is high, sustainability practices translate into greater innovation capability.

H6. Environmental Uncertainty Positively Moderates the Relationship between Innovation Capability and Competitiveness: Dynamic capabilities theory posits that innovation becomes more valuable under uncertainty because firms need flexibility to respond to regulatory, technological and market volatility (Teece, 2007) [22].

Evidence shows that innovation has stronger performance effects in turbulent environments where firms must frequently adjust operations and services (Jangga *et al.*, 2015) [8]. Recent studies find that environmental uncertainty strengthens the link between organisational capabilities and performance outcomes in logistics and supply chains (Leinonen *et al.*).

Innovation capability contributes more strongly to competitiveness when environmental uncertainty is high.

5. Measurement Instruments: To operationalise the constructs in the proposed conceptual model, this study consolidates established multi-item measurement scales drawn from prior research in sustainability, logistics management, innovation and strategic management. All constructs are assessed using seven-point Likert items that capture respondents' perceptions of organisational practices and performance. The selected scales prioritise validity and reliability based on their widespread use in empirical studies and their alignment with the theoretical foundations of the model, including the resource-based view, the natural resource-based view and dynamic capabilities theory. The table below summarises the constructs, subdimensions, representative items and primary sources that inform the measurement framework (Table 1).

Table 1: Measurement Instruments

Construct	Subdimension	Measurement Items	Sources
Sustainability Practices	Environmental Practices	1. The company monitors and reduces energy consumption. 2. The company reduces emissions from vehicles and equipment. 3. The company adopts environmentally friendly fuels or technologies. 4. The company implements waste and pollution reduction programs.	Zhu & Sarkis (2004) [29]; Yang *et al.* (2024) [32]
	Green Logistics Operations	1. The company optimises routes to reduce fuel use. 2. The company improves load consolidation to avoid empty runs. 3. The company shifts to rail or sea transport when feasible. 4. The company adopts eco-efficient logistics planning.	Rao & Holt (2005) [18]; Tan *et al.* (2015) [21]
	Digital Technologies for Sustainability	1. Digital systems are used to track emissions and fuel use. 2. IoT or telematics support real-time fleet monitoring. 3. AI tools optimise transport planning. 4. Digital platforms enhance supply chain visibility.	Dubey *et al.* (2019) [38]; Al-Shboul *et al.* (2024) [33]
	Green Supply Chain Management	1. The company collaborates with suppliers on environmental improvements. 2. The company applies green purchasing criteria. 3. Recycling, reuse or reverse logistics programs are implemented. 4. Environmental criteria are integrated into supplier contracts.	Zhu *et al.* (2008) [30]; Green *et al.* (2012) [3]
Innovation Capability	Product, Process, Technological, and Business Model Innovation	1. The company introduces new environmentally oriented services. 2. The company improves processes to support sustainability. 3. The company adopts new technologies earlier than competitors. 4. The company develops new business models related to	Calantone *et al.* (2002) [2]; Keskin (2006) [9]; Saunila *et al.* (2014) [20]

		green freight.	
Competitiveness	Cost Efficiency	1. The company provides services at lower cost than competitors. 2. Operating costs are efficiently controlled. 3. Fuel and operating costs have improved over time.	Poliak *et al.* (2021) [17]; Lai *et al.* (2002) [11]
	Service Quality	1. Deliveries are reliable and on time. 2. Customers receive accurate information. 3. Disruptions are handled promptly.	Parasuraman *et al.* (1988) [16]; Sivaslioğlu *et al.* (2021) [31]
	Market Differentiation	1. The company offers unique logistics services. 2. Sustainability practices improve brand image. 3. Service offerings attract high-value customer segments.	Porter (1985) [39]; Fikru (2021) [35]
Digital Adoption	Firm-level Digital Integration	1. Advanced digital tools are integrated into operations. 2. Employees are trained to use digital systems effectively. 3. Data analytics informs operational decisions.	Tornatzky & Fleischer (1990) [24]; Wang *et al.* (2025) [40]
Environmental Uncertainty	Market, Regulatory and Technological Uncertainty	1. Regulations change unpredictably. 2. Customer demand fluctuates significantly. 3. Technological change in the industry is difficult to anticipate.	Miller (1993) [41]; Jangga *et al.* (2015) [8]
Control Variables	Firm Characteristics	Firm size, firm age, transport mode, regulatory pressure, market concentration.	OECD (2021) [15]; Fikru (2021) [35]

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