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Three Essays on Sustainability in European Freight Transportation: Central Bank Regulations, Accounting Practices, and Economic Incentives

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Three Essays on Sustainability in European Freight Transportation: Central Bank Regulations, Accounting Practices, and Economic Incentives

Doctor of Philosophy Dissertation by:

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Cycle XXXVII

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Declaration

I, Ahmad Hatamabadi Farahani, declare that this dissertation is my own unaided work. It has been submitted for the Ph.D. in Methods and Models for Economic Decisions at Università degli Studi dell'Insubria, Varese, Italy. This dissertation has not been submitted before for any degree or examination at any other University.

Ahmad Hatamabadi Farahani

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Abstract

This thesis examines the multifaceted approaches to promoting sustainability within the European freight transportation sector, with a focus on the influence of central bank regulations, accounting frameworks, and economic incentives. The first essay investigates the impact of central bank regulations on sustainable practices in transportation companies across Europe. Using a comprehensive dataset from Orbis and Eikon and focusing on ESG-linked transportation firms, this study reveals that stringent command-and-control regulations by central banks may inadvertently stifle sustainability efforts. The findings suggest that while central banks aim to promote sustainable development, excessive regulatory pressures could impose financial constraints that limit transportation firms' capacity to invest in green technologies, highlighting a need for a balanced regulatory approach.

The second essay undertakes a systematic literature review to explore sustainable transportation from an accounting perspective. By examining 156 articles, this study uncovers a distinct gap in cohesive theoretical frameworks linking sustainable transportation with accounting principles. The analysis highlights that while there is significant academic interest in the integration of environmental, social, and governance (ESG) factors in transportation, practical guidelines for effectively embedding sustainability metrics into accounting systems remain underdeveloped. The study underscores the need for robust frameworks to support sustainable accounting practices that can comprehensively capture environmental impacts, cost efficiency, and social dimensions in the freight sector.

The third essay analyzes how taxation policies and economic incentives influence sustainable practices in freight transportation. Using generalized linear models, this study finds that tax incentives and subsidies have a limited direct impact on sustainability metrics but reveal important relationships between firm size, market share, and environmental performance. The findings indicate that profitability and growth often present a trade-off with environmental goals, suggesting that a nuanced policy approach aligning economic incentives with sustainability targets may be essential for promoting long-term green transitions in the sector.

Collectively, these essays provide empirical insights and a structured understanding of the financial, regulatory, and operational drivers of sustainability in European freight transportation. This research contributes to policy discussions on how central banks, accounting practices, and economic incentives can be optimized to foster sustainable

development, aiming to balance regulatory compliance, profitability, and environmental responsibility.

Introduction

Sustainability in freight transportation has emerged as a critical component of environmental policy, economic strategy, and social responsibility in Europe. As the backbone of international trade and domestic supply chains, freight transportation significantly influences greenhouse gas emissions, environmental degradation, and urban congestion, contributing to some of Europe's most pressing environmental challenges. Recognizing the importance of sustainability, this thesis explores the intersection of three key influences on sustainable freight transportation in Europe: central bank regulations, accounting practices, and economic incentives. By examining each of these areas, this work seeks to uncover how financial oversight, organizational transparency, and economic motivators converge to shape the sustainability trajectory of the European freight sector. The thesis, organized as three interrelated essays, investigates how central banks, accounting frameworks, and fiscal policies impact sustainability efforts within freight transportation, providing a cohesive overview of regulatory, economic, and operational dimensions.

The focus of this thesis is timely and relevant, given recent legislative advances and economic frameworks designed to address sustainability challenges in Europe. With ambitious targets to reduce emissions and foster sustainable development by 2050, European Union member states have aligned their policies with frameworks such as the Paris Agreement and the European Green Deal. In the transportation sector, freight accounts for nearly 30% of total greenhouse gas emissions, making it a central focus in achieving these environmental objectives. However, the economic and regulatory mechanisms supporting these objectives vary in their effectiveness, and the costs associated with implementing sustainable practices remain a barrier for many firms. Against this backdrop, this thesis endeavors to investigate and dissect the roles played by central banks, accounting, and economic incentives in promoting sustainable practices in European freight transportation. Through empirical analysis and a systematic review, each essay contributes a unique perspective to this overarching objective.

The first essay of this thesis delves into the influence of central bank regulations on sustainable practices within the freight transportation sector. Central banks play a pivotal role in promoting sustainable development through their capacity to control liquidity, monitor financial stability, and influence investor behaviors (Macey & O'Hara, 2006). However, the efficacy of central banks' regulatory influence on sustainability is not straightforward. This essay investigates the complex relationship between central bank regulations and sustainable practices in the

European freight industry, revealing that stringent regulatory measures, while aimed at promoting sustainability, may inadvertently hinder the sector's ability to adopt green practices (Breitenfellner, Andreas; Pointner, Wolfgang; Schuberth, 2019).

Employing a dataset from the Orbis and Eikon databases, this study investigates the impact of command-and-control regulations implemented by central banks on transportation companies across Europe. The empirical analysis draws on ESG (Environmental, Social, and Governance) data from listed transportation firms, allowing for a nuanced examination of how regulatory frameworks affect these companies' environmental performance. The findings reveal a paradox: while central banks' regulatory pressures are designed to encourage sustainable practices, the rigidity of these policies may instead impose financial burdens that discourage companies from adopting green technologies. Specifically, the study identifies a negative association between central banks' return-on-equity (ROE) requirements and sustainable transportation practices, suggesting that heightened financial compliance expectations could stifle sustainability by limiting funds available for green investments. This discovery challenges policymakers to reconsider whether current regulatory structures adequately balance the goals of financial stability and environmental responsibility (Kennedy et al., 2005).

Moreover, this essay highlights the potential for regulatory adjustments that could facilitate greater alignment between central banks' objectives and sustainable development targets. The findings underscore the importance of flexibility within regulatory frameworks, advocating for a balanced approach that encourages companies to pursue environmental goals without compromising financial stability. By addressing these dynamics, this essay offers valuable insights for central bank policymakers seeking to enhance sustainability in the freight transportation sector, thus supporting broader economic and environmental goals in Europe.

The second essay focuses on the intersection of sustainable transportation and accounting practices, examining how integrating sustainability metrics into accounting systems can support environmental goals within the freight sector. Accounting, traditionally centered on financial transactions, has increasingly embraced sustainability principles (Piatkowski et al., 2015) as corporations are held accountable not only for their financial performance but also for their environmental and social impact. However, the current accounting frameworks available for capturing the multi-dimensional aspects of sustainability in freight transportation are limited (Jones, 2010). Through a systematic literature review, this essay investigates the progress and challenges associated with incorporating sustainability within the accounting practices of freight transportation companies.

Conducting an exhaustive review of 156 articles published between 1991 and 2023, this essay explores the evolution of sustainable transportation accounting and identifies key gaps within the existing literature. The analysis reveals that while there is growing recognition of the need for sustainable accounting, theoretical frameworks linking accounting with sustainable transportation practices remain underdeveloped. This gap poses significant challenges for practitioners, who lack the tools to adequately capture and report sustainability metrics. The absence of robust frameworks is especially critical in freight transportation, where environmental impacts are substantial, and sustainability-related metrics, such as emissions and resource efficiency, are essential for evaluating corporate responsibility. Without standardized accounting practices that incorporate sustainability measures, it is difficult for firms to implement effective sustainability strategies or for stakeholders to assess their performance meaningfully.

The findings of this essay emphasize the necessity of developing comprehensive accounting models that consider the unique aspects of sustainable transportation. Drawing on the concept of substitution dynamics within freight transportation, the study suggests a framework for tracking shifts in transportation modes, trip chains, and destination choices that align with environmental goals (Baaij & Reinmoeller, 2018). By advancing the integration of ESG factors into accounting systems, this essay highlights the potential of accounting as a tool for guiding companies toward sustainable practices, thereby reinforcing accountability within the freight transportation sector (Chamseddine & Ait Boubkr, 2020). In doing so, the essay contributes to the discourse on sustainable accounting, proposing new directions for future research and practice that could bridge the gap between sustainability and financial reporting in freight.

The third essay explores the role of economic incentives, specifically taxation policies, and subsidies, in influencing the sustainability of freight transportation companies. Economic incentives are crucial levers for shaping corporate behavior (Yip & Bocken, 2018), especially within industries like transportation, where the adoption of sustainable practices often requires substantial capital investment. While policymakers have increasingly turned to tax incentives and subsidies as tools to encourage green practices, the effectiveness of these measures in driving sustainability remains contested. This essay analyzes how economic incentives interact with firm characteristics, such as size, profitability, and market share, to influence environmental performance in the European freight sector.

Using generalized linear models, the essay assesses the impact of tax policies and financial subsidies on sustainability indicators, focusing on profitability, growth, and

environmental impact. The results reveal that while tax incentives can reduce some financial barriers to sustainability, their direct impact on environmental outcomes, such as emissions reductions, is limited. Interestingly, the analysis finds that larger firms and those with significant market share are more likely to adopt sustainable practices, suggesting that financial strength and market positioning are critical enablers of green transitions in the freight sector (Ajeigbe et al., 2023; Moosavian et al., 2022). Conversely, the study identifies a trade-off between profitability and environmental performance, as rapid revenue growth can sometimes hinder a firm's commitment to sustainability. These findings highlight the nuanced relationship between economic growth and environmental goals, underscoring the need for policies that align economic and environmental priorities (Wong et al., 2009).

The insights generated from this essay provide valuable guidance for policymakers seeking to optimize economic incentives for sustainable freight transportation. By recognizing the conditions under which tax incentives and subsidies are most effective, this essay offers practical recommendations for crafting policies that support green investment without compromising corporate profitability. The analysis underscores the importance of a tailored approach to economic incentives, advocating for targeted subsidies that account for firm size and market dynamics. Through this approach, the essay contributes to a broader understanding of how economic levers can be designed to promote sustainability in an industry marked by high emissions and operational complexities.

Together, these three essays form a comprehensive analysis of the economic, regulatory, and operational factors influencing sustainability in European freight transportation. By focusing on central bank regulations, accounting practices, and economic incentives, this thesis offers a multi-dimensional perspective on sustainability, examining how financial oversight, corporate accountability, and fiscal policies shape the environmental performance of the freight sector. The essays highlight the interconnected nature of these influences, illustrating how regulatory and economic frameworks must evolve to support sustainable transportation.

The insights presented in this thesis contribute to ongoing policy debates and offer actionable recommendations for regulators, industry leaders, and academics interested in advancing sustainability within the transportation sector. As Europe moves towards more stringent environmental goals, the findings of this research underscore the importance of balanced, flexible, and contextually relevant policies that encourage sustainable practices without undermining economic stability or operational viability. By illuminating the intersections of finance, accounting, and economics within the realm of sustainable freight

transportation, this thesis lays the groundwork for further exploration into how these areas can work in concert to foster a greener, more resilient European transportation industry.

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Chapter I.

Central Banks Regulations and Sustainability in Transportation Companies (Case Study of European Countries)

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Narmin Nahidi: Methodology, Investigation, Project administration, Visualization, Review & Editing.

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Central Banks Regulations and Sustainability in Transportation Companies (Case study of European Countries)

Abstract

This study investigates the impact of central bank regulations on sustainable transportation practices in the banking sector in Europe. Using data from the Orbis and Eikon Database and focusing on publicly listed transportation firms with ESG codes included in the Bloomberg dataset, the study empirically analyzes the central banks' regulations and freight companies operating in Europe between January 1, 2012, and December 31, 2021. This study conducts a series of robustness tests to verify the principal findings of the paper. The results of the ordinary least squares regression analysis indicate that there is a negative association between command regulations of central banks and sustainable transportation practices. Specifically, the coefficient of central bank return on equity (ROE) is negative and statistically significant, suggesting that higher command regulations may lead to lower levels of sustainable transportation practices. This finding has important implications for policymakers, highlighting the potential unintended consequences of command regulations on sustainability practices in the banking sector. The study contributes to the literature on the impact of command regulations on sustainable practices in the banking sector. It underscores the need for policymakers to carefully consider the potential trade-offs between regulatory compliance and sustainability practices.

Keywords: Sustainable Transportation, Central Banks, Command Regulations, Banking Sector, Europe

JEL Classifications: O18, E5

1. Introduction

Sustainable development is growing in multiple dimensions, especially in finance and banking. Various networks have been established with the aim of sustainability, such as the Network for Greening the Financial System (NGFS), Sustainable Banking Network (SBN), and Task Force on Climate-related Financial Disclosures (TCFD). These networks aim to develop a sustainable financial system, monetary policy, and financial strategies. While the global economy stopped suddenly due to the spread of COVID-19, nobody thought that the shock of a pandemic on the global economy would be the biggest one after the Second World War, even more, significant than the Great Financial Crisis, which happened a decade ago (BIS, 2020). These events have brought sustainability issues to the attention of authorities even more than before. Human endeavors have formed a union to bond and reconcile with nature, environment, and society, such as the Paris Agreement, Intergovernmental Panel on Climate Change (IPCC), Sustainable Development Goals (SDGs), and Environmental Social and Corporate Governance (ESG).

Central banks of European countries (hereafter central banks) have a crucial role in governing the financial system, intermediating funds, controlling the stability of the financial market, and retaining the flow of financial movements (BIS, 2020)[4]. In addition to central banks Field's effective corporate governance role (Macey & O'Hara, 2006), central banks aim to lead private investors to transition to low-carbon and sustainable development by offering suitable policies through the banking system (Visco, 2019). Nowadays, the strategy of central banks is more in favor of sustainable development. Previous literature discusses the relationship between banks' strategies and business models that their customers are adopting (Masud et al., 2017; Nosratabadi et al., 2020). Moreover, both central banks and stakeholders evaluate each other's performance through corporate social responsibility.

Steg & Gifford, (2005) suggest that sustainable transport is an integral part of sustainable development. It is defined as the examination of the sustainability of the transportation system with

[4] "The **Bank for International Settlements** (**BIS**) is an international financial institution owned by European banks that "fosters international monetary and financial cooperation and serves as a bank for European banks"."

a focus on positive and negative transport values. Meanwhile, the importance of sustainable transportation is also highlighted (Durrani et al., 2020). To emphasize the important role of transportation, (Geurs & Van Wee, 2000) discuss that transportation can be the starting point of a chain of changes. This means that a macroeconomic change in transportation, such as "lower production values in transport and higher production values in trade and industry," can result in a change in GDP and employment levels. Default risk is one of the factors characterizing financial stability. This risk can define whether banks have financial stability or not. To avoid default risk, banks use various resources (Umar et al., 2021). However, in case of financial mishaps and crisis situations, banks have to concentrate more on strategies to escape the risk of default and maintain financial stability during the stress periods (Karim & Naeem, 2022;Naqvi et al., 2021). Thus, the current pandemic situation insinuates the sustainability and stability of the overall banking system to avoid the drastic effects of the crisis and retain its customer base.

This paper attempts to shape the premise that sustainable central banks directly impact sustainable transportation. The more sustainable mandates from banks are implemented, the more it is possible that the transportation system will become sustainable. To further highlight the role of the central banks, I will study how sustainable incentives from central banks impact transportation companies. This paper will contribute to the literature by discussing and providing insight into the role of central banks in promoting sustainable development, specifically transportation. The article is organized as follows. Section 2 develops the hypotheses and literature related to the aim of the paper. Subsequently, section 3 discusses the methodology and data, section 4 Model Specification, section 5 Empirical Results, section 6 robustness test, and section 7 Contribution and Conclusion.

2. Literature Review and Hypothesis Development

Central banks, as prominent monetary policymakers, have several mandates and regulations within their sustainable goals, including (a) monitoring and analyzing the impact of sustainability on the transmission of monetary policy and (b) defining sustainable rules to control financial stability (Breitenfellner, Andreas; Pointner, Wolfgang; Schuberth, 2019). The duties of the central banks to sustainable financial activities mandate them to preserve price stability, take risks, and supervise new sustainable regulations (Durrani et al., 2020). From a broader perspective, to achieve sustainable goals, central banks aim to provide sustainable products to their customers and motivate them to have socially responsible investments (Jeucken, 2001).

Over the past two decades, central banks' independence from national financial authorities led them to have more independent, sustainable policy outcomes (Cecchetti, 2000). To develop the financial infrastructure of transportation companies, (Kennedy et al., 2005) suggested that transportation companies mimic the strategy of central banks, liberate themselves from complex transportation economic systems, and form their sustainable strategy. (Black, 1996) suggests that in order to be more energy-efficient and greener, financial incentives such as operating costs ought to help firms to be more sustainable. In other words, the responsibility for sustainable infrastructure depends on central banks' goals that can have destructive damages for climate change and sustainable development.

2.1.Sustainable Transportation and Supply Chain

In contemporary times, the concept of sustainable transportation has gained widespread recognition among the masses. While many people use sustainable public transportation for their daily commute, sustainable transportation entails more than just that. According to previous literature, sustainable transport refers to a holistic approach that balances transportation's present and future environmental, social, and economic dimensions (Litman & Burwell, 2006; *WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT*, 1987). Scholars agree that sustainable transportation involves individual actions toward promoting sustainable practices in transportation settings (Frijns et al., 2014; Litman, 2003). The ever-increasing global population has necessitated the introduction of more sustainable techniques and practices by governments to ensure a greener planet. This emphasizes the need for transportation companies to act more sustainably, as their actions have far-reaching effects on the environment.

To promote sustainable development, central banks can strategically incentivize transportation companies to adopt sustainable practices. Bank regulations at macroeconomic levels are effective tools for shaping the financial system. Additionally, monetary authorities can promote sustainable finance and climate change by implementing policies that encourage sustainable practices (Durrani et al., 2020). To this end, central banks should allocate financial resources to their clients without discriminating against any particular sectors or companies (Dikau & Volz, 2019). As Maxfield (1994) argued, banks have financial, bureaucratic, and monetary policy incentives to perform well at the macroeconomic level. Thus, central banks can leverage these incentives to encourage sustainable practices in transportation companies.

In conclusion, sustainable transportation is a critical aspect of modern-day life, which involves balancing environmental, social, and economic considerations. It involves the actions of individuals toward promoting sustainable practices in transportation settings. The global population growth has further emphasized the need for transportation companies to adopt sustainable practices to ensure a greener planet. Central banks can incentivize sustainable practices in transportation companies by allocating financial resources and implementing policies that promote sustainability.

Sustainable transportation is a critical aspect of modern-day life that requires coordinated efforts from all stakeholders. Central banks can play a significant role in promoting sustainable transportation by implementing control and command regulations that incentivize transportation companies to adopt sustainable practices. Such regulations can include financing conditions that prioritize environmentally friendly transportation projects, such as electric vehicles and infrastructure. Banks can also impose stricter lending policies for companies that do not adhere to sustainable transportation practices. By doing so, central banks can promote sustainable transportation practices that contribute to a greener planet.

However, some scholars argue that command and control regulations may be counterproductive and stifle innovation in the transportation industry. Such regulations may lead to inefficiencies in the transportation sector, as companies may prioritize compliance over innovation. Furthermore, transportation companies may find ways to circumvent such regulations, which can result in unintended consequences. Therefore, there is a need for a balanced approach that considers the benefits and drawbacks of command-and-control regulations. This can be achieved by ensuring that regulations promote sustainable practices while also encouraging innovation in the transportation industry. Overall, central banks can play a crucial role in promoting sustainable transportation, and there is a need for well-designed regulations that balance sustainability and innovation.

2.2.Supply Chain and Policy Integrations on Freight Management

Supply chain regulations and policy integrations in logistics and freight management are essential to ensure goods' efficient and compliant movement. Here are the key aspects: Customs and Import/Export Regulations: International logistics involves complying with customs regulations, which vary by country. These regulations include documentation requirements, customs duties, and

tariffs. Failure to adhere to these rules can result in delays, fines, or confiscation of goods. Violating regulations, particularly customs and import/export rules, can result in severe penalties in the supply chain (LaPoint and Webster., 2004). Delays often occur as shipments are held up for inspections or documentation corrections. These delays disrupt schedules, increase holding costs, and damage customer relationships due to missed delivery deadlines (LaPoint and Webster., 2004). Fines and penalties are common consequences of regulatory violations. Monetary fines can be substantial, impacting a company's profitability. In more serious cases, goods may be confiscated, leading to significant financial losses and disruptions in the supply chain (Johnson and Bade., 2010). The impact of these penalties goes beyond the immediate financial costs. Repeated violations can damage a company's reputation, lead to legal action, and even jeopardize its ability to conduct international trade (Erian, S., 2021). For these reasons, strict adherence to regulations and robust compliance procedures are essential in supply chain management to avoid the detrimental effects of violations (Erian, S., 2021).

Various laws govern the transportation of goods, including road, rail, air, and maritime transport. These regulations cover areas like cargo securing, weight limits, safety standards, and driver working hours to ensure safe and efficient freight movement (Dempsey., 2000). The rigorous management of hazardous materials during transportation is governed by comprehensive regulations to ensure the protection of life, property, and the environment. As highlighted by Erkut et al., 2007, these regulations encompass a range of requirements, from correct labeling and packaging to the meticulous handling of materials. Environmental laws play a significant role in this context, as they impose emissions standards and rules for fuel efficiency and pollution control, which are critical for reducing the transportation sector's ecological impact. In the realm of international commerce, customs and trade regulations are influential in freight logistics, dictating the flow of goods across borders and outlining the operational framework for compliance and documentation. Freight managers are entrusted with the task of ensuring that every shipment adheres to the intricate documentation and regulatory stipulations of the involved countries, which encompasses managing comprehensive paperwork such as customs declarations and import permits.

The implications of these regulations are multi-faceted. Discrepancies in documentation can result in delays and stringent inspections, disrupting supply chains, increasing costs, and affecting customer satisfaction. Tariffs and duties imposed by cross-border trade regulations directly affect the cost structure of international trading, influencing pricing and profit margins. Understanding and leveraging trade agreements can offer significant financial advantages by reducing or eliminating certain tariffs, which requires freight managers to stay informed and strategically plan trade routes.

Moreover, failure to comply with customs regulations poses the risk of financial penalties or the seizure of goods, underscoring the need for meticulous management of all freight-related processes. Trade barriers resulting from these regulations can alter market accessibility and competitive dynamics, necessitating a strategic approach to freight management. Accurate documentation is essential for smooth customs clearance, and many companies rely on the expertise of customs brokers to navigate these complex regulatory landscapes efficiently. These professionals are instrumental in ensuring that freight operations comply with the myriad of legal requirements, thereby facilitating seamless management and transportation of goods. To simplify customs compliance, freight managers often use global trade software that automates documentation, calculates duties and taxes, and assists in adhering to regulations (Grainger, 2014). Scholars argue that enhanced visibility and real-time tracking in freight management help to identify potential customs-related issues, allowing proactive solutions to minimize delays and disruptions (Wong et al., 2009). In essence, customs and Import/Export regulations are pivotal in shaping the path of goods in the global supply chain. Freight managers must be well-versed in these regulations, employ effective documentation practices, and leverage technology to ensure smooth cross-border trade operations while mitigating potential delays and costs.

2.3.Banking Regulations on Supply Chain Performance

Banking regulations play a pivotal role in shaping the performance of supply chains, both directly and indirectly. Regulations influence a company's ability to procure financing for supply chain activities. As Wasan et al., 2023, point out, stringent banking regulations can restrict access to loans or credit lines, hampering a business's capacity to invest in essential supply chain components like inventory and transport. Furthermore, as Buiter (2008) notes, central bank policies, including interest rate adjustments, can directly affect the cost of financing, thus impacting supply chain budgets and investment capabilities in infrastructure and technological advancements. The international dimension of supply chains is subject to the influence of currency exchange regulations. Exchange rate volatility, often a result of regulatory actions, can alter the costs associated with importing and exporting goods, thereby affecting supply chain expenses and product pricing (Ma and Kao 1990). Additionally, trade finance regulations, including the issuance of letters of credit, are crucial in international transactions, where increased regulatory stringency can cause delays and elevate operational costs. The emphasis on risk management mandated by banking regulations also compels supply chains to adopt practices that minimize financial and operational risks (Ma and Kao 1990).

The impact of banking regulations extends to the compliance obligations of financial institutions, which, according to Khan et al. (2020), can result in additional costs being transferred to clients involved in supply chain operations. These regulations also influence company liquidity and access to short-term credit, which are critical for effective working capital management within supply chains. Mitra and Datta (2014) highlight that regulations advocating sustainability can lead companies to invest in greener supply chain practices. In response to the financial uncertainties posed by banking regulations, supply chain professionals might employ strategies to bolster resilience, such as diversifying financing sources and optimizing cash flow to manage disruptions effectively (Lamoureux and Evans 2011). Banking regulations significantly affect supply chain performance through their impact on financing access, interest rates, exchange rates, and trade finance. They also shape risk management practices, compliance costs, working capital, and investment in supply chain optimization. Professionals in this field must adeptly navigate the regulatory landscape to ensure financial and operational efficiency, aligning with the ever-evolving regulatory framework to maintain robust supply chain operations.

2.4.Banking Regulation on Freight Performance

Banking regulations have a profound influence on the performance of supply chains, particularly in the domain of freight operations. These regulations intersect financial and operational strategies, thereby determining the efficiency and reliability of freight management systems. For instance, stringent banking regulations may impede a company's ability to acquire necessary financing for logistical operations. As noted by Kashyap and Stein (1997), limited access to credit or loans could impede critical investments in transportation vehicles and storage facilities, which are the backbone of freight management. The ripple effects of banking regulations are also evident in the cost of financing, with interest rates being a key factor in the financial planning for freight operations. According to Musso et al. (2006), higher interest rates could lead to increased borrowing costs, which in turn could impact budgetary considerations for transportation, warehousing, and associated logistics activities. Additionally, regulatory influences on currency exchange and trade finance are pivotal for international freight operations, where compliance is essential for managing currency-related risks and facilitating seamless cross-border transactions (Gabaix and Maggiori 2015).

Furthermore, banking regulations stipulate stringent risk management and insurance requirements, affecting the cost and availability of insurance for freight ventures and influencing overall logistics strategies. Working capital management is another area where regulations play a critical role, affecting a company's liquidity and ability to efficiently conduct day-to-day freight

operations. In general, the breadth of banking regulations' impact on freight management is significant, ranging from capital access and interest rates to risk management and international trade finance. These regulations form the financial landscape within which freight operations are conducted, and companies must adeptly navigate these regulatory waters to ensure optimal financial and operational performance within the supply chain.

Policy integrations in freight transportation and logistics are critical for ensuring operational efficiency, safety, and sustainability. Safety policies are paramount; they encompass stringent guidelines for driver training, routine vehicle maintenance, and secure cargo handling to prevent accidents and safeguard both drivers and the public. The aim is to minimize risks associated with transportation and ensure compliance with safety regulations. In the realm of logistics, inventory management policies play a vital role. These policies are designed to maintain the delicate balance of inventory levels, ensuring that goods are available when needed while preventing excess stock that can tie up capital and storage space. Effective inventory policies facilitate the seamless movement and tracking of goods, which is crucial for the optimization of supply chains.

Route optimization policies are integrated to enhance the efficiency of freight transportation. By leveraging advanced algorithms and real-time data, these policies help in identifying the most efficient pathways, thereby reducing transit times and fuel consumption, which not only leads to significant cost savings but also contributes to the reduction of emissions. Meanwhile, risk management policies address the various uncertainties within the logistics sector, including insurance coverage, contingency planning, and security protocols to mitigate risks associated with theft, damage, and unforeseen accidents. Lastly, sustainability initiatives within policy frameworks are increasingly significant. These policies encourage the adoption of eco-friendly practices in logistics operations, aiming to reduce waste, lower emissions, and decrease resource consumption. Such initiatives may include investing in renewable energy sources, utilizing sustainable packaging materials, and adopting more fuel-efficient modes of transport. These integrations collectively support the goal of making freight and logistics operations more responsible and sustainable for the future.

2.5.Supply Chain Compliance and Logistics Management

Compliance with supply chain regulations is a cornerstone of effective logistics and freight management, ensuring the uninterrupted and smooth flow of goods. Non-compliance can have severe repercussions, including costly delays, financial penalties, and harm to a company's reputation. Conversely, well-executed policy integrations can bolster safety, operational efficiency, and

sustainability in the transport sector. The significance of supply chain compliance spans across various facets of logistics, from legal adherence to efficient goods movement. Meeting local, national, and international regulations is paramount to avoid fines and legal disputes, while compliance with customs and safety laws streamlines transit, enhances customer satisfaction, and mitigates risks. Such compliance also embraces environmental stewardship, meeting emissions and sustainability standards which not only reduces a company's ecological impact but also bolsters its public image.

Moreover, compliance engenders trust among customers, indicating reliability and quality. This trust is foundational for establishing robust business relationships and customer loyalty. Efficient documentation, a key aspect of compliance, aids in tracking, reduces errors, and simplifies dispute resolution, ultimately contributing to cost savings through reduced liabilities and insurance premiums. Companies that prioritize and effectively communicate their compliance efforts often secure a competitive edge, particularly when consumers and partners prioritize transparency and social responsibility. In the digital age, compliance extends to data privacy and security, protecting sensitive information throughout the logistics process. Adherence to data protection laws safeguards the privacy and security of all stakeholders involved. In conclusion, integrating compliance policies into logistics and freight operations is not just a legal necessity but a strategic imperative underpinning the overall effectiveness and long-term sustainability of supply chain operations.

3. Banking and Sustainability

3.1.Control and Command Regulation in Sustainable Finance

Sustainable banking is a pivotal factor in promoting sustainable development within modern companies. Banks hold a unique position as intermediaries in the market, giving them a significant responsibility in facilitating sustainability (Beck et al., 2011; Chenyihsu & Whalley, 2012; United Nations, 2015; Yip & Bocken, 2018). Scholars have defined sustainable banking in various ways, but in this study, I adopt Yip & Bocken's (2018) definition, which views it as a financial service that enables customers to make profits while meeting their financial needs. A growing body of literature has highlighted the critical role of banking in promoting sustainability and the environment from various perspectives. For example, Úbeda-García et al., (2022) discuss the role of the financial sector in reducing income inequality and argue that sustainable banking can build bidirectional trust to overcome institutional weaknesses. Other studies emphasize the effective role of banking, particularly when funds are allocated to specific industries such as health or education, leading to equal opportunities and distributional impacts on different sectors of the economy (Demirgüç-Kunt, 2008; Meniago & Asongu, 2018).

In recent times, financial institutions across the world have been increasingly adopting novel methods of sustainable banking (Carè, 2018; Lehner, 2013; Weber & Feltmate, 2018). Scholars and practitioners have recommended a range of strategies to implement sustainable principles in various service sectors, such as managing energy consumption (Zaitseva et al., 2019), water conservation (Li et al., 2014), and waste reduction (Trung & Kumar, 2005). However, as the adoption and implementation of sustainable banking practices continue to expand on a daily basis, it is crucial to explore further how these practices can impact different sectors of the economy. These practices can be broadly categorized into regulations that are implemented by banks to encourage sustainable behavior among customers and incentives that sustainable banks offer to motivate their customers to adopt environmentally responsible practices. This study specifically identifies two categories of bank regulations: control and command regulations (CCR), which serve as guidelines for customers, and incentive regulations (IR), which offer financial incentives to encourage customers to adopt sustainable practices (Berg, 2005). Further research is needed to better understand the effectiveness of these regulations and incentives in promoting sustainable behavior among bank customers.

3.2.Incentives Regulations in Sustainable Finance

Incentive regulations are a significant tool for promoting sustainable banking practices and creating a more sustainable economy. Unlike control and command regulations, which provide guidelines for customers to follow, incentive regulations motivate customers to adopt sustainable methods by providing rewards. These regulations include promotions to join, reward packages for adopting sustainable methods, and financial packages for individuals and firms. The rewarding nature of incentive regulations creates satisfaction among customers and increases the probability of firms acting more sustainably. One of the primary benefits of incentive regulations is their ability to encourage customers to take ownership of their actions and become more environmentally conscious. By offering rewards and incentives for sustainable behavior, banks can create a sense of accountability among their customers, making them more likely to adopt sustainable practices. For example, some banks offer cashback rewards or reduced interest rates for customers who use their credit cards to make eco-friendly purchases, such as buying energy-efficient appliances or using public transportation. These types of incentives help customers see the tangible benefits of sustainable practices, which can encourage them to continue making eco-friendly choices in the future.

Incentive regulations also provide an opportunity for banks to differentiate themselves from competitors by promoting their commitment to sustainability. In a highly competitive banking industry, offering sustainable incentives can be a powerful marketing tool to attract environmentally conscious customers. This strategy can be particularly effective for banks targeting younger generations, increasingly focused on sustainability and social responsibility. By providing sustainable incentives, banks can demonstrate their commitment to environmental stewardship and engage with customers on a deeper level. Incentive regulations are essential for promoting sustainable banking practices and creating a more sustainable economy. By offering rewards and incentives for sustainable behavior, banks can motivate customers to adopt eco-friendly practices and increase their accountability for their actions. Additionally, banks can differentiate themselves from competitors and attract environmentally conscious customers by promoting their commitment to sustainability. As the demand for sustainable banking practices continues to grow, banks must continue to develop innovative and effective incentive regulations to meet the needs of their customers and promote a more sustainable future. Drawing on the preceding discussions, the governance nature of control and command regulations, which involves the provision of guidelines and restrictions, can have positive and negative impacts on the sustainable performance of companies. Hence, I propose that:

Hypothesis) *There is a positive/negative association between control and command regulations of central banks and sustainable transportation.*

4. Methodology and Data

4.1.Sample and Data

This research employs a variety of analyses to investigate the mandates and objectives of central banks, drawing on data from the Orbis Database. The financial and accounting information for listed transportation companies is sourced from the collective data of Eikon. To be included in the sample, transportation firms must have an ESG code recorded in the Bloomberg dataset and have a clear focus on green banking and sustainability. The central question of this study is whether there is an association between a transportation firm's ESG activities and the green legislation of European central banks. The analysis begins by sorting transportation data for European countries between 2012 and 2021, based on data availability. I then impose two criteria: (1) the transportation firms must be public companies, and (2) only four TRBC Industry Names can be selected: Courier, Postal, Air Freight & Land-based Logistics, Ground Freight & Logistics, Highways & Rail Tracks, and Marine Freight & Logistics. Initially, data on 136 transportation firms in 30 European countries were

included, but the sample was reduced due to a lack of financial data and ESG scores. Finally, the empirical analysis draws on data from 9 central banks and 15 freight companies operating in Europe and announced between January 1, 2012, and December 31, 2021. Table 1 shows the distribution of different types of TRBC industry names for all the freight firms in the sample, including country and central bank names.

[Insert Table 1]

The table presents a sample distribution of freight firms, classified by TRBC industry, country, and central banks. The study analyzes central bank mandates and objectives, focusing on the relationship between a transportation firm's environmental, social, and governance (ESG) activities and the green legislation of European central banks. To conduct the analysis, the study gathered financial and accounting data of listed transportation firms from the Eikon collective data and the Orbis database. The sample consists of transportation firms that have an ESG code included in the Bloomberg dataset and demonstrate a clear commitment to green banking and sustainability. The study restricted the sample to public companies belonging to four TRBC industry names, including Courier, Postal, Air Freight and land-based Logistics, Ground Freight and Logistics, Highways and Rail Tracks, and Marine Freight and Logistics.

The initial sample included 136 transportation firms in 30 European countries. However, due to a lack of financial data and ESG scores, the sample size was reduced, and the final empirical analysis was based on data from 9 central banks and 15 freight companies operating in Europe between January 1, 2012, and December 31, 2021. The table shows the distribution of the sample, indicating the number of freight firms classified by TRBC industry and country for each central bank. For instance, the Deutsche Bundesbank has data on 1 freight firm in the Courier, Postal, Air Freight & Land-based Logistics and 1 Marine Freight and Logistics category. Overall, the sample comprises 9 central banks, 5 courier, postal, air freight, and land-based logistics firms,1 ground freight and logistics firm, 1 highway and rail tracks firm, and 8 marine freight and logistics firms.

4.2.Measurement of independent variables

The profitability measures of ROA and ROE are widely used in the banking industry to evaluate the financial performance of banks. ROA represents the return earned on each dollar of assets, while ROE measures the return on the equity invested in a bank (Giuliani et al., 2023). Both measures are important indicators of a bank's profitability and are used by investors and analysts to

assess a bank's financial health. In the context of sustainable banking regulation, ROA and ROE can provide valuable insights into the relationship between sustainable banking practices and financial outcomes. For instance, a bank that implements sustainable practices may have a higher ROA and ROE compared to a bank that does not. This may be due to several factors, such as reduced operational costs from sustainable practices, increased customer loyalty due to the bank's commitment to sustainability, or access to sustainable investment opportunities that generate higher returns.

The concept of sustainable banking regulations has gained increasing attention in recent years, as there is growing recognition that banks can contribute to the achievement of environmental and social sustainability objectives. To better understand the impact of sustainable banking regulations on bank performance, this study examines a sample of 150 banks in Europe from 2012 to 2021. By adopting the approach Karim et al. (2021) proposed, I measure the influence of sustainable banking regulations on profitability, as indicated by ROA and ROE, and bank-specific characteristics. By examining the impact of sustainable banking regulations on profitability and bank-specific characteristics, this study aims to contribute to the ongoing discussion on sustainable banking practices and their implications for the banking industry.

4.3.Measurement of the dependent variable

This study examines the relationship between the ESG (environmental, social, and governance) performance of transportation firms and their financial activities. The ESG score used in this study is derived from the Bloomberg ESG database, which assesses a firm’s ESG performance based on its commitment and effectiveness. The validity and reliability of the Bloomberg ESG database have been established in previous literature (Albuquerque, 2020; Arouri et al., 2019; Demers & Gond, 2020; Ding et al., 2020; Fatemi et al., 2018;Yen & André, 2019).

The univariate analysis estimates the ESG score of transportation firms and compares it with the financial variables from the previous section. To measure ESG performance, I use data on ESG strengths and ESG concerns compiled and reported by KLD Research and Analytics, and I use Bloomberg's ESG disclosure score (DISC) to indicate the extent of a firm's ESG disclosure. The use of ESG data ratings as a proxy for a firm's CSR (corporate social responsibility) has been widely used in previous studies(Crotti & Maggi, 2022). Through univariate analysis, I examine the relationship

between the ESG score and various financial variables such as firm size, leverage, profitability, and growth.

4.4.Control Variables

In order to account for the sustainable ability of transportation firms, this study includes several control variables. One of the important firm-level control variables is firm size, which is a significant predictor of sustainable banking regulations. This study measures firm size as the natural logarithm of a firm's assets during the fiscal year. This measure is commonly used in previous studies as a control variable to account for the effect of firm size on various financial performance indicators. Another essential control variable used in this study is leverage, which is calculated as the long-term debt divided by total assets in the fiscal year. Leverage is an important factor to consider, as it may have a significant impact on a firm's financial performance and risk-taking behavior.

Moreover, the study also includes several other control variables to account for the impact of various factors on the financial performance of transportation firms. These include the ROA and ROE measures, which are commonly used financial performance indicators. In addition, the board size, total assets, net income, revenue, capital, and total equity are included as control variables, as they are essential factors that can influence a firm's financial performance. The study also considers the Corporate Social Responsibility (CSR) score as a control variable, which reflects a firm's commitment to social and environmental issues. Lastly, liability for freight companies plus the profit margin of central banks are included as other control variables, as they may have a significant impact on the performance of transportation firms. The inclusion of these control variables ensures that the observed effects of ESG performance on financial activities are not biased by the effects of other important factors.

4.5.Model Specification

In this study, the dependent variable is represented by ESG, which reflects the impact of sustainable banking regulations on transportation firms. The independent variable is the return on asset (ROA) of central banks, which is denoted in the below regression equation.

$$ESG_{it} = \beta_0 + \beta_1 ROA_{it} + \gamma Control Z_{it} + \delta_j + \varepsilon_{it} \quad (1)$$

Where i indexes firms, and t indexes years. The dependent variable, ESG, represents the influence of sustainable banking regulations for firm i in year t, while ROA $_{it}$ represents the return on asset (ROA) of central banks in the regression results for firm i in year t. Control Z_{it} is a vector to control the effects of other variables on the relationship between the independent variables and the dependent variable, including board size, firm size (log assets), leverage, ROA, ROE, total assets, net income, revenue, capital, Corporate social responsibility (CSR) score, total equity, and liability for freight companies plus profit margin of central banks. The control variables are valid for other models as well.

$$ESG_{it} = \beta_0 + \beta_1 ROE_{it} + \gamma Control Z_{it} + \delta_j + \varepsilon_{it} \quad (2)$$

Where i indexes firms, and t indexes years. The dependent variable, ESG represents the influence of sustainable banking regulations for firm i in year t, while ROE_{it} represents the return on equity (ROE) of central banks in the regression results for firm i in year t. Control Z_{it} is a vector to control the effects of other variables on the relationship between the independent variables and the dependent variable, including board size, firm size (log assets), leverage, ROA, ROE, total assets, net income, revenue, capital, Corporate social responsibility (CSR) score, total equity, and liability for freight companies plus profit margin of central banks.

The regression analysis is conducted using Ordinary least squares (OLS), which is a widely used method for estimating the relationship between a dependent variable and one or more independent variables. The model is estimated to test the hypotheses that investigate the effect of sustainable banking regulations on transportation firms' ESG performance. In addition to the independent variable, the control variable vector Control Z_{it} is used to account for the potential influence of other factors on the dependent variable. These control variables include board size, firm size (log assets), leverage, ROA, ROE, total assets, net income, revenue, capital, Corporate social responsibility (CSR) score, total equity, and liability for freight companies plus the profit margin of central banks. Furthermore, the same model is applied to the return on equity (ROE) of central banks in equation (2) to explore its effect on ESG. The control variables used in the model are the same as those in equation (1). Overall, the regression analysis allows for the examination of the relationship between the independent and dependent variables, while controlling for other factors that may affect the outcome.

Figure 1 shows the scatter plot for the independent and dependent variables combined over the period 2012 to 2021. The figures represent the mean calculated for each variable. As indicated in

the graphs, the mean is demonstrated as the horizontal axis. Panel A is the scatter plot of Central-Bank-ROA, panel B is the scatter plot for Central-Bank-ROE. Central-Bank-ROA, Central-Bank-ROE, Freight-ESG

[Insert Figure 1.]

Figure 1 illustrates the distribution of Central-Bank-ROA and Central-Bank-ROE for the central banks. It is a graphical representation that shows the frequency distribution of Central-Bank-ROA and Central-Bank-ROE values. The y-axis represents the values of Central-Bank-ROA and ROE, and the x-axis represents the value of Freight-ESG. Figure 1 identifies that the distribution of Freight-ESG is skewed to the right, indicating that most freight companies have higher values of ESG. The mean values of Central-Bank-ROA and Central-Bank-ROE are also higher than the median values, indicating that the distribution is positively skewed. Furthermore, I can also observe that there is a significant variation in the values of Central-Bank-ROA and Central-Bank-ROE among the central banks. This suggests that there are differences in the financial performance of these banks.

5. Empirical Results

5.1.Descriptive statistics

Table 2 displays the descriptive statistics for the variables utilized in the study, which have winsorized at the 1st and 99th percentiles to reduce the influence of outliers. The table presents the number of observations, measures of central tendency (mean, median), measures of variability (standard deviation, minimum, maximum, quartiles), and other relevant information for various financial and ESG (Environmental, Social, and Governance) variables of a sample of 150 firms. The variables include Central-Bank-ROA, Central-Bank-ROE, Freight-ESG, Freight-ROA, Freight-ROE, Freight-Board-Size, Freight-Total-Asset, Log-Freight-Asset, Freight-Net-Income, Freight-Leverage, Freight-Revenue, Freight-Capital, Freight-CSR, Freight-Total Equity, Freight-Liability, and CB-Profit-Margin (Appendix A). For instance, the mean of Freight-ESG is 36.86, and the standard deviation is 11.72. The minimum and maximum values for Freight-ESG are 13.82 and 53.94, respectively. Similarly, the mean of Central-Bank-ROA is 0.00, and the standard deviation is 0.01. The minimum and maximum values for Central-Bank-ROA are 0.00 and 0.02, respectively.

The table provides insights into the distribution and range of the variables. For example, the mean of Freight-ROE is 0.27, indicating that the sample firms have a median return on equity of 27%. The standard deviation of Freight-ESG is 11.72, indicating that the firms' ESG scores vary widely in

the sample. Overall, the table provides a summary of the sample data, which can be used to gain insights into the characteristics of the firms in the sample.

[Insert Table 2.]

Table 3 reports the pairwise correlation coefficients between 16 variables. The values in the table represent the strength and direction of the linear relationship between each pair of variables. The correlations range from -1 to 1, where -1 indicates a perfect negative correlation, 0 indicates no correlation, and 1 indicates a perfect positive correlation. For example, the correlation coefficient between Central-Bank-ROA and Central-Bank-ROE is 0.400, indicating a moderately positive relationship between the two variables. Similarly, the correlation coefficient between Freight-ESG and Central-Bank-ROE is -0.216, indicating a moderately negative relationship between the two variables. The table also shows that some variables are strongly correlated with each other, such as Freight-Total Equity and Log-Freight-Asset, which have a correlation coefficient of 0.964, indicating a strong positive relationship. On the other hand, some variables are weakly correlated, such as Freight-ESG and Freight-Total-Asset, which have a correlation coefficient of 0.001, indicating almost no relationship. The table includes asterisks to indicate statistical significance, with *** representing $p < 0.01$, ** representing $p < 0.05$, and * representing $p < 0.1$. These symbols show which correlations are statistically significant and can be used to determine which variables are strongly related to each other.

[Insert Table 3.]

5.2. Multiple Regressions of ESG and Results

The outcomes of the Ordinary Least Squares (OLS) regression analysis for the dependent variable, which is the FREIGHT-ESG, and its independent variables CENTRAL-BANK-ROA, Central-Bank-ROE are presented in Table 4.

[Insert Table 4.]

The first model (Model 1) includes only financial performance variables as control variables, while the second model (Model 2) adds Central-Bank-ROE independent variables. The third model (Model 3) adds one additional independent variable, CENTRAL-BANK-ROA. The intercept values are statistically significant in all three models, with p-values less than 0.05. In Model 1, Freight-ROA and Freight-ROE have significant positive coefficients, while in Model 2, Freight-ROA, Freight-

ROE, and Freight-CSR have significant coefficients. In Model 3, only Freight-ROA and Freight-CSR have significant coefficients. Central-Bank-ROE has a significant negative coefficient in Model 2, but not in the other models. Central-Bank-ROA does not have a significant coefficient in any of the models. CB-PROFIT-MARGIN has a significant negative coefficient in Model 3. The adjusted R-squared values for the three models are 0.409, 0.450, and 0.409, respectively. This indicates that the models explain between 40.9% and 45% of the variance in FREIGHT-ESG, with Model 2 performing slightly better than the other two models.

In Model (1), the intercept is statistically significant at a 99% confidence level (p-value < 0.001), which indicates that there is a significant linear relationship between the independent variables and FREIGHT-ESG. The coefficient of Freight-ROA is also statistically significant at a 99% confidence level (p-value < 0.001), indicating that there is a positive linear relationship between FREIGHT-ESG and Freight-ROA. However, the coefficients of the other independent variables are not statistically significant at conventional levels. The adjusted R-squared value for this model is 0.409, which indicates that the independent variables can explain about 40.9% of the variation in FREIGHT-ESG in this model.

In Model (2), Central-Bank-ROE is included as an independent variable, while Central-Bank-ROA is not included. The intercept and the coefficient of Freight-ROA are still statistically significant at a 99% confidence level. The coefficient of Central-Bank-ROE is statistically significant at a 99% confidence level (p-value < 0.001), indicating that there is a negative linear relationship between FREIGHT-ESG and Central-Bank-ROE. However, the coefficient of Freight-ROE is not statistically significant at conventional levels. The adjusted R-squared value for this model is 0.45, which is slightly higher than the adjusted R-squared value for Model (1).

In Model (3), Central-Bank-ROA is included as an independent variable, while Central-Bank-ROE is not included. The intercept and the coefficient of Freight-ROA are statistically significant at a 99% confidence level. The coefficient of Central-Bank-ROA is not statistically significant at conventional levels. The coefficient of Freight-ROE is statistically significant at a 95% confidence level (p-value < 0.05), indicating that there is a positive linear relationship between FREIGHT-ESG and Freight-ROE. The adjusted R-squared value for this model is the same as Model (1), which is 0.409.

Drawing upon the outcomes of the analysis presented in the three models, it is evident that certain independent variables exhibit statistically significant relationships with FREIGHT-ESG. In Model (1), the intercept and the coefficient of Freight-ROA are both statistically significant at a 99% confidence level, suggesting a positive linear relationship between FREIGHT-ESG and Freight-

ROA. This supports the notion of a substantial link between environmental, social, and governance factors and a company's return on assets. Moving on to Model (2), the inclusion of Central-Bank-ROE as an independent variable highlights a negative linear relationship with FREIGHT-ESG, as indicated by its statistically significant coefficient at a 99% confidence level. This finding aligns with the hypothesis of an inverse association between ESG and regulatory variables, further emphasizing the intricate interplay of these factors in shaping organizational performance. In Model (3), the addition of Central-Bank-ROA as an independent variable reveals that it is not statistically significant at conventional levels. However, the coefficient of Freight-ROE is statistically significant at a 95% confidence level, indicating a positive linear relationship between FREIGHT-ESG and Freight-ROE. This underscores the complexity of the relationships between environmental, social, and governance factors and financial performance metrics, warranting further investigation.

These results collectively highlight the significance of ESG considerations in understanding organizational performance and sustainability outcomes. The statistical significance observed in these models underscores the need for businesses to carefully consider and integrate ESG principles into their strategies, as they can have a discernible impact on financial metrics and overall sustainability.

6. Robustness Test

This section presents a summary of the outcomes of supplementary analysis and rigorous testing that were conducted to verify the robustness of the principal findings presented in the paper. The table shows the results of an ordinary least squares regression where the dependent variable is FREIGHT-ESG, and the independent variables are CENTRAL-BANK-ROA, CENTRAL-BANK-ROE, and several control variables related to freight firms' characteristics (such as Freight-Board-Size, Freight-Total-Asset, Log-Freight-Asset, etc.). The table presents three models, each with a different combination of independent variables, based on data from 13 central banks and 23 freight companies announced operating in Europe between January 1, 2017, and December 31, 2021.

[Insert Table 5.]

The results indicate that the coefficient of Central-Bank-ROE is negative and statistically significant in Model 2, which means that there is a negative association between command regulations of Central banks and sustainable transportation and robust with the previous result. The regression analysis conducted in this study examines the relationship between the command regulations of Central banks and sustainable transportation, specifically focusing on the coefficient

of Central-Bank-ROE in Model 2. The results reveal that the coefficient of Central-Bank-ROE is negative and statistically significant, suggesting that there is a negative association between command regulations of Central banks and sustainable transportation. This finding is robust with the previous result reported in the paper.

The negative coefficient of Central-Bank-ROE suggests that Central banks subject to higher command regulations may have lower levels of sustainable transportation practices. This result is essential for policymakers as it highlights the potential unintended consequences of command regulations on sustainability practices in the banking sector. Banks may prioritize compliance with regulations over investing in sustainable transportation practices, negatively impacting the environment. It is worth noting that the results of Model 2 are statistically significant and have a higher adjusted R-squared value than the other models, indicating that the inclusion of Central-Bank-ROE as an independent variable improves the overall explanatory power of the model. The results contribute to the literature on the impact of command regulations on sustainable practices in the banking sector and highlight the need for policymakers to carefully consider the potential unintended consequences of such regulations.

7. Contribution and Conclusion

This paper contributes to the literature on the relationship between central bank regulations and sustainable transportation practices. The study examines the impact of command regulations on sustainability practices in the banking sector, with a specific focus on the European freight industry. While previous studies have explored the relationship between sustainable regulations and corporate behavior in general (Dikau & Volz, 2019), this research sheds light on how control and command regulations can influence sustainable transportation performance. To the best of my knowledge, this study is the first of its kind that examines the relationship between bank regulations and sustainable transportation performance in the context of Central banks. By uncovering the impact of sustainable banking on transportation sustainability, this study emphasizes the need to implement a broader paradigm for achieving sustainable transportation by imposing sustainable regulation by central banks.

This study provides evidence of the negative impact of command regulations on sustainable transportation practices in the banking sector, specifically in the European freight industry. The study's findings suggest that central banks' command regulations may lead to banks prioritizing compliance over investing in sustainable transportation practices, which may have adverse effects on

the environment. Furthermore, the study's findings highlight the importance of sustainability practices in the transportation sector and the need to encourage banks to adopt sustainable practices. The results of this study have significant implications for policymakers, businesses, and investors interested in sustainable development. Policymakers need to recognize the potential unintended consequences of command regulations on sustainability practices in the banking sector and create an enabling environment for promoting sustainable practices. Banks need to realize that investing in sustainable transportation practices not only benefits the environment but also creates long-term value for their businesses by enhancing their reputation and improving their financial performance. Investors need to incorporate sustainability considerations into their decision-making processes, including the evaluation of banks' sustainability practices in the transportation sector.

This study provides a starting point for future research on the relationship between central bank regulations and sustainable transportation practices. Future studies should explore the relationship between sustainable regulations and sustainable practices in other industries and regions. Additionally, studies could investigate the impact of incentives on promoting sustainable practices in the banking sector. Finally, researchers could explore the effectiveness of different sustainability practices in achieving sustainable transportation in the context of Central banks.

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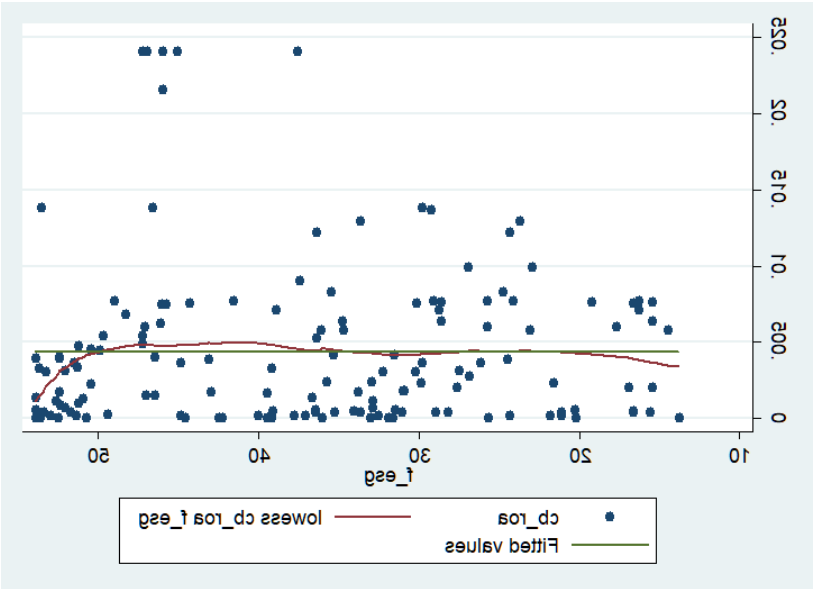
Figures

Figure 1.1: Distribution of ROA and ROE



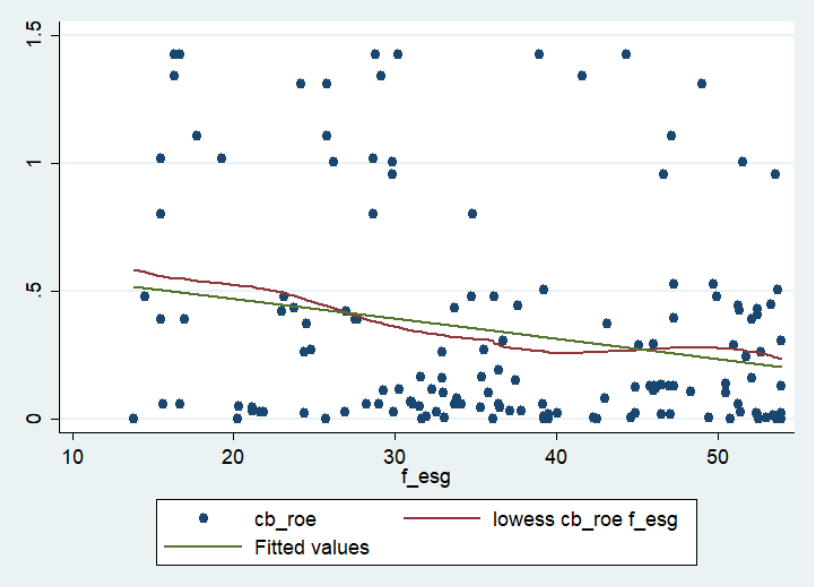


Figure 1 shows the scatter plot for the independent and dependent variables combined over the period 2012 to 2021. The figures represent the mean calculated for each variable. As indicated in the graphs, the mean is demonstrated as the horizontal axis. Panel A is the scatter plot of ROA, panel B is the scatter plot for ROE.

Tables

Table 1.1. Sample Distribution of freight firms, TRBC industry, country, and central banks

Row	Country	Central Bank Name	Courier, Postal, Air Freight & Land-based Logistics	Ground Freight & Logistics	Highways & Rail Tracks	Marine Freight & Logistics	Total
1	Austria	OESTERREICHISCHE NATIONAL BANK AG	1				1
2	Belgium	BANQUE NATIONALE DE BELGIQUE SA	1				1
3	France	BANQUE DE FRANCE			1		1
4	Germany	DEUTSCHE BUNDESBANK	1			1	2
5	Greece	BANK OF GREECE				3	3
6	Netherlands	NEDERLANDSCHE BANK NV (DE)	1				1
7	Norway	NORGES BANK				2	2
8	Switzerland	SCHWEIZERISCHE NATIONALBANK	1				1
9	United Kingdom	BANK OF ENGLAND		1		2	3
	Total		5	1	1	8	15

Table 1 represents the distribution of different types of TRBC industry names for all the freight firms in the sample, including country and central bank names. The vertical axis also represents the numbers of the freight firms for each country, and the horizontal axis represents the country, Central bank, and TRBC industry for the years of the sample from 2012-2021.

Table 1.2. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
Central-Bank-ROA	150	0.00	0.01	0	0.00	0.00	0.01	0.02
Central-Bank-ROE	150	0.34	0.42	0	0.03	0.13	0.44	1.43
Freight-ESG	150	36.86	11.72	13.82	28.69	36.47	47.15	53.94
Freight-ROA	150	0.05	0.06	- 0.08	0.01	0.05	0.08	0.20
Freight-ROE	150	0.27	0.33	- 0.11	0.05	0.15	0.33	0.93
Freight-Board-Size	150	10.13	4.05	6.00	7.00	8.00	13.00	20.00
Freight-Total-Asset	150	7,484.01	11,418.94	729.64	1,787.12	3,397.50	7,631.75	48,741.00
Log-Freight-Asset	150	3.58	0.47	2.86	3.25	3.53	3.88	4.69
Freight-Net-Income	150	351.72	713.49	-170.01	37.52	117.02	280.78	2,958.49
Freight-Leverage	150	0.29	0.18	0	0.15	0.32	0.41	0.64
Freight-Revenue	150	8,270.71	17,574.44	169.73	645.42	1,799.33	4,064.00	72,508.70
Freight-Capital	150	5,017.57	7,502.44	398.76	990.32	2,523.87	4,831.58	44,770.70
Freight-CSR	150	58.47	5.05	50.00	54.63	60.17	61.67	68.20
Freight-Total Equity	150	2,482.82	3,767.28	257.69	598.48	1,235.88	2,122.22	15,825.20
Freight-Liability	150	5,050.12	8,028.02	358.79	916.63	2,446.04	5,237.00	35,210.40
CB-Profit-Margin	150	0.48	0.29	0	0.20	0.53	0.68	0.98

Table 2 displays the descriptive statistics of the variables employed in the regression analysis. The sample consists of 150 public transportation companies involving central banks during the period of 2012 to 2021, which are extracted from Thomson Financials' EIKON, Orbis, and Bloomberg datasets. The table provides information on the number of observations, mean, standard deviation, minimum, and maximum values for each variable. The definition of all variables can be found in Table 1 of Appendix A.

Table 1.3. Correlation Matrix

Variables	Central-Bank-ROA	Central-Bank-ROE	Freight-ESG	Freight-ROA	Freight-ROE	Freight-Board-Size	Freight-Total-Asset	Log-Freight-Asset	Freight-Net-Income	Freight-Leverage	Freight-Revenue	Freight-Capital	Freight-CSR	Freight-Total Equity	Freight-Liability	CB-Profit-Margin
Central-Bank-ROA	1															
Central-Bank-ROE	0.400***	1														
Freight-ESG	0.001	-0.216***	1													
Freight-ROA	0.108	-0.395***	0.303***	1												
Freight-ROE	0.206**	0.243***	0.156*	0.085	1											
Freight-Board-Size	-0.034	0.171**	0.296***	-0.012	0.011	1										
Freight-Total-Asset	-0.057	-0.092	0.290***	0.133*	-0.06	0.734***	1									
Log-Freight-Asset	0.049	-0.200**	0.249***	0.142*	-0.08	0.551***	0.842***	1								
Freight-Net-Income	0.091	-0.130	0.321***	0.388***	0.067	0.574***	0.889***	0.700***	1							
Freight-Leverage	-0.173**	0.229***	-0.026	-0.350***	-0.12	-0.131*	-0.103	0.001	-0.264***	1						
Freight-Revenue	0.046	-0.105	0.304***	0.190**	-0.01	0.660***	0.955***	0.746***	0.924***	-0.263***	1					
Freight-Capital	-0.131*	-0.086	0.251***	0.085	-0.08	0.692***	0.937***	0.810***	0.799***	0.023	0.838***	1				
Freight-CSR	0.089	-0.178**	-0.206**	0.255***	0.029	-0.280***	0.079	0.057	0.232***	-0.151*	0.185**	0.037	1			
Freight-Total Equity	-0.090	-0.100	0.207**	0.158*	-0.05	0.714***	0.964***	0.817***	0.854***	-0.122	0.888***	0.951***	0.077	1		
Freight-Liability	-0.038	-0.084	0.329***	0.106	-0.07	0.718***	0.987***	0.824***	0.879***	-0.088	0.964***	0.907***	0.076	0.911***	1	
CB-Profit-Margin	0.737***	0.396***	-0.019	-0.104	0.108	0.062	-0.004	0.119	-0.025	-0.033	0.003	-0.062	-0.204**	-0.040	0.02	1

**** p<0.01, ** p<0.05, * p<0.1*

Table 3 reports the pairwise correlation coefficients between 16 variables. The sample consists of 150 public transportation companies involving central banks during the period of 2012 to 2021, which are extracted from Thomson Financials' EIKON, Orbis, and Bloomberg datasets. Central-Bank-ROA, Central-Bank-ROE, Freight-ESG, Freight-ROA, Freight-ROE, Freight-Board-Size, Freight-Total-Asset, Log-Freight-Asset, Freight-Net-Income, Freight-Leverage, Freight-Revenue, Freight-Capital, Freight-CSR, Freight-Total Equity, Freight-Liability, and CB-Profit-Margin. The definition of all variables can be found in Table 1 of Appendix A. The table includes asterisks to indicate statistical significance, with *** representing $p < 0.01$, ** representing $p < 0.05$, and * representing $p < 0.1$. These symbols show which correlations are statistically significant and can be used to determine which variables are strongly related to each other.

Table 1.4. Multiple Regression of ESG

Ordinary least squares Regression			
Dependent variable: FREIGHT-ESG			
Independent variable: Central-Bank-ROA & Central-Bank-ROE			
	Model (1)	*Model (2)*	*Model (3)*
Intercept	69.091***	72.907***	67.439**
	(0.000)	(0.000)	(0.002)
Central-Bank-ROE		-8.357***	
		(0.001)	
Central-Bank-ROA			-67.689
			(0.827)
Freight-ROA	79.164***	58.817**	79.051***
	(0.000)	(0.005)	(0.000)
Freight-ROE	6.087*	7.867**	6.088*
	(0.026)	(0.007)	(0.026)
Freight-Board-Size	0.243	0.6456	0.267
	(0.496)	(0.129)	(0.517)
Freight-Total-Asset	0.002	0.003	0.002
	(0.503)	(0.298)	(0.493)
Log-Freight-Asset	1.930	-1.692	2.220
	(0.578)	(0.634)	(0.56)
Freight-Net-Income	-0.001	0.000	-0.001
	(0.758)	(0.919)	(0.799)
Freight-Leverage	6.114	12.578	6.462
	(0.321)	(0.068)	(0.32)
Freight-Revenue	0.000	0.000	0.000
	(0.194)	(0.138)	(0.252)
Freight-Capital	0.001	0.001	0.001
	(0.101)	(0.057)	(0.116)
Freight-CSR	-.804***	-.734***	-.798***
	(0.000)	(0.000)	(0.000)
Freight-Total Equity	-0.006	-0.008	-0.006
	(0.142)	(0.066)	(0.146)
Freight-Liability	-0.002	-0.003	-0.002
	(0.618)	(0.351)	(0.597)
CB-Profit-Margin	-3.857	1.311	-2.945
	(0.240)	(0.726)	(0.628)
Observation	150	150	150
Adj R-squared	0.409	0.450	0.409

Table 4 reports the result of Ordinary least squares (OLS) regression for the dependent variable (FREIGHT-ESG) and independent variables (Central-Bank-ROE and Central-Bank-ROA). The sample consists of 150 public transportation companies involving central banks from 2012 to 2021, extracted from Thomson Financials' EIKON, Orbis, and Bloomberg datasets. Variables are defined in Appendix A. All variables are winsorized at the 1% and 99% levels and used Bonferroni adjustment to adjust the significance level. T-statistics are referred on standard errors adjusted for the autocorrelation and ∗, ∗∗, and ∗∗∗ represent statistical significance at the 10%, 5%, and 1% level, respectively. The table presents coefficients and t-statistics, and all the standard errors and P-values are reported in parentheses.

Table 1.5. Multiple Regression of ESG (Robustness test)

Ordinary least squares Regression			
Dependent variable: FREIGHT-ESG			
Independent variable: Central-Bank-ROA & Central-Bank-ROE			
	Model (1)	*Model (2)*	*Model (3)*
Intercept	56.477***	50.398***	54.762***
	(0.000)	(0.000)	(0.000)
Central-Bank-ROE		-14.127***	
		(0.000)	
Central-Bank-ROA			-585.751
			(0.066)
Freight-ROA	6.398	-27.801	5.212
	(0.751)	(0.178)	(0.802)
Freight-ROE	6.445**	11.378***	7.673**
	(0.009)	(0.000)	(0.002)
Freight-Board-Size	0.828**	1.639***	0.947***
	(0.003)	(0.000)	(0.001)
Freight-Total-Asset	-0.004**	-0.003*	-0.004**
	(0.002)	(0.014)	(0.007)
Log-Freight-Asset	1.317	-3.302	0.336
	(0.638)	(0.199)	(0.905)
Freight-Net-Income	.0057*	0.007	0.007*
	(0.048)	(0.055)	(0.032)
Freight-Leverage	-13.845*	0.356	-9.833
	(0.029)	(0.922)	(0.119)
Freight-Revenue	0.000	-0.000	0.000
	(0.472)	(0.884)	(0.551)
Freight-Capital	0.002*	0.001	0.001
	(0.031)	(0.112)	(0.063)
Freight-CSR	-0.442*	-0.2478	-0.400*
	(0.013)	(0.108)	(0.022)
Freight-Total Equity	0.001	0.001	0.001
	(0.306)	(0.302)	(0.532)
Freight-Liability	.004**	0.003*	0.003**
	(0.002)	(0.012)	(0.006)
CB-Profit-Margin	-0.038	0.061*	0.0136
	(0.255)	(0.046)	(0.746)
Observation	115	115	115
Adj R-squared	0.474	0.632	0.494

Table 5 reports the result of Ordinary least squares (OLS) regression for the dependent variable (FREIGHT-ESG) and independent variables (Central-Bank-ROE and Central-Bank-ROA). The sample consists of 115 public transportation companies involving central banks from 2017 to 2021, extracted from Thomson Financials' EIKON, Orbis, and Bloomberg datasets. Variables are defined in Appendix A. All variables are winsorized at the 1% and 99% levels and used Bonferroni adjustment to adjust the significance level. T-statistics are referred on standard errors adjusted for the autocorrelation ∗, ∗∗, and ∗∗∗ represent statistical significance at the 10%, 5%, and 1% levels, respectively. The table presents coefficients and t-statistics, and all the standard errors and P-values are reported in parentheses.

Appendix

Appendix A. Descriptions, Definitions, and Sources of Data

Variables	Descriptions and Definitions	Source of Data
Freight-ESG	Freight companies' Environmental, Social, and Governance scores contain three components that describe the performance of firms to reduce natural resources and energy. (Mussardo, 2019)	Bloomberg Finance L.P.
Central-Bank-ROE	Central bank return on equity is net profit divided by the equity in the recent year. (Chilale et al., 2018)	Orbis
Central-Bank-ROA	Central bank return on assets is net operating income divided by average target total asset in recent year. (Yang et al., 2019)	Orbis
Freight-ROA	Freight companies' return on assets is net operating income divided by the average target total assets in the recent year. (Yang et al., 2019)	Eikon
Freight-ROE	Freight companies' return on equity is net profit divided by the equity in the recent year. (Chilale et al., 2018)	Eikon
Freight-Board-Size	Freight companies' Board Size (Larmou & Vafeas, 2010)	Eikon
Freight-Total-Asset	Freight companies' Total Assets (Bourke, 1989)	Eikon
Log-Freight-Asset	The logarithm of freight companies' assets (Firm Size)	Orbis
Freight-Net-Income	Freight companies' Net Income (Skinner, 1999)	Eikon
Freight-Leverage	Freight companies' leverage (Agliardi et al., 2016)	Eikon/Orbit
Freight-Revenue	Freight companies' revenue (Endres et al., 2020)	Eikon/Orbit
Freight-Capital	Freight companies' (Lambert et al., 2007)	Eikon/Orbit
Freight-CSR	Freight companies' CSR Sustainability Reporting Score (Pisani et al., 2017)	Eikon/Orbit
Freight-Total Equity	Freight companies' Total Equity (Savastano et al., 2022)	Eikon/Orbit
Freight-Liability	Freight companies' Total Liabilities (Mengist et al., 2020)	Eikon/Orbit
CB-Profit-Margin	Central bank Profit Margin (Lichtenthaler, 2021)	Eikon/Orbit

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Chapter II.

Sustainable Transportation from an Accounting Perspective:

A Systematic Literature Review

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Sustainable Transportation from an Accounting Perspective:

A Systematic Literature Review

Abstract

Navigating the complexities of the 21st century requires an integrated approach to sustainable transportation and accounting principles; this Systematic Literature Review (SLR) aims to bridge the academic gap between these two essential domains. From an initial pool of 243 articles gleaned from prestigious databases, we narrowed our focus to 156 papers for in-depth review across multiple disciplines. Key findings include a growing academic interest in the intersection between accounting and sustainable transportation, evidenced by a shift towards more nuanced terminology. However, a glaring gap was identified: the need for robust theoretical frameworks cohesively linking these two fields. This absence is not merely an academic shortcoming but poses practical challenges, leaving practitioners without adequate guidance for effective integration. The SLR serves three primary objectives: to survey existing interdisciplinary research comprehensively, highlight significant yet overlooked research gaps, and suggest future research pathways that promise academic and practical enrichment. By offering rigorously researched insights with real-world applicability, this study aims to contribute meaningfully to the scholarly discourse and practical initiatives in sustainable transportation and accounting.

Keywords: Systematic literature review, Transportation, Sustainability, Accounting, Sustainable transportation, Accounting perspective, Environmental accounting, Social accounting, Economic accounting, Green accounting

JEL Classifications: Q56, R40, M41

1. Introduction

In the face of escalating environmental concerns and tightening regulatory frameworks, the intersection of sustainable transportation and accounting principles has become a crucial area of academic and practical interest. Sustainable transportation extends beyond environmental impact, encompassing significant economic and social dimensions that are crucial for societal well-being and justice. This integration with accounting, which has shifted from traditional bookkeeping to a focus on ethical governance and sustainability, is imperative yet underexplored in scholarly discourse (Lane, 2010). Despite the clear overlap and mutual benefits of these fields, there remains a surprising disconnect in academic literature, with few studies addressing the convergence of sustainable transportation practices and accounting principles. This Systematic Literature Review (SLR) aims to bridge this gap by employing a comprehensive, multi-decade analysis of literature from 1991 to 2023. Through thematic evolution mapping, we explore the shifting academic focus, revealing emerging trends that highlight 'accounting' and 'sustainable transportation' as increasingly significant areas of research. This approach not only traces the evolution of thought within these fields but also uncovers the nuanced ways they can inform and enhance each other, signaling a shift toward more integrated and holistic approaches.

One striking discovery from our study is the lack of robust theoretical frameworks that link accounting and sustainable transportation (Piatkowski et al., 2015). This isn't just an academic shortcoming; it's a real-world problem. Without sound theories, practitioners lack the guidance needed to integrate accounting and sustainable transportation effectively. Therefore, we see this as an opportunity for scholars and practitioners to collaborate on developing frameworks that not only stand up to academic scrutiny but also work in the real world. The present study seeks to address this gap through a systematic literature review (SLR) that investigates how sustainable transportation has been incorporated into accounting practices and identifies the theoretical underpinnings that have been utilized thus far. By doing so, this paper aims to highlight the academic and practical implications of this integration and suggest pathways for further research. The objectives of this SLR are layered. First, we aim to provide an exhaustive overview of existing research that intersects sustainable transportation and accounting principles. Second, we identify gaps that have been overlooked but have significant societal implications. Lastly, we suggest future research avenues that could enrich both academic knowledge and practical applications.

The conceptual framework guiding this study draws upon the principles of substitution dynamics within the broader realm of sustainable transportation, focusing on how shifts in transport modes and practices can be effectively captured and reported within accounting systems. This framework is crucial as it provides a structured lens through which the literature can be examined and understood. Our research methodology is as comprehensive as it is meticulous. The study's strategic selection of databases is based on renowned platforms such as Google Scholar, Web of Science, Scopus, Taylors & Francis, Springer, Science Direct, and Wiley Online Library. A combination of carefully defined keywords was used to sift through these databases, identifying a preliminary set of 243 articles based on the relevance of their titles. Through a stringent filtering process based on predefined inclusion and exclusion criteria, we narrowed this down to 156 papers for in-depth review and analysis. Our study includes a diverse spectrum of knowledge domains, including environmental science, engineering, energy studies, social sciences, business, and management. We employed in-depth thematic and inductive analyses, including thematic evolution mapping and co-occurrence network analysis, to scrutinize the literature. This analytical approach allowed us to explore the thematic evolution of research interests over time, establish thematic maps based on article titles, and construct a co-occurrence network based on the content within the abstracts of the selected articles. These analyses were instrumental in fostering a profound comprehension of the subject matter and facilitated the identification of novel insights that can guide future research endeavors.

Our research is driven by two primary questions: what is the current state of scholarly research at the intersection of sustainable transportation and accounting principles? This question seeks to uncover the body of existing literature, elucidating key themes and the evolution of discourse over time. And where do research gaps exist in the field of sustainable transportation from the perspective of accounting paradigms? This inquiry delves into identifying unexplored or insufficiently addressed areas within the existing literature, thus paving the way for future scholarly endeavors. The structure of this paper is designed for a comprehensive understanding. Following this introduction, we outline the research questions and methodologies that have guided our exploration. Then, we present the key findings that directly respond to our research questions. We also address the limitations of our study to provide a balanced view. We conclude by drawing out the theoretical and practical implications of our findings, offering a roadmap for future research

and real-world action. Through this SLR, we don't just aim to fill pages in an academic journal; we aim to catalyze change by offering rigorously researched insights that have real-world applications. In doing so, we hope to enrich both the academic landscape and practical efforts in the fields of sustainable transportation and accounting. This revised introduction aims to maintain academic rigor while also humanizing the text by emphasizing the research's real-world implications and broader societal context.

The paper is structured as follows: the second section outlines the research methodology, followed by a descriptive analysis of the selected articles in the third section. The fourth section categorizes and provides a detailed discussion of the existing work based on categorization criteria. The fifth section explores research trends and identifies gaps. In the sixth section, potential directions for future research are identified. Lastly, the paper concludes in the seventh section.

2. Conceptual Framework

2.1.Conceptual Framework and Substitution Dynamics

The presented conceptual framework for freight transport is a comprehensive blueprint that delves into the intricacies of substitution dynamics within the expansive realm of cargo movement (Edwards et al., 2021). This framework provides valuable insights and sheds light on its profound interplay with sustainable accounting and transportation practices. Within this dynamic ecosystem, stakeholders make critical choices related to mode selection, destination preferences, and the orchestration of complex "trip chains" (Baaij & Reinmoeller, 2018). These choices significantly influence freight transportation's environmental, social, and economic sustainability. As sustainability assumes a more prominent role in logistics and supply chain management, understanding how these substitution dynamics impact the selection of transport modes becomes imperative for sustainable accounting practices (Carter & Rogers, 2008; Seuring, 2013).

2.2.Sustainable Accounting Integration and Holistic Assessment

Within the domain of sustainable accounting, freight transportation emerges as a focal point. Lyu et al., (2023) suggest that sustainable accounting involves meticulous tracking and assessment, encompassing environmental metrics, social factors, and economic

considerations. It is a holistic endeavor that evaluates the impacts of diverse transport modes and decisions. Through sustainable accounting, stakeholders can quantify emissions, energy consumption, safety records, and economic viability, all of which contribute to a nuanced understanding of sustainability within freight transport (Jones, 2010; Zhong & Wu, 2015). Furthermore, this approach underscores the significance of safety, comfort, and attractiveness in destination selection, as these factors are integral components of sustainable accounting's preview.

The criticality of sustainable accounting in freight transport is further heightened when considering the repercussions of transport decisions on urban planning and infrastructure development (Chamseddine & Ait Boubkr, 2020; Mottee, 2022). As cities expand and seek to optimize traffic flow, the environmental and social impacts of freight movement become increasingly salient. Urban freight transport, specifically, presents a unique set of challenges and opportunities for sustainable accounting. The granularity of data required for effective urban freight planning necessitates comprehensive tracking systems and robust analytical tools. This allows for the assessment of not just the direct impacts of freight movement, such as emissions or noise pollution, but also the indirect effects, including urban congestion and the wear-and-tear on infrastructure. By incorporating these multifaceted considerations into their sustainable accounting frameworks, stakeholders are empowered to make more informed decisions that align with broader urban sustainability goals, such as reducing congestion and improving air quality. This integrative approach ensures that the freight transport sector contributes positively to the fabric of urban life, enhancing the livability of cities while maintaining the efficiency of supply chains (Santos et al., 2010).

2.3.Long-term Behavioral Transformations and Implications

The conceptual framework also elucidates long-term behavioral transformations driven by substitution dynamics. It sheds light on how stakeholders may gradually shift their preferences toward more sustainable transport modes and opt for locations with intermodal connectivity. These strategic choices represent a transition towards more sustainable freight transportation practices (Pamucar et al., 2022). Moreover, adopting sustainable transport modes as part of daily routines, beyond specific trip substitutions, reflects the profound impact

of lifestyle substitution choices. These dimensions within the framework collectively provide a foundation for research, policy development, and data-driven decision-making in pursuing more sustainable and accountable freight transportation practices. By recognizing the interdependencies among mode choices, destinations, trip chains, and sustainability considerations, the framework offers a structured path toward a more sustainable future in freight transport.

The ramifications of these behavioral shifts in freight transportation extend to global supply chain operations and the macroeconomic environment. As stakeholders increasingly prioritize sustainability, the ripple effects are observed in the reduction of greenhouse gas emissions, more efficient use of energy, and the promotion of a circular economy (Nika et al., 2020; Sasmoko et al., 2022). The evolution toward sustainable practices is also reflected in the development of green policies by governments and international bodies, incentivizing the adoption of low-emission vehicles and renewable energy use in transport. Furthermore, the expansion of research in this field provides critical insights into the effectiveness of various policies and stakeholder actions, contributing to a growing body of knowledge that supports the global imperative of sustainability. This symbiotic relationship between research, policy, and practice enriches the conceptual framework, fostering an environment where continuous improvement in sustainability is not just an aspiration but a practical objective (Medne & Lapina, 2019). It is through this iterative process of knowledge creation and application that freight transport can truly align with sustainable development goals, ensuring that the industry moves forward in a manner that is both economically viable and environmentally responsible.

[Insert Figure 1.]

2.4. Core Dimensions of Substitution Dynamics:

2.4.1. Mode Selection: Within this dimension, stakeholders engaged in freight transport meticulously weigh various transport modes, including road, rail, maritime, and others (Rodemann & Templar, 2014). A multifaceted interplay of factors, such as environmental impact, cost-efficiency, and capacity considerations, profoundly influences these decisions. When stakeholders assess various transport modes, they are faced with a complex decision matrix that extends beyond mere cost and

efficiency. The implications of these choices on environmental sustainability have become a paramount consideration. Emissions standards, fuel consumption rates, and even noise pollution are now critical metrics in mode selection. Furthermore, the emergent trend of incorporating social sustainability into transport logistics adds layers of community impact and worker well-being into the equation. Technological advancements, such as real-time data analytics and predictive modeling, are increasingly employed to enhance decision-making processes. These tools offer a more granular understanding of the trade-offs associated with each mode of transport, allowing for optimization that aligns with the principles of the triple bottom line: people, planet, and profit. Additionally, there is a growing recognition of the role of government policies in shaping the landscape of mode selection. Subsidies, tax incentives, and regulations are engineered to steer the industry toward a more sustainable trajectory (Chu et al., 2017; Westley et al., 2011). This policy intervention often aligns with international agreements on climate change and sustainability targets. As a result, stakeholders are not only incentivized to consider the immediate impacts of their mode choices but also their long-term alignment with a greener transport sector. This strategic approach to mode selection, underpinned by robust sustainability frameworks, is integral in charting a sustainable future for freight transport, reflecting a commitment to environmental stewardship and economic resilience.

***2.4.2. Destination Choices*:** The selection of destinations, a pivotal aspect of freight transportation, extends beyond mere geographic proximity. Sustainability considerations, including safety, accessibility, and community well-being, play an integral role in guiding these choices (Kent & Thompson, 2014; Wheeler, 2004). The selection of destinations is a strategic decision with multi-layered sustainability implications. Beyond geographic suitability, considerations now encompass a broad spectrum of sustainability criteria. Safety, a primary concern, demands rigorous assessment of transport infrastructure, ensuring that the routes to these destinations minimize the risk of accidents and facilitate secure cargo transit. Accessibility is another key factor, where ease of ingress and egress can significantly affect the environmental footprint through reduced congestion and idling times. Furthermore,

the impact on community well-being is increasingly scrutinized, with stakeholders considering how freight activities might affect local populations in terms of noise, air quality, and traffic. The importance of these factors is magnified when one considers the global push towards urban sustainability. Urban destinations require freight transport strategies that align with the principles of urban planning, supporting the development of green corridors and low-emission zones (Asekomeh et al., 2021; Lozzi et al., 2018). The integration of advanced technologies like Geographic Information Systems (GIS) and sustainable urban logistics models is instrumental in making informed decisions about destination choices. These tools enable a holistic view, factoring in the long-term urban development plans and environmental goals and ensuring that freight transportation contributes to, rather than detracts from, the overall sustainability of the urban environment. By incorporating these sustainability considerations into destination selection, freight transport stakeholders can contribute to the creation of more resilient and sustainable cities. This approach underscores the interconnectivity between freight transportation and broader societal goals, positioning the industry as a key player in the global effort to achieve sustainable development objectives.

2.4.3. Trip Chains: The intricate web of "trip chains" manifests as a manifestation of substitution dynamics. This involves a sequence of stops at various destinations within a single trip, introducing complexities in decision-making. The optimization of these trip chains has implications for resource efficiency and environmental sustainability. The concept of "trip chains" represents a sophisticated logistical challenge, with each link in the chain offering opportunities for efficiency gains and environmental impact reduction. The optimization of trip chains is not just about finding the shortest or quickest route but also involves strategic planning to consolidate cargo, reduce empty runs, and avoid congestion. The implementation of 'just-in-time' delivery systems and other lean logistical practices can significantly enhance the efficiency of trip chains, resulting in reduced fuel consumption and lower emissions (Chuah & Yingling, 2005). Moreover, the environmental sustainability of trip chains is greatly influenced by the use of intermodal transportation, which combines different modes of transport to leverage their respective strengths. For example, the integration of rail transport into

the freight journey can greatly reduce carbon footprint when compared to road-only transport, particularly over longer distances. Similarly, using electric or hybrid vehicles for the "last mile" delivery in urban areas can minimize local pollution and noise. The optimization of trip chains also requires real-time data and advanced analytics to adapt to dynamic conditions such as traffic patterns, weather disruptions, and changing customer demands. This agility in the logistics network enhances resource efficiency, ensuring that freight transportation can adapt and respond to the complex demands of modern supply chains while upholding the principles of environmental sustainability. The result is a more resilient transportation system that supports the long-term goals of reducing the industry's ecological footprint and contributing to a more sustainable future.

2.5.Sustainable Accounting Integration:

2.5.1. Environmental Metrics: Sustainable accounting within the freight transportation context delves into an exhaustive assessment of environmental metrics. This encompasses the meticulous quantification of emissions, energy consumption, and ecological footprints associated with each transport mode and decision. Such data forms the foundation for gauging the ecological sustainability of cargo movements. Environmental metrics serve as critical indicators for assessing the sustainability of transportation modes. These metrics encompass a wide array of data points, from carbon dioxide emissions and particulate matter release to energy efficiency and resource depletion rates. The quantification of these factors is essential for understanding the true environmental cost of transportation decisions and for identifying areas where improvements can be made. Advanced computational models and life cycle assessment tools are integral to this process, providing a comprehensive analysis of the environmental impacts from 'cradle to grave.' The importance of these environmental metrics is further emphasized by the increasing regulatory requirements and consumer demand for sustainable practices. Companies are encouraged to report on these metrics, driving a competitive advantage through demonstrated environmental responsibility. This data-driven approach facilitates the benchmarking of performance against industry standards and sustainability goals, pushing the entire sector towards more eco-friendly operations. The cumulative effect of these efforts is

a transportation industry that is more aligned with global environmental targets, such as those outlined in the Paris Agreement, contributing to the broader effort to mitigate climate change and preserve biodiversity.

2.5.2. Social Factors: Beyond environmental metrics, sustainable accounting extends its purview to evaluate social factors intricately linked to transportation choices. These factors encompass safety records, the creation of accessible and community-friendly transportation systems, and the well-being of individuals impacted by freight transport activities. In the sustainable accounting of freight transport, the assessment of social factors is of paramount importance, representing a comprehensive view that goes beyond environmental impacts to include the social dimensions of transportation choices. This holistic approach involves the thorough examination of safety standards within transport modes, striving to minimize accidents and ensure the protection of both workers and the public. It also considers the accessibility of transport systems, aiming to create inclusive logistics solutions that serve the community effectively and equitably. The evaluation of social factors also takes into account the overall well-being of individuals and communities affected by freight transport operations. This includes monitoring noise pollution, reducing congestion, and preventing the disruption of local ecosystems (Huntington et al., 2015). The aim is to design and manage transportation systems that are not only efficient but also enhance the quality of life for people in the vicinity of transport operations. Furthermore, the social aspects of sustainable accounting address the fair treatment and welfare of workers across the supply chain, from drivers and warehouse staff to administrative personnel. By integrating these social considerations into the decision-making process, stakeholders can ensure that freight transport systems contribute positively to society. This fosters a more responsible and ethical approach to logistics, reflecting a commitment to corporate social responsibility and supporting the United Nations Sustainable Development Goals, particularly those focused on human health, well-being, and decent work for all.

2.5.3. Economic Considerations: The financial dimensions of sustainable accounting scrutinize the economic sustainability of selected transportation modes and decisions. This entails an assessment of cost-efficiency, profitability, and the long-term viability

of the chosen freight transportation strategies. Within the framework of sustainable accounting for freight transportation, economic considerations hold a crucial role. The financial viability of transportation modes is closely examined, where cost-efficiency and profitability must be balanced with the long-term sustainability of the transportation strategy . This balance requires a detailed analysis of operational costs, including fuel, maintenance, labor, and infrastructure usage fees, in conjunction with the revenue generated by transport services. The economic analysis also extends to the assessment of the potential for cost savings through the adoption of sustainable practices, such as increased fuel efficiency or reduced tolls through eco-friendly transport choices. Moreover, the long-term viability of transportation strategies considers the evolving regulatory landscape, potential shifts in fuel prices, and the forecasted demand for freight services. It also encompasses the investment in and adoption of innovative technologies, which may present higher initial costs but offer long-term savings and environmental benefits. The strategic goal is to develop freight transportation systems that are not only environmentally and socially responsible but also economically sound, ensuring the sector's resilience and adaptability in the face of changing market conditions and global economic pressures. This comprehensive approach to economic sustainability in transportation decisions positions the industry to contribute positively to the broader economy while maintaining a commitment to sustainable development principles.

2.6.Influence on Sustainable Transportation:

2.6.1. Mode-Environment Nexus: The crux of sustainable transportation lies in the nexus between chosen transport modes and their environmental impact. Decisions regarding mode selection directly influence environmental sustainability, with far-reaching implications for emissions reduction, resource conservation, and ecological preservation. The interconnection between transport modes and environmental impact is a critical focus area for achieving sustainability in freight transportation. The selection of transport modes has a direct and measurable effect on emissions, necessitating a strategic approach that prioritizes low-impact options. This includes the integration of electric vehicles, optimization of maritime transport to leverage natural wind patterns, and increased reliance on rail, which generally has a lower

environmental footprint compared to road transport. Additionally, the push towards the use of alternative fuels, such as biofuels or hydrogen, reflects the industry's commitment to reducing greenhouse gas emissions. The conservation of resources extends to the efficient use of energy, where modal choices that optimize fuel consumption contribute to a more sustainable operation. Ecological preservation is also a key factor, where transport decisions are made with a consciousness of protecting biodiversity and minimizing the fragmentation of natural habitats. This nexus underscores the need for a systemic transformation in the transport sector, where environmental considerations are embedded in the core of logistical planning and operations, promoting a future where economic growth and environmental stewardship go hand in hand.

2.6.2. Destination Sustainability: Sustainable transportation practices are inherently tied to destination choices. Opting for destinations that prioritize safety, accessibility, and community well-being contributes to the creation of safer, more sustainable, and socially responsible transportation systems. The selection of destinations that adhere to sustainability principles is a testament to a transport system's commitment to social responsibility and environmental stewardship. Destinations that are designed with safety as a priority not only protect the well-being of the public and the workforce but also mitigate potential disruptions in the supply chain caused by accidents or hazardous conditions. Accessibility is another cornerstone of destination sustainability, ensuring that all members of the community benefit from the transportation infrastructure, including those with disabilities and those in underserved regions. Moreover, such inclusive practices bolster the efficiency of freight movement by facilitating smoother transitions between different transportation modes. The emphasis on community well-being ensures that transport systems contribute positively to local economies, enhance the quality of life, and minimize negative impacts such as pollution and noise. By integrating these considerations into destination planning and development, sustainable transportation practices foster the growth of communities that are resilient, thriving, and harmonious with their natural surroundings.

2.7. Long-term Behavioral Transformations:

2.7.1. Shifts in Mode Preferences: Substitution dynamics, when analyzed over time, can yield insights into the shifting preferences of stakeholders toward more sustainable transport modes. These shifts are indicative of long-term behavioral transformations driven by environmental and economic considerations.

2.7.2. Sustainability-Centric Operations: Corporations and logistics providers may strategically opt for locations with favorable intermodal connectivity. Such decisions, rooted in sustainability goals, represent a shift toward more sustainable freight transportation practices.

2.7.3. Lifestyle Substitution: The adoption of sustainable transportation modes as part of daily routines, even beyond specific trip substitutions, underscores the profound impact of these behavioral shifts. Lifestyle substitution choices have wide-reaching implications for both individuals and organizations, aligning with broader sustainability objectives.

2.8. Holistic Sustainability Assessment:

2.8.1. Comprehensive Analysis: The holistic approach of sustainable accounting endeavors to comprehensively analyze the multifaceted impact of substitution dynamics on environmental, social, and economic sustainability within the freight transportation sector.

2.8.2. Alignment with Sustainability Goals: Through rigorous assessment, sustainable accounting provides critical insights into the alignment (or misalignment) of transportation choices with broader sustainability goals and targets.

2.8.3. Quantification of Benefits: Sustainable accounting practices go beyond qualitative evaluations by quantifying the benefits of efficient trip chains and mode choices. This quantification allows for a data-driven approach to decision-making, supporting the pursuit of sustainability objectives.

2.9. Research and Policy Implications:

2.9.1. Data for Decision-Making: The insights gleaned from this framework provide a wealth of data for informed decision-making within the freight transportation sector. Such data can inform stakeholders, allowing them to make choices that align with sustainability goals.

2.9.2. Policy Formulation: Policymakers can draw upon the findings derived from sustainable accounting and substitution dynamics to formulate targeted policies that promote sustainable freight transportation practices.

2.9.3. Future Research Directions: The framework also serves as a launchpad for future research endeavors to deepen the understanding of sustainability and substitution dynamics within the context of freight transport. This ensures a continual evolution toward more sustainable and accountable freight transportation practices.

3. *Background and Research Questions*

3.1.Sustainability

Sustainability is a multi-dimensional, dynamic concept that goes beyond mere endurance over time. It demands a holistic understanding and concerted efforts across different sectors and disciplines to realize its full potential for enhancing the quality of life globally. There are different definitions of sustainability. Sustainability is the capability of a set-up to carry out or develop the condition and accessibility of desired affairs or states over a long period (Harrington, 2016). Mainly, sustainability is not the main part of a business for companies, but it is essential for them to observe and consider the relationship between their activities and emissions for both internal and external customers(Løkke & Madsen, 2023). According to(Sharma & Singh, 2020), economic, environmental, and social are three major dimensions of sustainability. Transportation (freight transportation), which consists of a dynamic network, has linked social, economic, and environmental factors with resources and human mobility(Bao et al., 2023). Adding further nuance to the discourse on sustainability are its tripartite dimensions: economic, environmental, and social, as outlined by Sharma & Singh (2020). Each of these dimensions is interdependent and requires a balanced approach for genuine sustainability to be achieved. For instance, an economic model that disregards environmental responsibility may offer short-term gains but is likely unsustainable in the long run due to resource depletion and environmental degradation.

Moreover, the complexity of sustainability is exemplified in the realm of transportation, which acts as a nexus connecting various facets of human life (Bao et al., 2023). The transportation sector is a dynamic network that has far-reaching implications not just for human mobility but also for resource allocation, social equity, and environmental conservation. It serves as a microcosm that encapsulates the intricate relationships among the three major dimensions of sustainability. It

is also important to consider that sustainability is not a static concept; it evolves in response to technological advancements, policy changes, and shifts in public awareness. The landscape of sustainability is continuously reshaped by innovation in renewable energy, advancements in waste management, and the emergence of sustainable agriculture practices, among other factors. Furthermore, the concept of sustainability has also permeated educational systems, shaping curricula and pedagogical approaches to foster a generation equipped with the knowledge and skills necessary to navigate the complexities of a sustainable future. Thus, sustainability is not merely an academic or corporate concern but a societal imperative that requires a multi-disciplinary, collaborative approach.

3.2.Sustainable Transportation

It is widely acknowledged that sustainable development, particularly in the context of transportation, involves achieving an appropriate equilibrium among environmental, social, and economic factors, both in the present and the future (e.g., (OECD, 1996); (Steg & Gifford, 2005); (Litman, 2008)). Consideration of sustainability aspects has increased during the last two decades in transportation due to environmental problems and social growth (Aloui et al., 2021). A study by (Bao et al., 2023) shows that since 2015, there has been a fast growth of studies in the field of sustainable transportation. Sustainable transport plays a pivotal role in sustainable development by striving for universal access, improved safety, minimized environmental impact, increased resilience, and enhanced efficiency (UN, 2021). Therefore, sustainable transport is crucial for realizing the objectives outlined in the 2030 Agenda for Sustainable Development and the Paris Climate Change Agreement. To facilitate sustainable transport projects, it is important for national and sub-national governments to establish effective governance structures, encourage transparent fiscal accounting practices, and actively support financially viable initiatives (UN, 2021).

3.3.Sustainability in Accounting

The term "sustainability accounting" is widely used but lacks a clear and consistent definition, and in many cases, sustainability accounting is used interchangeably with terms like environmental accounting or reporting (Schaltegger & Burritt, 2010). Sustainability accounting encompasses the measurement and disclosure of an organization's economic, environmental, and social impacts, as well as the management of environmental and social resources, with a focus on

creating long-term value and addressing sustainability challenges (SASB, 2017). Accountability and transparency have emerged as crucial prerequisites for fostering collaborative and positive engagement of employees, customers, the financial community, and civil stakeholders in a society where companies are increasingly expected to showcase their commitment to sustainability (Schaltegger & Burritt, 2010).

Both paths: the critical path, which identifies sustainability accounting as a source of problems and emphasizes the need for awareness, and the managerial path, which views sustainability accounting as a solution provider and focuses on decision-making tools, must be pursued for sustainability to move beyond awareness and effectively address problems(Burritt & Schaltegger, 2010).

4. Research Question

As far as our understanding extends, a void exists in the realm of systematic literature reviews concerning sustainable transportation when viewed through the accounting lens. This article endeavors to bridge this gap by embarking on a comprehensive systematic literature review centered on sustainable transportation from the vantage point of accounting principles and practices. The overarching objective of this inquiry is to address the following two pivotal research inquiries:

Primarily, an exploration is undertaken to discern the landscape of extant endeavors and prevailing research trajectories concerning sustainable transportation, all examined through the prism of accounting perspectives. The primary aim is to uncover the corpus of existing scholarly undertakings in this intricate intersection, elucidating the foundational works and capturing the evolving trends that have emerged over time. This imperative assessment offers a holistic comprehension of the present scholarly discourse within the realm of sustainable transportation, drawing insightful connections between sustainability concerns and accounting frameworks.

Furthermore, this investigation rigorously probes into the panorama of research lacunae that persist within the sustainable transportation domain underpinned by accounting paradigms. By diligently identifying gaps that persist in the current scholarly discourse, the endeavor seeks to shed light on hitherto unexplored avenues that await rigorous inquiry. In tandem with these

revelations, the inquiry is poised to offer prospective contributions that could shape the trajectory of future scholarly undertakings. This discernment of potential research directions enriches the existing academic dialogue and serves as a clarion call for continued explorations to advance the nexus between sustainable transportation and the nuances of accounting principles.

With all the above explanations, this research asks:

1. **What is the current state of scholarly research at the intersection of sustainable transportation and accounting principles?**
    - This question aims to comprehensively assess existing literature and research trajectories in the context of sustainable transportation, viewed through an accounting lens. It seeks to identify foundational works, evolving trends, and connections between sustainability concerns and accounting frameworks within this domain.
2. **Where do research gaps exist in the field of sustainable transportation from the perspective of accounting paradigms?**
    - This question delves into identifying research gaps within the realm of sustainable transportation, particularly in the context of accounting principles and practices. It seeks to uncover areas that remain unexplored or underrepresented in the current scholarly discourse, thus providing potential directions for future research.
3. **How can prospective contributions in the nexus of sustainable transportation and accounting principles shape future scholarly endeavors?**
    - This question explores the potential impact of the study's findings on the broader academic dialogue. It aims to understand how insights derived from the systematic literature review can inform and influence future research directions, emphasizing the dynamic interplay between sustainability imperatives and accounting scholarship in the context of transportation.

These research questions align with the overarching objective of the inquiry, which seeks to bridge the gap in systematic literature reviews related to sustainable transportation through an

accounting perspective and advance scholarly exploration in this field. The present study endeavors to transcend the existing boundaries of scholarly exploration by conducting a meticulous, systematic literature review that delves into sustainable transportation and accounting interplay. Through this endeavor, it aspires to unravel existing works, deciphers ongoing research trends, and unveil the uncharted frontiers that beckon scholarly investigation, thereby accentuating the dynamic interplay between sustainability imperatives and the realms of accounting scholarship.

5. Research Methodology

5.1. Formulation and Keyword Definition

To address the research questions outlined in the preceding section, a systematic literature review (SLR) was conducted to offer a thorough and comprehensive analysis of the current state of knowledge. The SLR methodology employed in this study follows the guidelines Durach et al. (2017) put forth for conducting SLRs in the field of supply chain management. The study methodology encompasses six distinct steps:

(i) formulating the search question and selecting appropriate keywords,
(ii) establishing inclusion and exclusion criteria,
(iii) conducting database searches,
(iv) selecting relevant papers,
(v) analyzing the results, and
(vi) reporting the findings.

The following sequential procedures constitute the study's methodological framework:

(i) Formulation of the Search Question and Selection of Appropriate Keywords: At the outset, a precise and focused research inquiry is formulated, while concurrently, suitable keywords are selected. These keywords are pivotal in facilitating efficient and comprehensive database searches, ensuring the retrieval of relevant literature corresponding closely to the research domain.

(ii) Establishment of Inclusion and Exclusion Criteria: Explicit inclusion and exclusion criteria are defined, delineating the scope of the study. This involves the stipulation of criteria determining the eligibility of scholarly works for potential inclusion in the review. Simultaneously,

criteria for exclusion are delineated to ensure the incorporation of literature that meets predefined quality and relevance standards.

(iii) Conducting of Database Searches: The phase of database searches entails systematically exploring relevant academic databases and repositories. Utilizing the curated set of keywords, scholarly sources such as peer-reviewed journals, conference proceedings, and academic databases are systematically combed through in pursuit of literature aligning with the research themes and objectives.

(iv) Selection of Relevant Papers: Following the exhaustive database search, the process of selecting relevant papers is initiated. The amassed literature is rigorously scrutinized to ascertain alignment with predefined inclusion criteria. Each potential candidate undergoes meticulous assessment for pertinence, academic rigor, and thematic congruence. The outcome of this curation phase results in the identification of works qualifying for subsequent analysis.

(v) Analysis of the Results: The analytical phase is undertaken upon assembly of a judiciously curated selection of literature. The identified papers are systematically and rigorously evaluated, dissecting thematic patterns, theoretical perspectives, and methodological nuances. This process yields an integrative understanding of the collective body of literature, facilitating the extraction of key insights, trends, and research gaps.

(vi) Reporting of the Findings: The ultimate stage of the methodology involves the comprehensive reporting of findings derived from the analytical exploration. A coherent and structured presentation of salient outcomes, including synthesized interpretations, emergent themes, and implications, is crafted. This synthesis contributes to scholarly discourse, offering a nuanced understanding of the research domain and paving the way for informed discussions and future investigations.

Collectively, these meticulously orchestrated steps underpin the methodological framework, ensuring the rigor, coherence, and scholarly integrity of the study's research methodology.

[Insert Figure 2.]

In the realm of conducting a systematic literature review (SLR), the initial step involves the precise formulation of research inquiries that will guide the exploration. For this particular endeavor, our primary focus centers on comprehensively understanding the existing knowledge landscape about sustainability, with a specific emphasis on integrating sustainable accounting principles within the dynamic landscape of the transportation sector. Establishing a refined set of keywords becomes imperative to align with the overarching research objectives effectively. We propose the organization of keywords into three distinct categories, each contributing strategically to guide the trajectory of our inquiry.

The first category comprises pivotal keywords that anchor our study in the heart of the transportation domain, capturing the essence of sustainable transportation. Keywords such as "Transportation" and "Sustainable Transportation" are intended to encapsulate the core theme of our exploration. Moving beyond, the second category delves into the intricate interplay between accounting principles and sustainable practices. This category encompasses terms such as "Accounting," "Sustainable Accounting," "Accounting Perspective," "Environmental Accounting," "Social Accounting," "Economic Accounting," and "Green Accounting." These nuanced terms collectively reflect the multifaceted dimensions of accounting frameworks that intersect with the realm of sustainability. Lastly, the third category culminates with the term "Sustainability," a unifying concept underpinning our research. Through these meticulously chosen keywords, we embark on a structured journey, navigating through the scholarly landscape to derive meaningful insights at the crossroads of sustainability, transportation, and accounting perspectives.

5.2. Conducting a Systematic Literature Review

In spite of the relatively nascent status of the systematic review (SR) field, a commendable methodological framework has emerged, as elucidated by Tranfield et al. (2003). Per the extant scholarly discourse, initiating a systematic review entails a series of iterative processes involving the definition, elucidation, and refinement cycles. The operationalization of a systematic review entails traversing several distinct phases. The inaugural phase, denoted as the planning stage, encompasses the determination of the imperative need for a review, the formulation of a comprehensive proposal, and the formulation of a meticulously detailed review protocol.

Subsequently, the executing phase entails a multifaceted endeavor, encompassing the identification of pertinent scholarly research, the judicious selection of relevant studies, the rigorous evaluation of the quality of these selected studies, and the scrupulous extraction and subsequent analysis of data. The culmination of this arduous undertaking resides in the reporting and dissemination phase, wherein the researcher proffers a comprehensive report alongside insightful recommendations. This, in turn, paves the way for the ultimate integration of the acquired evidence into practical application, as envisioned by Tranfield et al. (2003).

It should be noted that various methodological paradigms are available to approach the process of systematic review, ranging from the evidence-based review method posited by Thorpe et al. (2005) to the more specialized domain of content analysis, as elucidated by Gaur and Kumar (2018). In the present evaluative endeavor, a conceptual framework is harnessed, and a corpus of 1183 published articles is subjected to scrutiny. This comprehensive investigation is conducted through the rigorous execution of a systematic literature review (SLR) methodology, with the overarching goal of addressing pertinent research inquiries.

5.3.Inclusion/exclusion criteria

Alongside the keywords meticulously established in the initial phase, a distinct set of inclusion and exclusion criteria has been crafted to refine the scope of the literature search and pinpoint articles of primary relevance. These criteria play a pivotal role in steering the direction of the research inquiry, shaping the trajectory of the study's exploration. A comprehensive elucidation of the criteria employed in this search can be found in Table 1, encompassing the multifaceted considerations that guide the selection of literature for this study. By formulating a set of criteria that intricately aligns with the research objectives, the study ensures a methodical and focused approach to sourcing scholarly materials. These criteria collectively serve as a compass, aiding in identifying articles that harmonize closely with the thematic intersections of sustainable transportation and accounting principles. Initially, we began with a dataset encompassing information from 243 scholarly articles. Following a meticulous screening process, which excluded articles falling under the categories of conference proceedings, reviews, and book chapters, our dataset was refined, resulting in a subset of 155 articles.

Our selection criteria were rigorous and included the following parameters: articles had to be available in full-text, published within the timeframe spanning from January 1991 to September 2023, composed in the English language, peer-reviewed, and situated within the intersecting realms of Transportation, Sustainability, and Accounting. Furthermore, these articles were specifically chosen to explore topics related to firm performance, managerial performance, and the various economic channels through which these aspects are intertwined, as expounded upon by Afzal et al. (2009).

[Insert Table .]

5.4.Data Search

In this particular phase of our methodology, we have meticulously outlined three successive sub-steps, each of which contributes to the comprehensive execution of our research approach. The first sub-step entails a deliberate and strategic selection of databases that will serve as repositories for collecting relevant scholarly materials. Among these chosen source databases are renowned platforms such as Google Scholar, Web of Science, Scopus, Taylors & Francis, Springer, Science Direct, and Wiley Online Library. These repositories collectively encompass a diverse array of scholarly resources that align with the purview of our study.

Subsequently, proceeding to the next sub-step, we initiated the data search process across the identified databases. This endeavor involved a judicious combination of the keywords meticulously defined in our methodology's preceding phase. By harmoniously amalgamating these keywords, we explored the databases extensively, meticulously sifting through the available literature to identify materials that resonate with the core objectives of our study. During this literature search phase, we initiated the identification process by evaluating the relevance of article titles by the contextual underpinnings of our research endeavor. Through this iterative process, a preliminary set of articles emerged as potential candidates for further consideration and analysis, marking a significant stride in the progression of our study. During the literature search phase, we identified an initial collection of articles based on the relevance of their titles to the study's context. A total of 243 articles were identified during this phase.

5.5.Selecting relevant papers

To streamline the extensive database compiled in the preceding stage and to undertake a comprehensive yet manageable review, a filtering process was employed employing the predefined inclusion/exclusion criteria. This step assumes significance in pinpointing the studies of utmost relevance, thereby eliminating those that do not align with the focal points of our investigation. During the selection phase, each article was thoroughly perused in its entirety, supplemented by an examination of the reference lists for each article. Moreover, to ensure a thorough exploration, we identified the key authors who have contributed significantly to the discourse of sustainable accounting within the transportation realm. A subsequent search, rooted in their names, was carried out to incorporate any relevant materials that might have eluded the initial database compilation. As a result of these meticulous efforts, a compilation of 89 papers emerged as the selected corpus for in-depth review and analysis, encapsulating the studies that best resonate with the scope and objectives of our research.

In addition to this rigorous approach, a supplementary strategy was implemented to ensure a robust and exhaustive landscape coverage. Specifically, to amplify the inclusiveness of our literature pool, a targeted identification of eminent scholars pivotal to the discourse of sustainable accounting within the transportation sector was initiated. A subsequent exploration, grounded in the works authored by these esteemed contributors, was executed with meticulous precision, thereby affording the incorporation of any pertinent materials that might have eluded the initial database curation. Noteworthy is the endeavor's commitment to encompassing a diverse spectrum of knowledge domains, spanning environmental science, engineering, energy studies, social sciences, business, and management, among other facets. This calculated approach enriched the selection process by encapsulating a multifaceted repository of scholarly contributions. As a culmination of these methodological undertakings, an aggregate of 156 meticulously chosen papers emerged as the final corpus, designated for comprehensive scrutiny, analysis, and synthesis in alignment with the delineated research objectives. To further elucidate the meticulous refinement process, a deliberate inclusion criterion necessitated selecting pertinent studies from peer-reviewed articles. This exclusion of conference papers, book chapters, reviews, and conference reviews were motivated by the intention to prioritize scholarly contributions that embody a higher degree of depth, rigor, and comprehensive exploration. Such a discerning

approach sought to curate a collection of literature that upholds scholarly integrity and substantive inquiry, thus aligning coherently with the scholarly underpinnings of this research endeavor.

5.6.Inductive Analyses

Within this section, a comprehensive application of thematic analysis is undertaken to scrutinize the manner in which keywords, titles, and abstracts are systematically categorized and mapped across various protocols in this study, as elucidated by Clarke et al. (2013). The dataset was meticulously scrutinized, allowing the formulation of theories and conceptual frameworks. Notably, the process of inductive analysis, a fundamental component of systematic literature review (SLR), was employed to discern prevailing patterns and themes inherent in the data. This method entailed the systematic collection of data, followed by the segmentation of the data into discrete units or categories, each appropriately labeled or "coded." Subsequently, intricate data analysis was executed, culminating in the constructing of a theoretical and conceptual framework, as posited by Tark et al. (2023).

The utilization of inductive analysis is instrumental in fostering a profound comprehension of the subject matter, thereby facilitating the identification of novel insights and knowledge that can subsequently serve as a wellspring of guidance for future research endeavors, as Conz and Magnani (2020) underscored. Moreover, the inductive analysis process was methodically subdivided into three distinct dimensions: firstly, the exploration of thematic evolution through chronological time mapping; secondly, the establishment of thematic maps through an examination of article titles; and thirdly, the construction of a co-occurrence network predicated on the content encapsulated within the abstracts of the selected articles.

5.7.Thematic Analyses

These analyses are powerful tools within a systematic literature review, offering insights into the historical development of research themes, providing a thematic overview of selected articles, and facilitating a deeper understanding of conceptual relationships within the literature. By leveraging these analytical approaches, researchers can conduct more rigorous and structured reviews, enhancing the process's systematic nature and producing more comprehensive and insightful literature reviews.

5.7.1. Thematic Evolution Chronological Time Mapping (Authors' Keywords): This analysis provides a chronological perspective on the evolution of themes or topics within academic literature. It allows researchers to identify how research interests and focus areas have shifted over time. A systematic literature review can be invaluable for understanding historical context, tracking the development of key research themes, and identifying gaps or trends in the field. By visualizing the changing landscape of research topics, researchers can better structure their literature review to provide a comprehensive and historical overview of the subject matter.

[Insert Figure 3.]

5.7.2. Thematic Map (Title of Selected Articles): Thematic mapping of article titles offers a clear snapshot of the major themes and subjects covered within a collection of academic articles. For systematic literature reviews, this analysis helps researchers categorize and prioritize articles based on their thematic relevance. It aids in the initial screening process by identifying articles that align closely with the review's research questions or objectives. Consequently, it streamlines the selection of articles that warrant more detailed examination, contributing to the systematic nature of the review by ensuring that the chosen articles are closely aligned with the predefined criteria and research focus.

[Insert Figure 4.]

5.7.3. Co-occurrence Network Analysis (Abstracts): Co-occurrence network analysis explores relationships between terms within abstracts, illuminating connections between concepts. In a systematic literature review, this analysis can assist in identifying key concepts and their interrelationships. By visualizing these relationships as a network, researchers gain insights into the core ideas and how they are connected across a body of literature. This aids in organizing and categorizing articles based on their conceptual content. It also identifies central concepts that should be thoroughly investigated in the review. Co-occurrence network analysis enhances the systematic literature review by providing a structured approach to conceptual mapping and

analysis. This ensures that the review comprehensively covers the relevant topics and their associations.

[Insert Figure 5.]

6. Results and Descriptive Findings

The results in Figure 3 show the Thematic Evolution Chronological Time Mapping analysis with insightful trends in research themes over time. Spanning multiple years, the analysis identified key themes and their temporal evolution. Prominent themes consistently appeared, reflecting their enduring significance in the research domain, while emerging and declining themes offered a dynamic perspective on evolving trends. Connections and overlaps between themes underscored the interconnected nature of research topics. Importantly, these findings closely aligned with the study's research questions, providing valuable insights into how research focus areas have evolved, thus enhancing our understanding of the field's development. Figure 3 provides a compelling visual representation of the prevailing keyword trends in the research landscape. Notably, it underscores the enduring significance of keywords such as biomass, sustainability, CO2 emissions, sustainable development, and urban metabolism, which exhibited a consistent upward trajectory in popularity from 1991 to 2018. These themes have evidently maintained their relevance over an extended period. In contrast, a noticeable shift in keyword prominence occurred from 2019 to 2023, with a strong emergence of terms like sustainable development, ESG (Environmental, Social, and Governance), sustainable assessment, sustainability, and CO2 emissions. This shift highlights the dynamic nature of research interests in recent years, reflecting the evolving priorities in the scholarly discourse. Moreover, Figure 3 delves deeper into the intricate web of relationships among these keywords, shedding light on how they interconnect within studies conducted during the two distinctive periods. This analytical division, grounded in the frequency of keywords, provides a valuable lens through which to explore the evolving research landscape. By discerning the shifting patterns in keyword prominence and their interplay between the periods of 1991-2018 and 2019-2023, researchers gain a comprehensive understanding of the dynamic nature of research within this domain.

Within our analysis framework, Figure 4 takes on an alternative conceptual structure, illuminating significant periods in the thematic mapping of selected article titles. Drawing upon

the research conducted by Khare and Jain (2022), we have discerned four distinct thematic clusters within this visual representation. These clusters encapsulate various dimensions of research focus, each characterized by its degree of development and relevance. As we delve into each theme, we uncover intriguing patterns that shed light on the evolution of research interests and their intersections in the scholarly discourse. Let's explore these four themes in detail:

- **Basic Themes**:
    - Highly relevant but less developed themes.
    - Includes keywords like "carbon," "emission," "urban," and more.
    - Bubble size represents word proportion in abstracts.
    - The main focus of the studies is characterized by more central bubbles.
    - The focal point is "Waste."
    - Strong emphasis on digitalization, digital transformation, and related fields.
    - Keywords include "cycle," "life," "road," "management," "finance," and "research."
    - Indicates a rising focus on sustainability in the transportation sector.
- **Emerging or Declining Themes**:
    - Reflect a new phase of research growth.
    - Introduce new interests like "settings" and "comparison index."
    - Incorporate concepts like "effect" and "systematic."
    - Evidenced by a surge in articles focusing on "intelligence" and diverse "strategies."
- **Niche Themes**:
    - Comprising a single bubble, discussing "Vehicle," "Bioenergy," and "Method factors."
    - The highest occurrence is for "adaptation" (about 32 articles), suggesting integrating sustainable factors into various economic strands.
    - Characterized by lower bubble density and centrality.

These four thematic categories provide a comprehensive overview of the major areas of focus within the selected articles, offering insights into the development, centralization, emergence, and niche discussions within the research field. We employed co-occurrence network analysis (CNA) (Lozano et al., 2019; Vošner et al., 2016) to scrutinize abstracts, visually revealing relationships between concepts, terms, and themes in our selected literature. This method entails constructing a network graph with nodes representing concepts and edges indicating co-occurrence in the text. It facilitated the identification of key concepts, their relationships, and clusters systematically and visually, offering insights into our literature's structure and patterns. This analysis also allowed us to visualize potential connections between actors within abstracts, a critical component of systematic literature reviews. Notably, Figure 5 showcases the co-occurrence network, highlighting the most frequent words in abstracts, with "accounting," "transportation," and "sustainability" emerging as influential actors.

7. Conclusion

This systematic literature review scrutinized the interface between sustainable transportation and accounting principles, as directed by our conceptual framework, which emphasized the dynamics of substitution and integration within the transportation sector. Addressing our two main research questions has led us to several crucial findings, each supported by the foundational elements of our framework. First, our analysis confirmed that while there is robust engagement with environmental and social accountability in transportation, there is a discernible need for stronger theoretical constructs, as outlined in our framework. Our review highlighted that existing studies often lack a cohesive theoretical approach to integrating sustainability with accounting practices, particularly in complex logistical settings. This gap directly correlates with the "Sustainable Accounting Integration" dimension of our framework, which calls for a holistic assessment that captures all facets of sustainability—environmental, social, and economic. Second, in response to our second research question regarding research gaps, we identified an urgent need for research that connects theoretical models with practical applications. This aligns with the "Long-term Behavioral Transformations" and "Influence on Sustainable Transportation" components of our conceptual framework, which suggest that deeper insights into substitution dynamics and mode-environment nexus could lead to more sustainable transportation practices.

The limitations of this study include its focus on English language publications and published research, which may have excluded relevant perspectives and emerging trends. Continual updates and broader linguistic and geographical inclusivity in future reviews could mitigate these limitations. Future research should explore the integration of our conceptual framework with real-world data, potentially through case studies or empirical research that tests the framework's components in practical settings. Such studies could provide valuable feedback loops to refine the framework further and enhance its applicability and robustness in guiding both academic research and practical implementation in the fields of sustainable transportation and accounting.

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Figures

Figure 2.1. Conceptual Framework

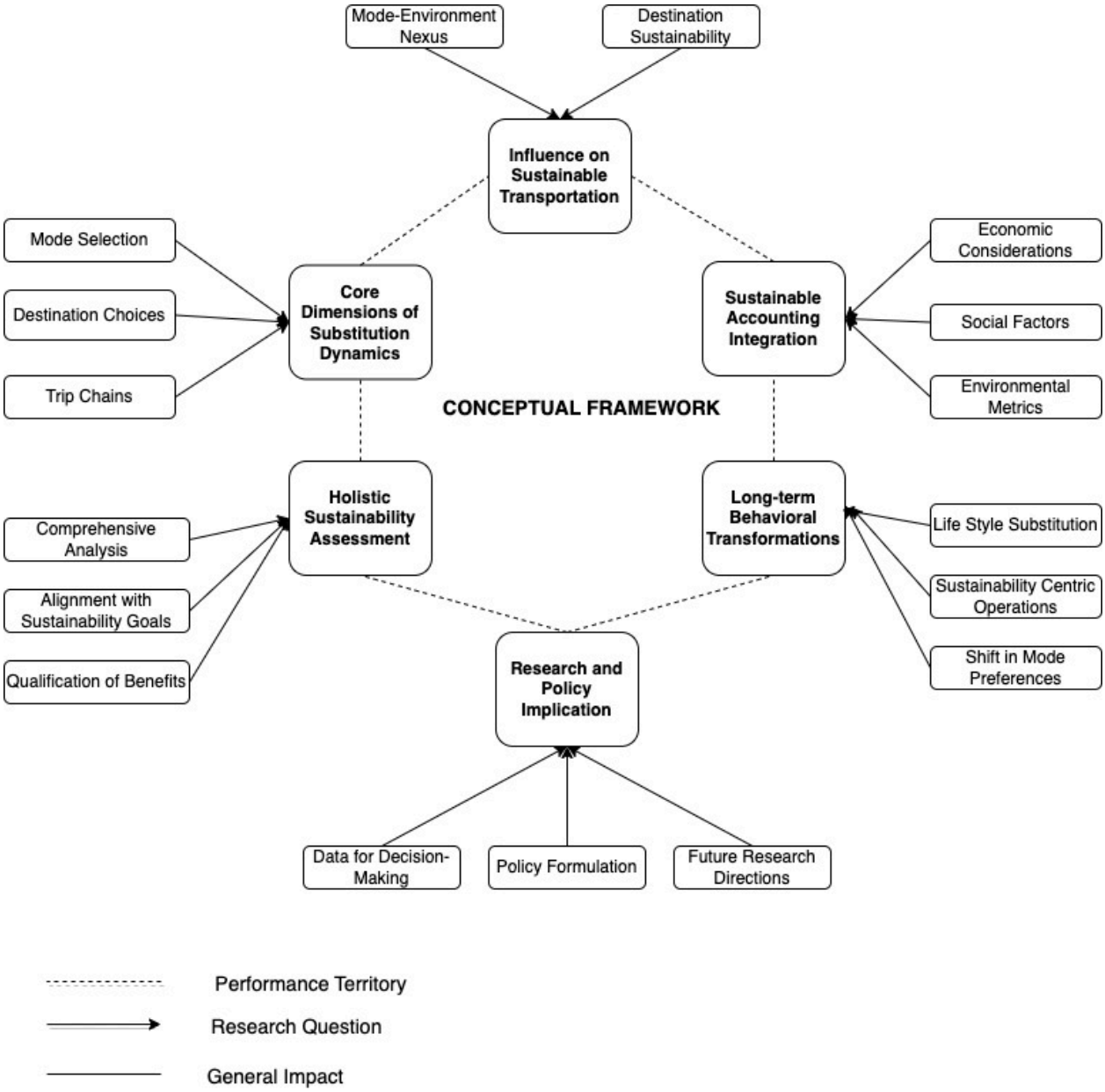

Figure 1 explores five core dimensions of substitution dynamics within freight transportation, from mode selection to trip efficiency, integrating sustainable accounting metrics. It underscores their impact on sustainable transportation practices and long-term behavioral shifts. Through holistic assessment, it informs data-driven decision-making and policy formulation while serving as a foundation for future research in sustainable freight transportation.

Figure 2.2. Six-step Research methodology

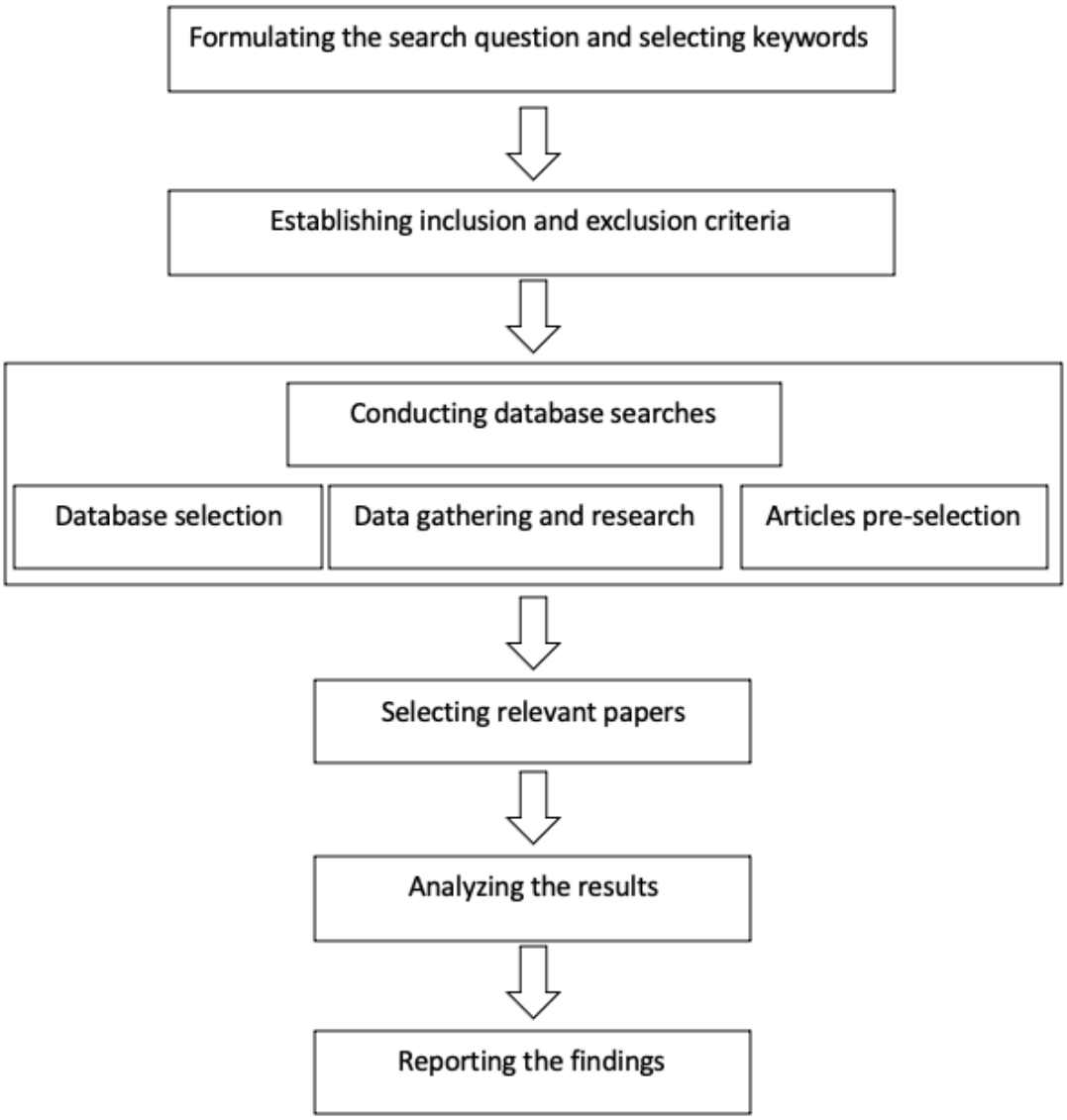

Figure 2, an illustrative chart, depicts the sequential phases essential for conducting a thorough and methodical research synthesis. The journey begins with the pivotal step of formulating the search question and meticulously selecting keywords that encapsulate the research focus. Next, the process of establishing inclusion and exclusion criteria ensures a precise scope for the study. Subsequently, the chart illustrates the systematic endeavor of conducting database searches, which comprehensively explores relevant academic repositories. These six integral stages collectively guide researchers in navigating the intricate research synthesis process, from the inception of inquiry to the culmination of insightful reporting.

Figure 2.3. Thematic Evolution Chronological Time Mapping (Authors' Keywords)

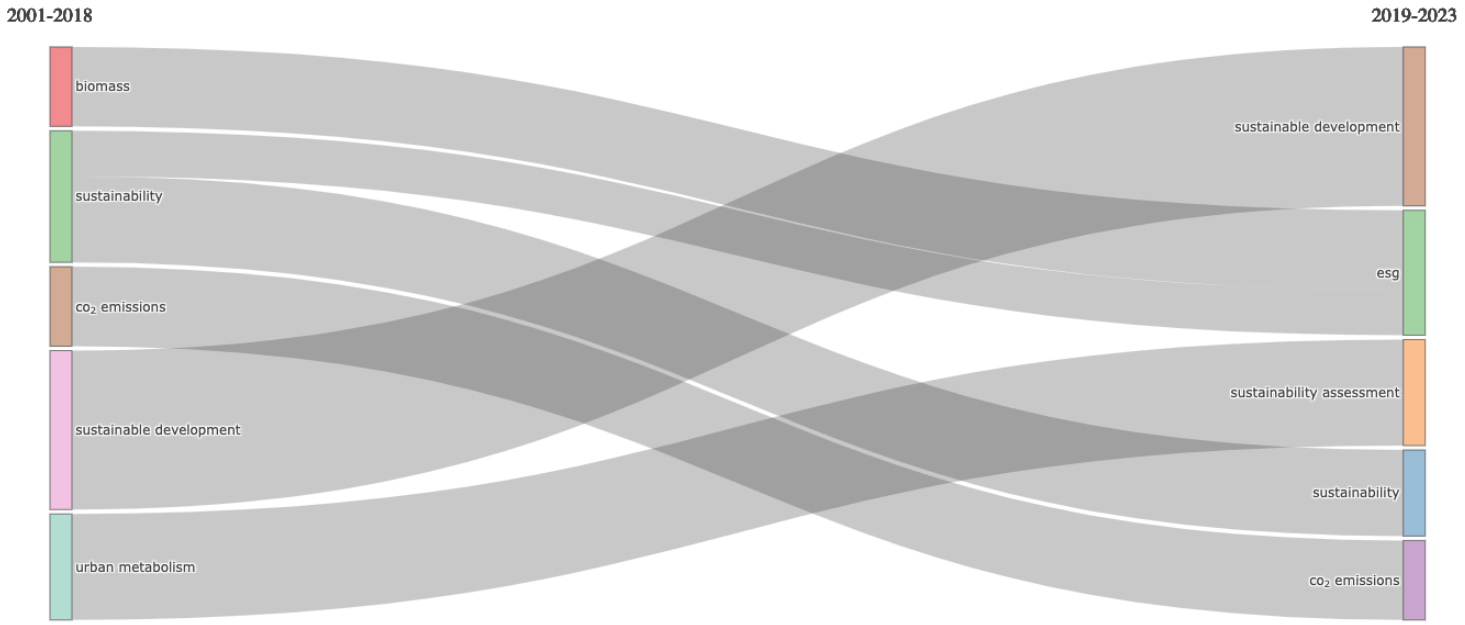

Figure 3 illustrates the thematic evolution of sustainability research from 2001-2018 to 2019-2023. The transition shows a shift in focus, with emerging themes like "ESG" and "sustainability assessment" gaining prominence in recent years, while foundational themes such as "sustainability" and "CO_2 emissions" continue to hold relevance. This mapping reflects a growing emphasis on integrating sustainable development frameworks with contemporary environmental, social, and governance (ESG) considerations.

Figure 2.4. Thematic Map (Title of Selected Articles)

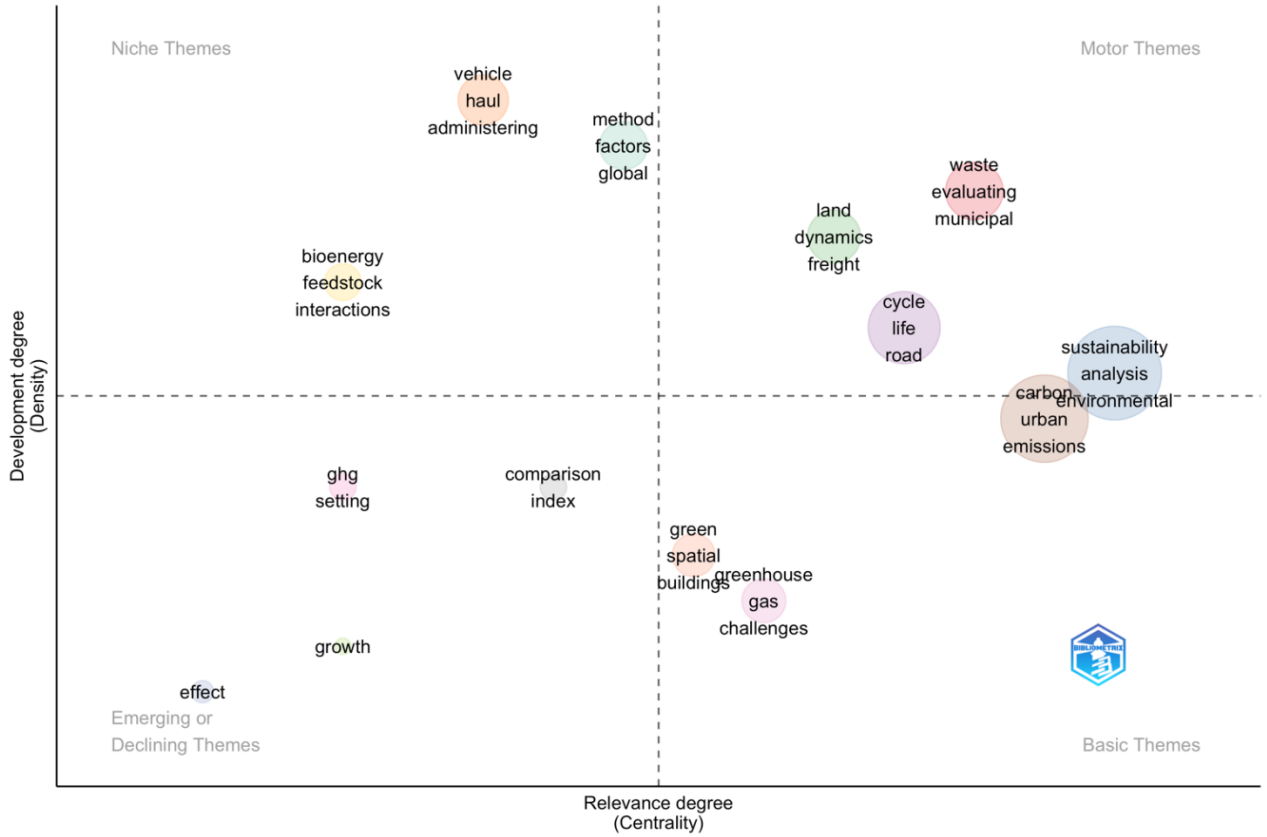

Figure 4 is the thematic map that categorizes research themes based on their development degree (density) and relevance degree (centrality). Basic themes such as "sustainability," "carbon," and "environmental analysis" exhibit high centrality but lower density, indicating foundational concepts with broad relevance. Motor themes, including "waste," "municipal," and "evaluating," reflect well-developed areas with high relevance. Niche themes like "bioenergy" and "feedstock interactions" are specialized with limited centrality, while emerging or declining themes, such as "growth" and "effect," are less developed and exhibit lower centrality, suggesting evolving or potentially declining interest.

Figure 2.5. Co-occurrence Network Analysis (Abstracts)

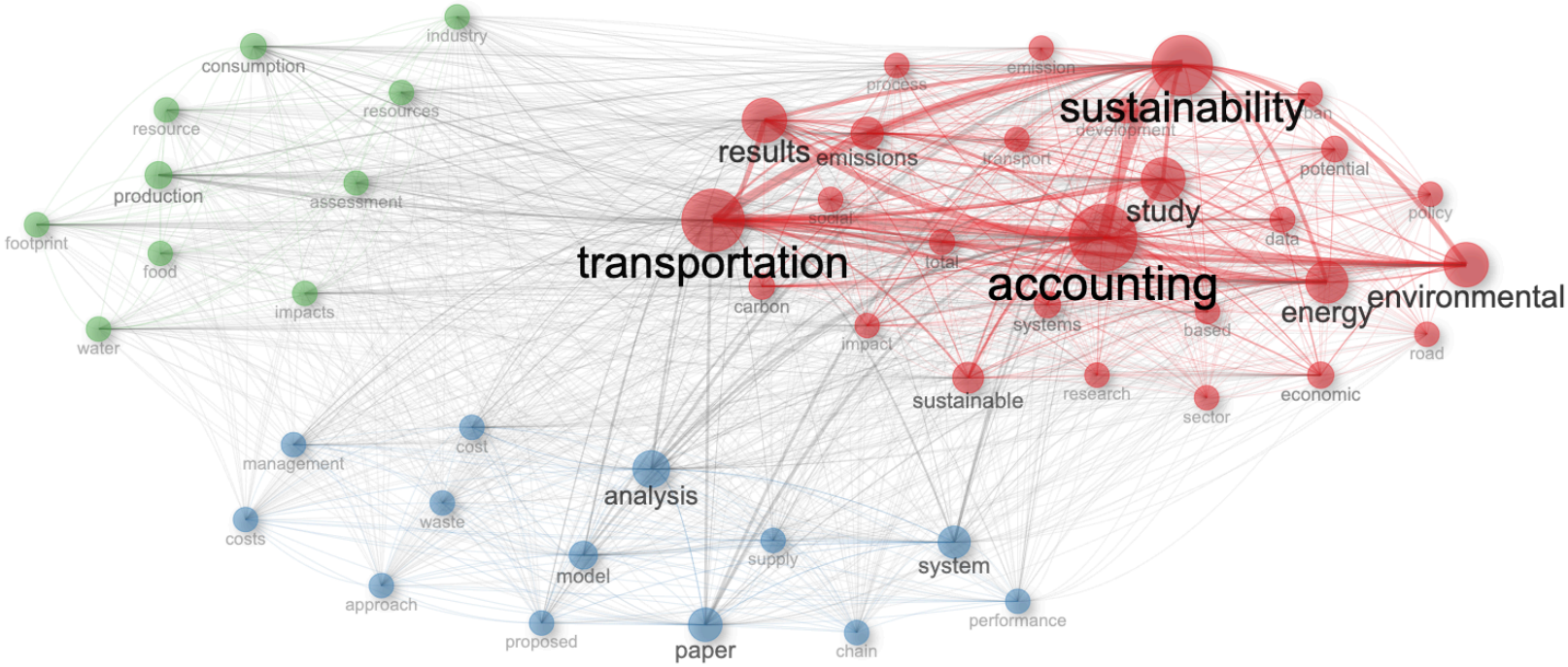

Figure 4 is this co-occurrence network visualizes the relationships between key terms within article abstracts, identifying clusters of frequently associated concepts. Major nodes like "sustainability," "accounting," and "transportation" are central, highlighting their prominence in the literature and their interconnectedness with terms related to "environmental," "energy," and "emissions." The network features distinct clusters: red nodes emphasize themes in accounting and emissions, green nodes reflect resource and production-related concepts, and blue nodes connect with management and cost analysis. This map demonstrates the diverse thematic intersections in sustainability-related research, particularly focusing on environmental and economic assessments.

Tables

Table 2.1. Inclusion and exclusion criteria used to select papers.

	Criteria	Justification
Inclusion	Papers published between 1991 and the second semester of 2023	To encompass all pertinent publications
	Document type; articles, conference papers, book chapters, reviews, and conference reviews	To prioritize in-depth articles and other credible materials for a thorough and extensive literature exploration
	Papers with subject area; social sciences business, management and accounting economics, and econometrics and finance	To focus on work related to economics, management, finance, accounting, and social sciences
	Papers focused on transportation, accounting, and sustainability	The focus on initiatives involving in transportation, accounting and sustainability
Exclusion	Studies in languages other than English language	The researchers engaged in this project possess proficiency in this language.

Table 1 illustrates the carefully delineated criteria for inclusion and exclusion that guide the selection process of relevant literature for this study. The criteria are strategically established to ensure a comprehensive and coherent exploration of the research landscape while maintaining the study's focus and academic rigor. The inclusion criteria encompass the publication timeline, document types, subject areas, and thematic focus, collectively contributing to a well-rounded investigation. Conversely, the exclusion criteria serve to refine the scope of the study by considering factors such as language proficiency and alignment with the research objectives. These criteria collectively shape the study's methodological framework, facilitating the systematic identification of scholarly materials that are instrumental to the study's objectives and scholarly integrity.

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Chapter III.

Green Taxes and Economic Incentives: Driving Sustainability in Freight Transportation

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Credit author statement

Ahmad Hatamabadi Farahani: Methodology, Writing, Resources, Data curation, Software, Formal analyses, Investigation, Project administration, Visualization, Review & Editing.

Green Taxes and Economic Incentives: Driving Sustainability in Freight Transportation

Abstract

This study investigates the effects of taxation policies and economic incentives on sustainability in freight transportation, specifically examining how tax rates, subsidies for green technologies, and financial incentives influence environmental performance and the adoption of sustainable practices. Using generalized linear models (GLM), the analysis finds that profitability is negatively associated with environmental performance, while larger firms and those with greater market share tend to exhibit stronger sustainability efforts. Tax incentives and subsidies, however, show a limited direct impact on improving sustainability. The study also highlights a negative relationship between rapid revenue growth and sustainability, indicating a potential trade-off between economic expansion and environmental goals. These findings emphasize the need for integrated policies that align economic incentives with sustainability objectives, reinforcing the importance of financial strength alongside environmental responsibility in achieving sustainable freight transportation.

Keywords: Sustainable Freight Transportation, Taxation Policies, Economic Incentives, Environmental Impact, ESG (Environmental, Social, and Governance)

JEL Classifications: Q58, Q01, H23, L91, M14

1. Introduction

In the relentless pursuit of global sustainability, the intricate interplay between economic activities and environmental preservation has emerged as a focal point of concern (Chowdhury et al., 2021; W. Li & Puppim de Oliveira, 2021). Freight transportation, a major contributor to greenhouse gas emissions, plays a pivotal role in this dynamic, as policymakers and industry leaders seek to transition towards more sustainable practices (Cristea et al., 2013). The relationship between taxation policies and sustainable freight transportation is a complex and nuanced subject, with governments exploring ways to balance economic incentives with environmental responsibility (Ahmad & Satrovic, 2023). This study seeks to provide a comprehensive assessment of how these taxation policies influence sustainability, focusing on environmental, economic, and social dimensions within the freight transportation sector. The importance of sustainable freight transportation extends beyond merely reducing carbon emissions. This presents a holistic approach that integrates economic viability, social equity, and long-term environmental stewardship. Central to achieving sustainability in freight transportation are the strategic decisions around logistics, technology adoption, and policy implementation (Centobelli et al., 2020; Marchet et al., 2014). These decisions not only impact environmental outcomes but also affect energy consumption, air quality, and broader ecological health. Recognizing this, scholars have increasingly called for a shift from traditional carbon-centric perspectives to more integrative approaches that consider the interplay of economic, social, and environmental factors.

Taxation policies have emerged as crucial tools in shaping the behavior of stakeholders within the freight transportation sector (Bask & Rajahonka, 2017; Dey et al., 2011). Governments can influence business practices by imposing charges, offering incentives, or implementing penalties, thereby steering the sector towards greater sustainability. Despite the theoretical support for the role of taxation, empirical research specifically examining its effects on freight transportation remains limited. This study aims to fill this gap by providing evidence of how taxation policies, combined with other economic and social factors, impact the sustainability of freight activities. In doing so, this research contributes to a deeper understanding of how policy interventions can drive both economic and environmental objectives in this sector. The hypotheses guiding this study focus on the critical question of how taxation and economic incentives influence sustainability outcomes (Hansen & Lund, 2018; Uddin et al., 2023). The first hypothesis (H1) investigates the relationship between

taxation policies such as tax rates and subsidies and the environmental impact of freight transportation. The second hypothesis (H2) explores how economic incentives, particularly through tax breaks or financial subsidies, affect the adoption of sustainable technologies and practices within the sector. Finally, the third hypothesis (H3) examines the broader integration of economic incentives with sustainable practices, assessing how these combined efforts promote overall sustainability within the freight transportation industry.

The empirical results from this study demonstrate varying degrees of influence for the key variables. As an example, while tax rates and subsidies show limited direct impact on sustainability measures like ESG scores, variables such as profitability and revenue growth reveal significant relationships, often highlighting trade-offs between financial expansion and environmental performance (Ajeigbe et al., 2023; Moosavian et al., 2022). Robustness checks were employed, including panel data models with heteroskedasticity-robust standard errors and clustered standard errors, ensuring the stability of the results. These analyses underscore the complex nature of sustainability in freight transportation, where policy interventions alone may be insufficient without considering the broader economic and operational context of the sector. The remainder of this study is structured as follows. The subsequent sections review the literature on sustainable freight transportation and taxation policies, establishing a theoretical foundation for the analysis. This is followed by the methodology section, which outlines the data, variables, and econometric techniques used in the study. The results section presents the findings from the regression models and robustness checks, offering insights into the impact of taxation and economic incentives on sustainability. Finally, the paper concludes with a discussion of the implications for policy and practice, as well as suggestions for future research aimed at fostering sustainable freight transportation practices.

2. Literature Review and Hypothesis Development

2.1. Sustainable Freight Transportation

The discourse on sustainable freight transportation has gained considerable momentum as societies grapple with the pressing challenges of environmental degradation and climate change (Rodrigue et al., 2001). Sustainable freight transportation is not simply a matter of reducing carbon emissions but involves a holistic approach that integrates economic viability, social equity, and long-term environmental stewardship (Santos et al., 2010a). The adoption of sustainable practices in freight transportation encompasses the optimization of logistics, the integration of cleaner technologies, and

the alignment of industry practices with overarching environmental objectives. The complexities of sustainable freight transportation are multifaceted, requiring a delicate balance between economic efficiency and environmental preservation. (Triantafyllou et al., 2014) highlight the need for a paradigm shift beyond traditional carbon-centric perspectives, acknowledging the interplay of economic, social, and environmental factors. The choices made in freight transportation have far-reaching consequences, influencing not only carbon footprints but also energy consumption, air quality, and overall ecological health.

2.2. Taxation Policies for Sustainable Freight Transportation

Taxation policies emerge as pivotal instruments in shaping the behavior of stakeholders in the transportation sector, particularly in the context of sustainable freight transportation (Santos et al., 2010b). Governments can guide businesses and individuals toward environmentally responsible practices by imposing charges, offering incentives, or implementing penalties. This aligns with the broader literature emphasizing the role of policy instruments in steering societal behavior toward sustainability (Steurer, 2010). The potential of taxation policies to influence sustainable behavior within the transportation sector is underscored by the economic concept of externalities. Externalities refer to the unintended impacts of economic activities on third parties, such as the environmental costs associated with freight transportation(Rao, 2003). Taxation policies, when designed thoughtfully, have the capacity to internalize these external costs, providing economic incentives for the adoption of sustainable practices. The interdependence between taxation policies and sustainable behavior is particularly pronounced in the transportation sector due to its significant contribution to carbon emissions.

2.3. Empirical Studies on Taxation Policies and Sustainability

Taxes have the potential to stimulate economic growth, mitigate income inequality, and play a role in advancing the Sustainable Development Goals (SDGs) (Rahman, 2023). While theoretical discussions on the role of taxation policies in promoting sustainability abound, empirical studies specific to freight transportation are notably scarce (Domagała & Kadłubek, 2023). Existing research often focuses on broader economic implications or individual behavior, leaving a substantial gap in understanding the concrete impacts of taxation policies on the complex dynamics of the freight transportation sector. This study seeks to address this gap by providing empirical insights into the tangible effects of taxation policies on sustainable freight transportation. The scarcity of empirical studies is a prominent challenge in the current body of research.

Addressing this concern (Domagała & Kadłubek, 2023) highlights the limited attention given to empirical investigations in the realm of freight transportation and taxation policies. The existing body of research tends to concentrate on broader economic consequences or individual-level behaviors, overlooking the nuanced dynamics within the freight transportation sector. To bridge this gap, our study endeavors to contribute empirical evidence, drawing insights from the intricate interplay between taxation policies and sustainable practices in freight transportation.

2.4. Challenges in Implementing Sustainable Practices:

Implementing sustainable practices within the freight transportation sector poses significant challenges. High capital costs associated with adopting green technologies, resistance to change within established industry practices, and the potential for unintended consequences of poorly designed policies are among the hurdles faced by businesses and policymakers (Moultak et al., 2017). Navigating these challenges necessitates a nuanced understanding of how taxation policies interact with industry dynamics to either facilitate or hinder the adoption of sustainable practices. The economic challenges associated with sustainable freight transportation are particularly significant. A study by (Leung et al., 2023) highlights the substantial upfront costs associated with integrating green technologies, acting as a major hurdle for businesses. Decision-making becomes more intricate due to uncertainties surrounding the return on investment as businesses carefully evaluate the economic viability of sustainable practices against conventional, often less environmentally friendly, alternatives. Moreover, the potential impact on overall supply chain efficiency introduces an additional layer of complexity. Research by (Reefke & Trocchi, 2013) and (Chaabane et al., 2011; Zhang et al., 2021) underscores the need to strike a delicate balance between sustainability objectives and broader economic considerations within the supply chain. Achieving sustainability in freight transportation necessitates not only the adoption of green technologies but also a strategic restructuring of supply chain processes to seamlessly accommodate these transformative changes.

2.5. Environmental Impacts of Sustainable Freight Transportation:

Sustainable freight transportation aims to mitigate its environmental footprint by incorporating cleaner energy sources, optimizing transportation routes, and integrating innovative technologies (K. Li et al., 2023). The multifaceted environmental impacts of these sustainable practices include a significant reduction in greenhouse gas emissions and improvements in air quality and overall ecological health. K. Li et al. (2023) also illuminate the intricate relationship

between sustainable freight transportation practices and their environmental consequences. The adoption of fuel-efficient vehicles, the optimization of transportation routes, and the integration of green technologies collectively contribute to a substantial decrease in the carbon footprint associated with freight activities. Understanding these specific environmental impacts is crucial for evaluating the efficacy of taxation policies in attaining environmental objectives. The spatial dimension of freight transportation further accentuates the complexity of environmental impacts. Urban areas, in particular, grapple with challenges such as congestion, air pollution, and noise resulting from freight activities (Jacyna et al., 2017). Policymakers, in designing taxation policies, must consider the spatial distribution of these impacts to effectively address both overarching environmental objectives and the unique challenges faced by urban communities.

2.6. Economic Considerations in Sustainable Freight Transportation:

The economic feasibility of sustainable freight transportation practices significantly shapes their widespread adoption. Businesses face challenges such as substantial upfront costs, unpredictable returns on investment, and potential disruptions to overall supply chain efficiency (Leung et al., 2023). Recent research underscores the critical role of taxation policies in navigating these economic hurdles, emphasizing the need for alignment with broader economic considerations. Furthermore, scholars assert the importance of taxation policies striking a delicate equilibrium between environmental objectives and economic viability. The considerable upfront costs associated with the incorporation of green technologies often deter businesses, particularly smaller enterprises with limited financial resources. Effective taxation policies featuring well-designed tax incentives and subsidies can effectively alleviate these financial barriers, rendering sustainable practices more economically appealing. Moreover, the economic dynamics extend beyond individual businesses to encompass the intricate processes within supply chains. Recent literature by (Leung et al., 2023) highlights the interconnected nature of supply chain operations and the potential cascading effects of adopting sustainable freight transportation practices. Taxation policies that intricately consider these economic complexities play a crucial role in motivating the seamless integration of sustainability into comprehensive supply chain strategies.

2.7. Social Dimensions of Sustainable Freight Transportation:

The imperative for sustainable freight transportation transcends the realms of environmental and economic considerations, encompassing pivotal social dimensions. In a study underscoring this multifaceted perspective, (Aloui et al., 2021) shed light on the intricate social

impacts of freight transportation. Emphasizing the well-being of communities affected by freight activities and advocating for an equitable distribution of benefits and burdens within transportation systems, (Aloui et al., 2021) contribute to the discourse on social sustainability in freight transportation. The significance of social dimensions becomes particularly pronounced in urban areas, where the concentration of freight activities can wield substantial influence over local communities. The spatial distribution of freight transportation impacts is acknowledged as a critical factor in policymaking, especially concerning the design of taxation policies (Santos et al., 2010b). (Santos et al., 2010b) argue that effective taxation policies should not only address environmental concerns but also attend to the social dimensions of sustainable freight transportation. By incorporating social considerations into policy frameworks, there is potential for fostering a more comprehensive and equitable approach, promoting both social equity and community well-being in the realm of sustainable freight transportation.

2.8. The Interplay of Environmental, Economic, and Social Factors

The dynamics of sustainable freight transportation are inherently intertwined, necessitating a holistic consideration of environmental, economic, and social factors. Scholars emphasize the imperative of comprehending the intricate interplay between these dimensions to formulate effective policies and practices (Mo & Wang, 2019). The incorporation of sustainability into freight transportation extends beyond the mere reduction of environmental impacts, demanding thoughtful consideration of economic efficiency and social justice. This interconnectedness of factors becomes particularly pronounced in the context of urban freight transportation, where concentrated activities amplify both environmental and social repercussions. Recent research by (Muñoz-Villamizar et al., 2020) underscores the significance of addressing the specific challenges confronted by urban communities, such as congestion, air pollution, and disruptions to daily life. It is within the urban landscape that the ramifications of freight transportation on the environment and society are most palpable, necessitating targeted strategies for sustainable urban logistics. Taxation policies, when designed with a nuanced understanding of the intricate relationships between environmental, economic, and social factors, hold the potential for a more substantial and enduring impact on the sustainability of freight transportation (Lindholm, 2010). By acknowledging and addressing the multifaceted nature of these interactions, policymakers can craft taxation frameworks that not only curb environmental degradation but also foster economic prosperity and social equity.

3. *Hypotheses Development and Methodology*

3.1. Sample and Data

The sample for this study comprises a comprehensive dataset collected from multiple sources, focusing on taxation policies and their impact on the freight transportation industry. The primary source of data is Datastream, a leading financial and economic database that provides extensive historical data on tax rates, financial incentives, penalties, and economic performance. Additional data sources include government reports, industry publications, and ESG (Environmental, Social, and Governance) metrics from company reports to ensure a robust analysis. Data is collected on the following key variables: tax rates, subsidies for green technologies, penalties for high emissions, adoption of sustainable practices, upfront costs, environmental impact, and overall sustainability. Tax rate information comes from national and regional tax databases that are available in Datastream. Data on financial support for sustainable technologies is obtained from government reports and financial statements of companies. ESG metrics detailing financial penalties for high-emission activities are accessible through Datastream and company sustainability reports. Information on the adoption of sustainable practices is gathered from ESG data and company reports that indicate the extent to which businesses implement green technologies and practices. Financial data related to the initial capital required for adopting sustainable practices is sourced from company financial statements, while company financial performance data, which can be used to calculate ROI, is available in Datastream. Metrics related to environmental performance, such as reduction in emissions and energy consumption, are accessible through ESG data in Datastream. Composite measures of environmental and economic sustainability are derived from ESG indices.

In the study, we used the term "ESG" (Environmental, Social, and Governance) to represent the dependent variable in all three hypotheses, even though we framed it with different names such as "Environmental Impact," "Adoption of Sustainable Practices," and "Overall Sustainability." The reason for this approach is that ESG, as a holistic measure, captures a wide array of sustainability-related aspects across environmental, social, and governance dimensions. For each hypothesis, we chose to focus on different facets of ESG. For example, in the context of environmental impact (H1), ESG was used to measure how economic and operational factors influence a firm's environmental performance. In contrast, for the adoption of sustainable practices (H2), we were interested in how taxation policies encouraged sustainable investment decisions, which were also captured by ESG metrics. Finally, in the integrated approach (H3), we examined how a combination of economic and

operational factors influenced overall sustainability, once again reflected in the ESG scores. While the term "ESG" remained constant in the data, the different framing in each hypothesis allowed us to emphasize specific elements of sustainability relevant to each research question, thereby making the analysis more nuanced and reflective of the multi-dimensional nature of ESG. This approach allowed us to maintain consistency in the dependent variable while adapting it to fit the specific context of each hypothesis. To empirically test the hypotheses, the following econometric models are employed:

3.2. Taxation and Environmental Impact (H1)

Hypothesis: How do economic and operational factors, including tax rates, subsidies for green technologies, firm size, profitability, leverage, and asset turnover, influence the environmental impact of freight transportation?

(1)

$$g(Envirnomental\ Impact)_{\ t} = \beta_0 + \beta_1(Tax\ Rate)_t + \beta_2(\text{Subsidies for Green Technologies})_{\ t} + \beta_3(Firm\ Size)_t + \beta_4(Profitability)_t + \beta_5(\text{Leverage})_t + \beta_6\ (Asset\ Turnover)_t + \epsilon_t$$

where the Environmental Impact at time t, measured by the ESG Environmental Score, represents the firm's overall environmental performance. In the context of the Generalized Linear Model (GLM), the link(log) function transforms the ESG score by modeling the logarithm of the ESG score as a linear function of the independent variables. This transformation helps to account for the non-linearity and ensures that predictions remain within a reasonable range. The model assumes a family(gaussian) distribution, indicating that the errors are normally distributed, similar to ordinary least squares regression. The Tax Rate, referring to the total income taxes paid by the firm in period t, reflects the financial burden of taxation on the firm, which may influence its ability to invest in sustainable practices. Higher taxes might deter investment in green technologies, whereas tax reliefs or lower rates could promote such investments. Subsidies for Green Technologies are represented by capital expenditures related to environmental investments during period t, capturing the extent to which firms are investing in green technologies, possibly influenced by government subsidies or incentives, and directly impacting the firm's environmental score.

Firm Size, measured by Total Assets in time t, is a control variable that accounts for the scale of the company, as larger firms might have more resources to invest in sustainability initiatives, which

could influence their environmental impact. Profitability, represented by Return on Assets (ROA), indicates the firm's financial health in time t, where more profitable firms may have greater capacity to fund environmental initiatives, thus influencing their environmental score. Leverage, measured by Total Debt to Total Assets, represents the firm's financial obligations relative to its assets in time t, where high leverage may limit a firm's ability to invest in sustainability due to financial constraints. Asset Turnover, the ratio of Revenue to Total Assets, serves as a measure of how efficiently a firm uses its assets to generate revenue, whereas firms with higher asset turnover might have different incentives or capacities for investing in sustainable practices. The lagged value of the dependent variable captures the momentum or persistence in environmental performance over time and allows for the influence of past environmental performance on current performance. The ϵ_t is the error term in period t, capturing unexplained variance. This hypothesis explores the relationship between taxation policies and their influence on the environmental performance of freight transportation. This hypothesis emphasizes how tax rates, subsidies for green technologies, firm size, profitability, leverage, and asset turnover collectively impact the environmental outcomes of freight operations. The core idea here is to examine how these financial and operational factors shape the industry's environmental impact, particularly in terms of emissions reduction and the promotion of greener practices. The focus is narrowly tailored to understand how these variables, especially taxation policies, act as incentives or deterrents for high-emission activities.

3.3. Economic Incentives and Adoption (H2)

Hypothesis: How do taxation policies, through economic incentives, reduce financial barriers and motivate businesses to invest in sustainable technologies and practices in freight transportation?

(2)

$$g(Adoption\ of\ Sustainable\ Practices)_t = \beta_0 + \beta_1(Tax\ \text{Incentives})_t + \beta_2(\text{Upfront Costs})_t + \beta_3(Firm\ Size)_t + \beta_4(Profitability)_t + \beta_5(\text{Leverage})_t + \beta_6(\text{Market Share})_t + \beta_7(\text{Growth Opportunities})_t + \epsilon_t$$

where the Adoption of Sustainable Practices in time t, represented by the ESG Environmental Score, measures the extent to which a firm implements environmentally friendly practices and uses a Generalized Linear Model (GLM) with a Gaussian family and an identity link function. Tax Incentives, represented by deferred taxes or general tax reductions in time t, indicate financial

incentives provided by the government to encourage sustainable investments, which can reduce the cost of adopting green technologies. Upfront costs, measured by total assets, represent the initial investment required to implement sustainable practices in time, where high upfront costs might deter adoption unless mitigated by economic incentives. Firm Size, measured by Total Assets, is a control variable reflecting the scale of the company, as larger firms may be better positioned to adopt sustainable practices due to their resources. Profitability, indicated by ROA in time t, reflects the firm's financial strength, where profitable firms might be more inclined to invest in sustainable practices. Leverage, measured by Total Debt to Total Assets, controls the firm's financial obligations in time t, where firms with higher leverage might face financial constraints impacting their ability to adopt sustainable practices. Market Share, represented by the firm's revenue relative to the industry, serves as a proxy for the firm's competitive position, where firms with larger market shares might face more pressure or have more capacity to adopt sustainable practices. Growth Opportunities, measured by the Revenue Growth Rate, reflect the firm's potential for expansion in time t, whereas firms with high growth opportunities may be more likely to invest in sustainability to ensure long-term viability. Growth Opportunities are represented by the firm's year-over-year revenue growth, which measures the percentage change in a firm's total revenue from one year to the next. It is calculated as the difference between the revenue in time t and the revenue in time t-1, divided by the revenue in time t-1, and then multiplied by 100 to express it as a percentage. This variable captures the firm's potential for expansion and growth over time. Firms experiencing higher growth may be more inclined to adopt sustainable practices to ensure their long-term viability. The second hypothesis shifts its focus to the **adoption of sustainable practices** within freight transportation. It explores how economic incentives, such as tax incentives, and factors like upfront costs, firm size, profitability, leverage, market share, and growth opportunities, influence businesses' decisions to invest in sustainable technologies and practices. Here, the emphasis is on understanding the drivers behind adopting green practices, particularly examining how financial incentives or barriers along with operational characteristics determine whether firms move towards more sustainable operations.

3.4. Integrated Approach (H3)

Hypothesis: How do economic incentives, along with factors such as environmental impact, firm size, profitability, leverage, market share, asset turnover, and growth opportunities, influence the overall sustainability of freight transportation?

(3)

$$g(Overall\ Sustainability)_{\ t} = \beta_0 + \beta_1(Environmental\ Impact/CSR)_t + \beta_2(\text{Economic Incentives})_{\ t} + \beta_3(Firm\ Size)_t + \beta_4(Profitability)_t + \beta_5(\text{Leverage})_t + \beta_6\ (\text{Market Share})_t + \beta_7\ (Asset\ Turnover)_t + \beta_8(\text{Growth Opportunities})_t + \epsilon_t$$

where Overall Sustainability in time *t*, measured by the ESG Overall Score and a Composite Index with log of ESG score, reflects the firm's performance across environmental, social, and governance dimensions. The ESG score serves as a proxy that captures the multidimensional aspects of sustainability. Alternatively, the Composite Index, created by standardizing and averaging key sustainability-related variables such as profitability, revenue growth, and leverage, also represents overall sustainability. This measure provides a broad reflection of the firm's aggregated performance in terms of sustainable practices and financial metrics. Environmental Impact, represented by Corporate Social Responsibility (CSR), measures the firm's commitment to responsible business practices, including social, environmental, and governance aspects, directly contributing to its overall sustainability. Economic Incentives, represented by Capital Expenditures in time t, reflect the financial incentives and investments in sustainability that affect the firm's overall sustainability. Firm Size, measured by Total Assets in time t, controls for differences in scale that could influence a firm's sustainability efforts. Profitability, indicated by ROA in time t, controls for the effect of financial performance on sustainability. In our financial performance evaluation, we have chosen to use both ROA due to their complementary insights, which are particularly useful for assessing how efficiently the company uses its assets to generate profits. Leverage, measured by Total Debt to Total Assets in time t, controls the firm's financial obligations, which could impact its ability to invest in sustainable practices. Market Share, proxied by revenue, controls the firm's position within the industry, which might affect its approach to sustainability. Asset Turnover, represented by the ratio of Revenue to Total Assets, controls for operational efficiency in time t, which might impact the firm's sustainability practices. Growth Opportunities, measured by the Revenue Growth Rate in time t, control for the firm's potential for future expansion, influencing its investment in sustainable practices. The third hypothesis takes a more **holistic approach** to sustainability in freight transportation. Rather than focusing solely on environmental impact or the adoption of sustainable technologies, this hypothesis considers the broader concept of **overall sustainability**. It integrates environmental, economic, and operational factors, such as environmental impact, economic incentives, firm size, profitability, leverage, market share, asset turnover, and growth opportunities. The goal is to investigate how these various elements interact to enhance sustainability across

multiple dimensions, not just in terms of environmental benefits but also in economic performance and operational efficiency.

The data analysis process comprises several key steps. First, descriptive statistics summarize the dataset's primary characteristics, offering insights into the basic features and distributions of the variables, including ESG scores, financial metrics, and other relevant factors. Next, correlation analysis is performed to evaluate the relationships between these variables and to identify any potential multicollinearity concerns. Following this, regression analysis is conducted using the specified econometric models to test the hypotheses and assess the impact of taxation policies and related factors on sustainable practices in freight transportation. Lastly, robustness checks are implemented to confirm the validity and reliability of the findings. The appendix includes detailed information on the variables' distribution, calculations, and descriptions.

The scatter plot in Figure 1.1 with color-coded countries offers a comprehensive view of how tax rates and ESG scores interact across European nations, revealing considerable diversity in the impact of ESG on taxation. Countries like Belgium and Germany show a positive association between ESG scores and tax rates, suggesting that higher tax environments might support or at least coexist with, advanced ESG initiatives. This relationship may imply that these countries' fiscal policies encourage companies to adopt ESG practices through tax-related incentives or regulatory support. In contrast, other countries, such as France, exhibit a weaker or inverse relationship between ESG scores and tax rates, indicating that high tax rates do not necessarily correlate with higher ESG performance. Such variances underscore the nuanced landscape of public regulation within Europe, where tax policies affect ESG outcomes differently.

The scatter plot also highlights clusters and outliers, providing insight into the alignment between national regulatory frameworks and ESG initiatives. For example, the United Kingdom displays a relatively scattered ESG-tax correlation, possibly reflecting a more flexible regulatory approach to ESG, where tax policies may not directly incentivize sustainability. This variability could be attributed to differing priorities or regulatory frameworks within each country, emphasizing that a uniform policy approach may not account for national contexts effectively. These observations suggest that while some European countries use tax policy as an instrument to drive ESG practices, others may depend on alternative regulatory mechanisms, such as direct incentives or mandates, to achieve sustainability goals.

[Insert Figure 1.1]

The trend lines by country further illustrate the trajectory of ESG scores relative to tax rates over time, underscoring distinct patterns in how ESG initiatives evolve under varying fiscal conditions. In countries like Germany and Belgium, trend lines show a steady upward movement, indicating that their public regulations, perhaps including ESG-focused tax incentives, have fostered progressive ESG engagement. This consistency reflects the possibility of sustained policy support, enabling companies to integrate ESG practices more readily as part of their compliance or corporate responsibility frameworks. For such countries, the gradual upward trend in ESG scores suggests a stable regulatory environment that may help organizations prioritize sustainability without disruptive policy changes.

On the other hand, countries such as Greece and France present more volatile trend lines, with fluctuations rather than a clear upward trajectory, pointing to potential instability or weaker linkages between tax policies and ESG progression. This variability might indicate challenges in maintaining consistent regulatory support for ESG practices or possible economic factors affecting corporate sustainability commitments. The trend line analysis thus provides insight into the differential impact of public regulations, where steady, upward ESG trends align with robust and stable regulatory frameworks, while erratic ESG movements may signal an evolving or less cohesive policy approach. Together, these patterns underscore the complex interplay between tax regulation and ESG, with country-specific factors significantly influencing ESG advancement trajectories across Europe.

[Insert Figure 1.2]

Table 1 presents the descriptive statistics for the variables in this study. The data have been winsorized at the 1st and 99th percentiles to minimize the influence of extreme outliers. It includes the number of observations and the mean, standard deviation, minimum, 25th percentile, median (P50), 75th percentile (P75), and maximum values for each variable. The ESG score, measuring firms' environmental performance, varies from 13.822 to 53.938, highlighting differences in how firms manage environmental risks. Tax Rate shows significant diversity, ranging from -950.161 to 3058.556, reflecting the varying taxation policies firms face. Subsidies for Green Technologies (SGT) exhibit substantial variation, with values from 0.006 to 1488.000, indicating differing levels of investment in environmental initiatives.

[Insert Table 1.]

Firm Size, measured by total assets, spans from 144.065 to over 2 billion, offering insights into how firm scale might influence sustainability efforts. Profitability, as indicated by ROA, averages 0.004, while Leverage, at 0.310, suggests moderate debt levels across firms. Asset Turnover shows

notable differences in efficiency, with a mean of 1.168 and a maximum of 20.532. Tax Incentives and Upfront Costs further highlight variability in tax strategies and capital investment. Return on Equity (ROE) has a mean of 0.351, signaling different levels of profitability across firms, and Economic Incentives, with values from -949.385 to 3060.163, show how varied economic conditions affect sustainability efforts. Control variables such as Liabilities, Pretax Income, Revenue, Stockholders' Equity, Income Taxes, log-transformed assets (Log assets), Capital, and CSR offer additional perspectives on firm financial health while Prima provides further context on potential financial conditions relevant to central bank policies.

Table 2 represents the pairwise correlation matrix for the key variables in the study based on 140 observations. The correlation coefficients indicate relationships between the dependent variable, ESG (Environmental, Social, and Governance score), and various independent variables. Significant correlations are denoted by asterisks, with $p < 0.05$, $p < 0.01$, and $p < 0.001$ representing varying degrees of significance. Notably, ESG does not show any strong correlations with most variables, though there are weak positive correlations with Firm Size ($r = 0.063$), Capital ($r = 0.259$, $p < 0.01$), and CSR ($r = 0.262$, $p < 0.01$), suggesting that larger firms, those with more capital, and those engaging in corporate social responsibility are more likely to exhibit better environmental, social, and governance practices. ESG shows no significant correlation with Tax Rate ($r = 0.060$) and SGT ($r = 0.053$), indicating that these factors may not have a strong relationship with a firm's ESG score in this sample.

Interestingly, Profitability exhibits a negative but not statistically significant relationship with ESG ($r = -0.147$), indicating that higher profitability does not necessarily correspond to better ESG performance. However, some notable relationships among the independent variables themselves offer insights into potential interactions that may affect the regression models. For instance, Firm Size is strongly correlated with Tax Rate ($r = 0.559$, $p < 0.001$), Economic Incentives ($r = 0.569$, $p < 0.001$), and Liabilities Total ($r = 1.000$, $p < 0.001$), suggesting that larger firms are more likely to face higher tax rates, receive greater economic incentives, and have higher liabilities. Additionally, Leverage has a weak negative correlation with Profitability ($r = -0.190$, $p < 0.05$), indicating that firms with higher debt levels tend to be less profitable. The absence of very high correlations between independent variables suggests that multicollinearity is unlikely to be a significant issue in the analysis. Subsequent VIF (Variance Inflation Factor) tests confirmed this, with no VIF values exceeding the critical threshold of 10. This indicates that multicollinearity does not pose a serious concern in this dataset.

[Insert Table 2.]

3.5. Measurement of independent variables

In this study, the independent variables are selected to explore the relationship between taxation policies, economic incentives, and overall sustainability in the freight transportation sector. Each hypothesis is supported by a model that incorporates specific independent variables representing aspects such as taxation rates, subsidies, and capital expenditures. The selection of these variables is based on the availability of relevant data, including financial metrics, ESG scores, and other firm-level characteristics. The independent variables are intended to capture the economic, environmental, and policy factors that influence sustainable practices in freight transportation.

For hypothesis 1: Taxation and Environmental Impact, the Tax Rate is measured using the "Income Taxes - Total" variable, which reflects the total amount of taxes paid by the firm. This variable indicates the overall tax burden on the company, influencing its environmental performance by either incentivizing or deterring certain practices. Subsidies for Green Technologies are approximated using "Capital Expenditures," specifically focusing on expenditures directed toward sustainability-related investments. This variable signifies a firm's commitment to investing in green technologies, which may be encouraged through subsidies.

For hypothesis 2: Economic Incentives and Adoption of Sustainable Practices, Tax Incentives are measured using "Deferred Taxes" and the overall "Taxation" variables, capturing the benefits or reductions in taxes that companies may receive for adopting sustainable practices. These variables reflect how tax benefits can lower financial barriers to sustainability investments. The Upfront Costs are measured using "Total Assets" and "Capital Expenditures," which indicate the initial financial resources required for sustainable investments, with higher costs potentially acting as barriers to adoption. Return on Investment (ROI) is assessed using "Return on Equity (ROE)" or "Return on Assets (ROA)," which provide insights into the profitability of these investments, influencing the likelihood of their adoption.

For hypothesis 3: Integrated Approach to Overall Sustainability, Environmental Impact is measured using the "ESG Environmental Score," reflecting a company's environmental performance. This score serves as a proxy for the environmental dimension of overall sustainability, highlighting the effectiveness of a company's environmental management. Economic Incentives are again represented by the "Taxation" and "Capital Expenditures" variables, similar to those in Hypothesis 1, to assess how financial incentives promote sustainable practices and contribute to overall

sustainability. Policy Integration is captured through the "ESG Overall Score," which combines environmental, social, and governance factors to provide a holistic view of a company's sustainability performance. This score reflects the integration of various policy areas, indicating the company's overall sustainability strategy.

3.6. Measurement of the dependent variable

The dependent variables in this study are designed to capture the outcomes related to the hypotheses on the impact of taxation policies, economic incentives, and overall sustainability in the freight transportation sector. Each dependent variable is carefully chosen to align with the specific focus of the hypotheses and is measured using available data from ESG scores and financial metrics.

For hypothesis 1: Taxation and Environmental Impact, the dependent variable is Environmental Impact, which is measured using the "ESG Environmental Score." This score is a comprehensive indicator of a company's environmental performance, capturing the effectiveness of its environmental policies, practices, and outcomes. The ESG Environmental Score reflects the level of emissions, waste management, energy usage, and other environmental factors that are influenced by taxation policies, such as green taxes or incentives for reducing emissions.

For hypothesis 2: Economic Incentives and Adoption of Sustainable Practices, the dependent variable is the Adoption of Sustainable Practices, also measured using the "ESG Environmental Score." This score serves as a proxy for the extent to which companies in the freight transportation sector have adopted environmentally sustainable practices. The score reflects how economic incentives, such as tax breaks or subsidies, influence the adoption of green technologies, energy efficiency measures, and other sustainable practices.

For hypothesis 3: Integrated Approach to Overall Sustainability, the dependent variable is Overall Sustainability, which is measured using the "ESG Overall Score." This score provides a composite measure of a company’s sustainability performance across environmental, social, and governance dimensions. The ESG Overall Score captures the holistic impact of integrated policies, assessing how well a company balances environmental responsibilities with social and governance aspects, and how these contribute to its overall sustainability.

3.7. Control Variables

In this study, control variables are included in each model to account for other factors that might influence the dependent variables, thereby ensuring that the observed effects of taxation policies and economic incentives are not confounded by these additional influences. These control variables are derived from the financial and operational characteristics of the companies in the dataset and are critical for isolating the true impact of the independent variables. Firm Size is controlled by using Total Assets as a measure. Larger firms often have more resources to invest in sustainable practices and may have different tax liabilities compared to smaller firms. Total Assets provide a comprehensive view of a firm's scale and capacity to implement environmental measures.

Profitability is controlled using Return on Assets (ROA) and indicates how efficiently a company is using its assets to generate profit. These profitability metrics are important because more profitable companies might have more resources available to invest in sustainability initiatives or face different tax situations. Leverage is controlled by including Total Debt to Total Assets. The level of a firm's indebtedness can influence its ability to invest in sustainable practices, as companies with higher leverage may have fewer resources available for such investments due to debt servicing obligations. Industry Type is controlled using Industry Dummy Variables. Different industries have varying levels of environmental impact and may be subject to different regulatory pressures and tax treatments. Including industry dummies helps to account for these sector-specific differences. Market Conditions are controlled by using Market Capitalization. The size and market position of a company can affect its access to capital and its ability to respond to tax incentives or regulations. Market capitalization is a measure of a company's total value as determined by the stock market, and it serves as a proxy for market conditions that might influence a firm's environmental and financial strategies.

[Insert Figure 2.]

The scatterplot matrix provides a visual summary of the relationships between pairs of variables included in the first model. Each cell in the matrix displays a scatterplot that compares two distinct variables, enabling a visual examination of potential relationships, patterns, and the spread of data points. The diagonal cells serve as reference points, showcasing individual variables, while the off-diagonal scatterplots allow for an assessment of linear trends or potential associations between the variables. Upon inspection of these scatterplots, some relationships are more concentrated, while others are more dispersed, suggesting either a weak or non-existent relationship. For instance, the plot comparing Revenue Total and Leverage shows scattered points, implying a weak correlation or

a non-linear relationship. Certain variables, such as Profitability and Tax Rate, present some extreme outliers where points deviate significantly from the main cluster, indicating possible anomalies in the data. In general, the matrix shows minimal evidence of strong correlations across most variables. For example, the scatterplot between Tax Rate and ESG reveals widely dispersed points with no apparent linear trend. Similarly, there is no discernible linear relationship between Log Firm Size and ESG. While some clustering appears in variables like Firm Size and ESG, the overall trend suggests no strong linear correlation between them. Revenue Growth displays significant variability, which may influence its relationships with other variables. The presence of high variability in certain variables weakens their correlation with others, while some clusters of points suggest moderate but not strong relationships.

[Insert Figure 3.]

The scatterplot matrix for Figure 3 offers a visual representation of the relationships between pairs of variables in the dataset for the second model. Each cell in the matrix shows a scatterplot that compares two distinct variables, allowing for the assessment of potential relationships, patterns, and how the data points are spread across different variables. The diagonal cells represent individual variables, acting as reference points, while the off-diagonal scatterplots allow for examining linear or non-linear trends and possible correlations between the variables. In the scatterplots, certain relationships appear more clustered, while others are widely dispersed, suggesting either a weak or non-existent correlation. For instance, the scatterplot between Firm Size and Tax Rate exhibits dispersed points, indicating no strong linear relationship. Additionally, some variables, such as Profitability and Leverage, show clusters of points with more dispersion, suggesting that any relationships between them may be weak or complex. The relationship between Firm Size and ESG appears somewhat scattered, indicating a lack of clear linearity. On the other hand, relationships like Asset Turnover and ESG exhibit more clustering but still do not show a pronounced linear correlation. Extreme outliers are also noticeable in certain scatterplots, such as those involving Tax Rate and SGT, where a few points deviate significantly from the main clusters, signaling potential outliers or anomalies in the data. Overall, there is little evidence of strong relationships between most variables. For example, the scatterplots between Profitability and ESG show widely dispersed points, suggesting a weak or non-existent linear correlation. Similarly, Asset Turnover and Firm Size show considerable spread, indicating variability across observations that may weaken potential correlations. The scatterplot matrix suggests that while there are areas of moderate clustering, most relationships between the variables appear weak or absent. The presence of outliers and high variability may be influencing the overall trends, necessitating further analysis through more rigorous statistical methods

such as regression analysis or correlation testing. This matrix serves as an initial exploration of the dataset, providing insight into potential areas for further investigation while highlighting the variability and complexity within the model's variables.

[Insert Figure 4.]

The scatterplot matrix in Figure 4 offers a comprehensive visual representation of the relationships between pairs of variables in the dataset for the third model. Each off-diagonal cell in the matrix presents a scatterplot that compares two distinct variables, allowing for the examination of potential relationships, patterns, and the distribution of data points. The diagonal cells serve as reference points, representing individual variables, while the scatterplots in the off-diagonal cells enable us to explore possible linear or non-linear trends and correlations. The relationship between log_ESG and CSR is depicted as widely dispersed in the scatterplot, with no clear linear trend, suggesting a weak or non-existent correlation between these two variables. When examining Firm Size, particularly its relationship with log_ESG and CSR, the scatterplots show a broad dispersion of data points, indicating that there is no strong linear relationship. Similarly, the scatterplot between Firm Size and CSR appears scattered, with no evident pattern, reinforcing the conclusion of a weak or absent correlation. The scatterplots involving profitability show that when compared with other variables such as log_ESG and CSR, the points are dispersed without clear clustering, suggesting weak or complex non-linear relationships. The scatterplot between Profitability and Leverage reveals a slight negative trend but still shows a wide dispersion, indicating a potential yet weak negative correlation. Leverage also demonstrates broad dispersion when compared with other variables, pointing to variability and weak correlations within the dataset.

In the case of Revenue Total, scatterplots with other variables such as log_ESG and Firm Size show a significant spread of data points, suggesting high variability and weak correlations. This broad spread is also evident in the scatterplots involving Asset Turnover, where its relationship with other variables like Firm Size and Leverage displays a wide dispersion, indicating weak relationships and considerable variability. Revenue Growth further follows this pattern, with its scatterplots showing dispersed points and no clear patterns, suggesting weak or non-existent correlations with the other variables. The scatterplot matrix highlights that strong relationships between most variables are not evident. Most scatterplots in the matrix display widely dispersed points with no clear linear trends, indicating weak or no significant correlations between most pairs of variables. The presence of extreme outliers in some scatterplots, such as those involving Revenue Total and log_ESG, suggests potential anomalies in the data that warrant further investigation. Given the high variability and lack of strong correlations observed, further analysis through more rigorous statistical methods like

regression analysis or correlation testing is necessary to gain a deeper understanding of the relationships between these variables. This matrix serves as an initial exploration of the dataset, offering insights into potential areas for further investigation while highlighting the complexity within the model's variables.

4. Empirical Results

In this analysis, we chose to employ Generalized Linear Models (GLM) for all three models due to several advantages GLM offers over traditional ordinary least squares (OLS) regression. The decision to use GLM is rooted in the need to account for certain characteristics of our data that may not align well with the assumptions required by OLS. One key reason for utilizing GLM is its ability to handle dependent variables that deviate from a normal distribution. In our study, variables such as the ESG score, Adoption of Sustainable Practices, and Overall Sustainability may not follow a perfectly normal distribution, which is a core assumption of OLS regression. GLM allows us to model these relationships more accurately by specifying different families of distributions, such as Gaussian, Poisson, or Binomial, depending on the nature of the dependent variable. Furthermore, GLM permits the use of different link functions, such as the log link, to better capture the relationship between the independent and dependent variables, especially in cases where this relationship may be multiplicative or otherwise non-linear.

[Insert Table 3.]

The flexibility of GLM is another crucial factor in our choice. Unlike OLS, which assumes a linear relationship between variables, GLM can handle non-linear relationships more effectively. For instance, the relationship between firm size and sustainability or between market share and the adoption of sustainable practices might be non-linear. By applying a log link or other suitable transformations in GLM, we can better account for these complexities, leading to a model that more accurately reflects the underlying data structure. Moreover, GLM generalizes beyond the limitations of OLS by allowing for the relaxation of several assumptions. OLS requires normally distributed residuals, constant variance (homoscedasticity), and a linear relationship between variables. However, in real-world data, these assumptions are often violated. GLM provides a way to model the data even when these assumptions do not hold, thereby offering a more robust framework for analysis. For example, in cases where the variance of the residuals is not constant or the errors are not normally distributed, GLM can still provide reliable estimates by accommodating these issues within its flexible structure. In our study, the shift to GLM was particularly beneficial when traditional OLS

models did not yield significant results or when the model fit was poor. By allowing for non-normality in the error terms and non-linearity in the relationships between variables, GLM provided a better fit for the data, leading to significant results that were not captured by OLS. This suggests that the relationships between our variables, such as those between Tax Incentives, Upfront Costs, Environmental Impact, and Growth Opportunities, are more complex than a simple linear model can accommodate.

4.1.Multiple Regressions of ESG and Results

4.1.1. Model 1

The results of the generalized linear model (GLM) for Hypothesis 1 focused on how taxation policies influence the environmental performance of freight transportation by either incentivizing greener practices or deterring high-emission activities provide several insights into the relationship between the dependent and independent variables. Starting with log_TaxRate, the coefficient is -0.0193, indicating a negative relationship between the tax rate and the ESG score. This suggests that, in this model, higher tax rates slightly decrease environmental performance. However, the p-value for this variable is 0.463, meaning that this result is not statistically significant. Therefore, we cannot definitively conclude that taxation policies, in the form of tax rates, have a strong effect on environmental performance in this model. This finding implies that taxation may not be directly influencing firms' environmental behaviors or that other factors may dilute the impact of tax rates on green practices. SGT (Subsidies for Green Technologies) has an almost negligible coefficient of -2.56e-06 and a p-value of 0.986, which shows no significant relationship between green subsidies and environmental performance in this model. Despite expectations that subsidies would incentivize companies to adopt sustainable practices, this result suggests that subsidies alone may not be sufficient to drive improvements in environmental scores. This could imply that firms either are not utilizing these subsidies effectively or that other barriers to sustainability, such as upfront costs or operational priorities, limit the influence of these financial incentives.

One of the more promising results is the coefficient for Profitability, which has a negative and statistically significant coefficient of -20.1908 with a p-value of 0.046. This suggests that firms with higher profitability are less likely to perform well on environmental measures, as indicated by the negative relationship with ESG scores. One potential explanation is that highly profitable firms may prioritize short-term financial gains over long-term investments in sustainability. Profit-maximizing behavior could sometimes come at the cost of environmental performance, as resources may be

directed toward expanding operations or maximizing returns rather than investing in green initiatives. The significance of this variable reinforces the idea that profitability and sustainability may not always align in corporate strategies. Leverage also shows a negative relationship with ESG performance, with a coefficient of -0.3748 and a p-value of 0.068. Although the result is not statistically significant at the conventional 5% level, it is close, which suggests that firms with higher leverage tend to score lower on environmental performance. The negative relationship may be because firms with higher levels of debt face financial constraints that limit their ability to invest in sustainability, possibly prioritizing debt servicing over green practices.

For log_Firmsize, the coefficient is positive at 0.0430, suggesting that larger firms tend to have better environmental performance. However, this result is not statistically significant (p-value = 0.194). This finding aligns with expectations that larger firms have more resources and capacity to implement sustainability initiatives, but the lack of significance implies that firm size alone may not be a decisive factor in driving better environmental outcomes. Asset Turnover also shows a positive but insignificant relationship with ESG performance, with a coefficient of 0.0115 and a p-value of 0.541. This suggests that the efficiency with which firms use their assets to generate revenue may not play a major role in their environmental performance, at least within the confines of this model. Finally, the constant term (cons) has a positive and highly significant coefficient of 3.3538 (p-value < 0.001), indicating that, when all other factors are held constant, firms still maintain a certain level of environmental performance. This baseline level of performance could be influenced by external pressures such as regulations, public expectations, or industry standards, which push firms to maintain a certain environmental standard regardless of their specific tax strategies or profitability. The results for analyzing the first model suggest that taxation policies, specifically tax rates and subsidies for green technologies, do not have a statistically significant influence on the environmental performance of firms in this model. However, profitability appears to have a significant negative impact, indicating that highly profitable firms may not prioritize environmental performance. Leverage also shows a potential negative relationship, suggesting financial constraints may hinder sustainability efforts. Overall, the findings indicate that while taxation policies are a critical tool in encouraging sustainability, they may need to be complemented by other measures that address profitability incentives and financial constraints within firms.

4.1.2. Model 2

The results of the regression for Hypothesis 2, which posits that economic incentives embedded in taxation policies reduce financial barriers and encourage businesses to invest in

sustainable technologies and practices in freight transportation, provide valuable insights into the relationships between the variables. First, Tax Incentives are found to have a negative coefficient of -0.0204, but with a p-value of 0.380, this relationship is not statistically significant. This implies that while the negative coefficient suggests that higher tax incentives might reduce environmental sustainability performance, the lack of significance suggests that this effect is not robust. Therefore, economic incentives in the form of tax breaks or benefits may not directly influence environmental performance as expected within this model, indicating the need for a more comprehensive strategy that combines taxation with other forms of support or encouragement for businesses to adopt sustainable practices. Upfront Costs have a coefficient of -0.0003 with a p-value of 0.786, which is also not statistically significant. This suggests that the initial financial investments required to adopt sustainable technologies or practices do not have a strong impact on the overall environmental sustainability of firms. This could indicate that firms are either finding ways to finance these costs or that the upfront financial burdens are not the primary determinant of whether a firm invests in sustainable technologies.

A key observation is the result for Firm Size, which has a coefficient of 0.000006 and a p-value of 0.054, indicating that this variable is just shy of the conventional 5% significance level. However, the nearly significant result suggests that larger firms tend to be more environmentally sustainable, possibly because they have more resources to invest in green technologies and can absorb the costs of sustainable practices more easily than smaller firms. The positive relationship between firm size and environmental performance supports the idea that bigger companies are better positioned to take on sustainability initiatives, as they can leverage their scale and financial capacity to implement eco-friendly strategies effectively. Profitability shows a negative relationship with sustainability, with a coefficient of -579.56 and a p-value of 0.059, similar to firm size, indicating that the result is close to being statistically significant. The negative coefficient suggests that more profitable firms might not necessarily invest more in sustainability, which could be due to a prioritization of profit maximization over environmental initiatives. This finding may indicate that firms with higher profitability could be focusing on other financial priorities rather than directing resources toward sustainability. However, given that the p-value is marginally above the 5% threshold, this relationship should be interpreted with caution.

Revenue Growth is a significant variable in this model, with a coefficient of -0.000947 and a p-value of 0.014, suggesting a statistically significant negative relationship between revenue growth and sustainability. This indicates that as firms experience higher revenue growth, their sustainability performance tends to decrease. The negative relationship may highlight a trade-off between growth

and sustainability, where firms that are rapidly expanding might focus on scaling their operations and increasing profits at the expense of environmental concerns. This underscores the challenge for fast-growing firms to balance economic expansion with the adoption of sustainable practices, as rapid growth might divert attention and resources away from long-term sustainability objectives.

Leverage does not show a significant relationship with environmental performance, with a coefficient of 1.1083 and a p-value of 0.890, indicating no strong evidence that firms' debt levels influence their sustainability efforts in a meaningful way. This finding suggests that the financial obligations of firms may not be a key determinant of whether they invest in sustainable practices, at least in the context of this model. The results provide mixed support for Hypothesis 2. While some variables, like revenue growth, show significant impacts on environmental performance, the expected role of tax incentives in mitigating financial barriers and promoting sustainability does not appear to hold strong in this model. The findings highlight the complexity of promoting sustainability through economic and financial incentives alone, suggesting that a broader set of policies and business strategies may be needed to encourage the widespread adoption of sustainable technologies in the freight transportation sector.

4.1.3. Model 3

The results of Model 3, which investigates the relationship between CSR (Corporate Social Responsibility) initiatives and overall sustainability (measured by the ESG score), show several key insights into the impact of economic, social, and financial factors. The coefficient for Economic Incentives/CSR is -0.032, with a p-value of 0.000, indicating a strong negative and statistically significant relationship with overall sustainability. This finding suggests that as firms engage more in CSR initiatives, their ESG scores could paradoxically decline. This counterintuitive result might be explained by potential trade-offs or complexities in how these firms are balancing social responsibility with other factors that impact their overall ESG scores. On the other hand, Market Share exhibits a positive and statistically significant relationship with ESG, with a p-value of 0.004. This suggests that firms with larger market shares are in a better position to improve their sustainability performance. The ability to leverage greater resources and influence might allow these firms to better align their operations with sustainability goals. Additionally, Growth Opportunities show a significant negative relationship with sustainability, reflected by a coefficient of -0.000 (p-value of 0.000***), indicating that firms focusing on growth might be sacrificing sustainability in favor of financial expansion.

Other variables in the model, including Firm Size, Profitability, Leverage, and Asset Turnover, do not show statistically significant relationships with overall sustainability, as reflected by their p-values: 0.260 for Firm Size, 0.074 for Profitability, 0.831 for Leverage, and 0.643 for Asset Turnover. These results suggest that these variables may not play a direct role in determining sustainability outcomes, or their effects may be mediated through other factors not captured in this specific model. Despite their lack of statistical significance, these variables still contribute to understanding the broader context of how firms manage financial and operational factors alongside sustainability objectives. The findings of this model underscore the complexity of achieving sustainability in firms, where economic incentives like CSR and market share play critical roles, while traditional financial metrics such as profitability and firm size appear less directly impactful. The significant negative relationship between Growth Opportunities and ESG suggests that rapid expansion may lead to compromises in sustainability practices. These results emphasize the need for a more nuanced approach to fostering sustainability, integrating economic performance, and CSR efforts to achieve long-term sustainability objectives.

5. Robustness Test

5.1. Heteroskedasticity Robust Standard Errors

In this study, we employed a Generalized Linear Model (GLM) to analyze the relationship between a firm's ESG performance and several key financial and economic variables. The dependent variable, ESG, measures the firm's environmental, social, and governance performance, which is increasingly important in modern corporate responsibility frameworks. Given the nature of the data, we specified a Gaussian family for the distribution of the dependent variable and used a log link function to ensure that the predictions were positive and allowed for nonlinear relationships between the predictors and the outcome. This log transformation captures the multiplicative effects that the independent variables may exert on ESG performance, providing a more flexible model than a simple linear specification.

(4)

$$ESG_t = \beta_0 + \beta_1 Tax\ Insentives_t + \beta_2 Prima_t + \beta_3 Capital_t + \beta_4 Profitability_t + \beta_5 Leverage_t + \beta_6 Growth\ Opportunities_t + \epsilon_{it}$$

The model incorporates a variety of independent variables that influence ESG performance. These include tax incentives, which represent the financial incentives for sustainable practices, along with Prima and Capital, which account for the firm's premium-related expenses and overall capital availability, respectively. Firm-specific factors such as Profitability and Leverage were included to capture differences in financial performance and obligations across firms. Additionally, Growth Opportunities reflect the firms' potential for expansion and innovation, which are critical in determining their ability to invest in sustainability efforts.

[Insert Table 4.]

To ensure the validity and reliability of our findings, we applied heteroskedasticity robust standard errors in the estimation of the model. This approach addresses the issue of heteroskedasticity, where the variance of the error terms may differ across observations. In real-world datasets, particularly in the context of financial and sustainability data, it is common for the variance of residuals to vary due to unobserved factors such as firm-specific idiosyncrasies or external economic shocks. If left uncorrected, heteroskedasticity can lead to inefficient estimates and biased standard errors, which could result in incorrect conclusions about the significance of the relationships between variables. By using heteroskedasticity robust standard errors, we correct for these potential inconsistencies, thereby improving the robustness of our statistical inferences. This method ensures that the p-values and confidence intervals of our estimates are reliable, even in the presence of heteroskedasticity. Employing this robustness check strengthens the credibility of our results, particularly when assessing the statistical significance of the independent variables in relation to ESG performance.

In the GLM regression model, heteroskedasticity-robust standard errors were applied to ensure that the results are more reliable and less affected by any inconsistencies in the variance of the error terms. This method helps address potential biases in the coefficients, which could arise from heteroskedasticity, where the variability of the dependent variable differs across levels of an independent variable. By using robust standard errors, we ensure that the test statistics and confidence intervals are accurate, thereby making the model results more trustworthy. Several key findings stand out in this robustness analysis, particularly regarding the significance of financial factors in shaping ESG performance. Profitability has a negative and significant impact on ESG performance, with a coefficient of -542.430 and a p-value of 0.0196. This result suggests that firms with higher profitability may be less inclined to perform well on environmental metrics, possibly due to a focus on financial gains over sustainability initiatives. In contrast, Capital shows a positive and highly

significant coefficient of 0.000 with a p-value of 0.000, indicating that firms with greater capital resources are better positioned to improve their ESG scores. Additionally, Growth Opportunities exhibit a negative and significant relationship with ESG performance, with a coefficient of -0.000 and a p-value of 0.000. This suggests that rapidly growing firms might struggle to balance expansion with sustainability efforts, potentially prioritizing growth over environmental responsibility. Similarly, CSR also has a significant negative impact on ESG performance, with a coefficient of -0.034 and a p-value of 0.000, indicating that firms heavily focused on CSR might find it challenging to maintain high environmental standards simultaneously. The consistent significance of these variables underscores the complex interplay between financial performance, growth, and sustainability in shaping ESG outcomes.

5.2. Panel Data with Clustered Standard Errors

We use Panel Data with Clustered Standard Errors in this analysis to account for the structure of the data, where observations are repeated for different entities (e.g., firms or countries) over time. In panel data, observations within the same cluster, such as a firm, are likely to be correlated across time, which violates the assumption of independent observations required for traditional regression methods. If this correlation is ignored, it can lead to underestimated standard errors, resulting in overstated statistical significance of the estimated coefficients. By clustering the standard errors on a variable representing the different entities, we adjust for this within-group correlation, producing more accurate standard errors, p-values, and confidence intervals. This approach allows us to obtain robust inferences, even in the presence of heteroskedasticity or autocorrelation within clusters. Moreover, the clustered standard errors method is particularly useful in empirical research that involves multiple observations for the same entity across time. It ensures that the variability within each cluster is properly accounted for, leading to more reliable conclusions. In the context of this study, where we are examining the impact of economic, organizational, and financial variables on firms' environmental performance (ESG), this method provides a more robust test of the hypotheses. It corrects for any potential biases in standard errors that could arise from the panel structure of the data, ensuring that the relationships between key independent variables and ESG outcomes are accurately captured.

In the panel data analysis, we employ Panel Data with Clustered Standard Errors to introduce robustness to our model by accounting for potential correlations within clusters of data. The dependent variable in our model is Environmental, Social, and Governance (ESG) performance,

while the independent variables include Tax Incentives, Pretax Income, Liability, Profitability, Leverage, Market Share, Growth Opportunities, and Corporate Social Responsibility (CSR). This method is particularly effective in panel data settings where observations within the same group might exhibit correlation, which can bias standard error estimates. By clustering standard errors, we ensure that the variability within each group is accurately represented, providing more reliable inferences about the estimated relationships between variables. The Panel Data with a Clustered Standard Errors model allows for heteroskedasticity and autocorrelation within clusters while ensuring consistency across different clusters. This approach is critical in panel data analysis because it adjusts for potential biases in standard errors caused by repeated observations within the same clusters. Without this adjustment, standard errors could be underestimated, leading to overstated test significance. Clustering helps mitigate this risk by reflecting the true variability in the data and ensuring that p-values and confidence intervals are reliable. This robustness check aligns well with our model by providing more precise estimates of the relationships between the independent variables such as Tax Incentives, Profitability, and CSR—and the dependent variable, ESG performance.

(5)

$$ESG_{it} = \beta_0 + \beta_1 Tax\ Insentives_{it} + \beta_2 Pretax\ Income_{it} + \beta_3 Liability_{it} + \beta_4 Profitability_{it} + \beta_5 Leverage_{it} + \beta_6 Marketshare_{it} + \beta_7 Growth\ Opportunities_{it} + \beta_8 CSR_{it} + \epsilon_{it}$$

where i indexes' entities (such as firms or central banks), and t indexes time (years). ESG represents the environmental, social, and governance performance of the entity in year t. The independent variables include Tax Incentives, which is an economic variable influencing sustainable practices. The model also incorporates Pretax Income as a measure of financial performance and Liability, which represents the entity's total liabilities. Profitability, Leverage, and CSR are included as key financial performance indicators and corporate social responsibility variables, respectively. Market Share captures the entity's share within its respective market, while Growth Opportunities represent the potential for future expansion. The error term ϵit\epsilon_{it}ϵit accounts for unexplained variation within the model. This model captures the relationship between economic incentives, financial performance, and ESG outcomes for entities over time, allowing for a robust understanding of how sustainability is shaped by economic and financial factors.

[Insert Table 5.]

The results from this panel model align with the hypotheses by examining the effects of key economic, organizational, and financial factors on an entity's environmental performance. The hypotheses suggest that economic incentives, such as tax incentives, alongside organizational factors like profitability, leverage, market share, and CSR practices, influence the entity's sustainability outcomes. The regression results provide several significant findings that support or challenge the hypotheses. The Profitability has a negative and significant effect on ESG (Coefficient = -842.846, p = 0.021), suggesting that higher profitability might be associated with lower ESG performance, possibly due to profit-maximizing behaviors that overlook sustainability. Similarly, Growth Opportunities are negatively and significantly associated with ESG (Coefficient = -0.001, p = 0.004), indicating that entities focusing on growth may deprioritize environmental considerations, potentially to the detriment of sustainability. Additionally, CSR also shows a negative and significant effect on ESG (Coefficient = -0.816, p = 0.012), implying that while CSR efforts are important, they may not immediately lead to improved environmental outcomes. These results offer robust insights, confirming or refining the initial hypotheses by accounting for potential within-cluster correlations and providing a more nuanced understanding of the factors influencing environmental performance in organizations.

6. Contribution and Conclusion

The findings of this research shed light on the intricate and often unexpected relationships between economic incentives, corporate social responsibility (CSR), financial performance, and sustainability outcomes. One of the key takeaways is the complexity involved in using traditional economic tools like tax rates and incentives to promote sustainability (Lozano, 2020; Ribeiro Siman et al., 2020). While it might seem intuitive that lowering tax burdens or providing subsidies for green initiatives would lead to more environmentally friendly practices, the results show that these factors alone may not significantly impact sustainability performance. This suggests that sustainability is not merely an outcome of financial incentives; it involves a broader set of conditions, including regulatory environments, corporate strategies, and perhaps even the cultural context in which these firms operate. Therefore, economic tools must be part of a more comprehensive framework that addresses the multifaceted nature of sustainability challenges. The surprising result that CSR activities have a negative association with sustainability scores raises important questions about how CSR is implemented and measured. While CSR is generally assumed to be beneficial for sustainability, our findings suggest that firms engaging heavily in CSR might experience unintended

consequences that detract from their overall sustainability performance (Baird et al., 2012; Lee & Lee, 2019). One possible explanation could be that firms focus on highly visible social initiatives while neglecting deeper, systemic changes needed to improve environmental outcomes. Alternatively, CSR initiatives might be more about enhancing the firm's public image rather than making meaningful contributions to long-term sustainability. These findings underscore the need for companies to adopt a more integrated approach to CSR, one that aligns with both their financial strategies and long-term environmental goals. Moving forward, firms should ensure that their CSR efforts are not merely symbolic but substantively contribute to sustainability in a holistic way.

Firm size and profitability are also revealed to be more nuanced factors in determining sustainability. Contrary to the expectation that larger firms, with more resources at their disposal, would naturally perform better in terms of sustainability, the study found that firm size alone does not guarantee better environmental outcomes. Similarly, while profitability is often viewed as providing the financial means to invest in green initiatives, our findings suggest that higher profitability can sometimes be associated with poorer sustainability performance. This may be because profitable firms prioritize short-term financial gains, such as expanding their market share or optimizing their returns, over the long-term investments necessary to improve sustainability. This insight calls for a reevaluation of how we understand the relationship between financial success and sustainability. It suggests that, for sustainability to be prioritized, it must be embedded deeply within corporate strategy rather than viewed as a peripheral concern to financial performance. Lastly, the trade-off between growth and sustainability is an important dynamic highlighted by this study. The significant negative relationship between revenue growth and sustainability performance indicates that firms that are growing rapidly may often prioritize expansion and profitability over their environmental commitments. This presents a challenge for firms and policymakers alike, as it shows that rapid growth can come at the expense of sustainability. As firms scale up their operations, they may find it difficult to maintain the same level of focus on sustainability initiatives, leading to a decline in their ESG performance. For sustainable development to truly take root, there must be a balance between growth and environmental responsibility. This finding underscores the importance of developing policies and strategies that encourage firms to pursue growth in a way that is compatible with long-term sustainability objectives, ensuring that environmental and social considerations are not sacrificed in the pursuit of economic success.

7. Limitations

This study, titled " Green Taxes and Economic Incentives: Driving Sustainability in Freight Transportation" provides valuable insights into the economic mechanisms influencing sustainability within the freight transportation sector. However, several limitations should be acknowledged to better contextualize the findings. One of the primary limitations is related to the scope of data available for analysis. The study leverages aggregated data on environmental, social, and governance (ESG) metrics, along with firm-level financial indicators, but does not delve deeply into specific environmental practices or detailed components of sustainability efforts within firms. This lack of granularity could obscure the nuanced ways in which different dimensions of sustainability environmental, social, and governance are impacted by economic incentives and green taxation policies. Moreover, the study's focus on freight transportation firms limits its generalizability to other sectors where the dynamics between economic performance and sustainability may differ.

Another limitation stems from potential endogeneity and omitted variable bias. Despite efforts to include key financial and operational variables, unobserved factors such as variations in regulatory environments, management strategies, or regional differences may influence both sustainability outcomes and the adoption of green taxation incentives. The exclusion of these variables may introduce bias into the estimates and lead to incomplete conclusions. Moreover, although the use of Generalized Linear Models (GLM) addresses certain issues, such as non-normality and heteroskedasticity, the study still faces challenges related to model assumptions. For instance, the potential for non-linear relationships or time-dependent changes in firm behavior, which are difficult to capture with cross-sectional data, could affect the robustness of the findings. Lastly, the study's reliance on cross-sectional data presents limitations in determining causality. While the analysis uncovers significant relationships between variables such as profitability, tax incentives, CSR, and sustainability outcomes, the data only provide a snapshot in time, making it difficult to assess the direction of these relationships. For example, while the study identifies that profitability may be negatively associated with sustainability, it is unclear whether firms deprioritize sustainability as they become more profitable or if other factors, such as increased market pressures, drive this behavior. Longitudinal data tracking firms over time would better allow for assessing the causality of these relationships and understanding how green taxes and other economic incentives influence the adoption of sustainable practices over time. Additionally, implementing instrumental variables or propensity score matching methods could help mitigate endogeneity issues and provide more robust

causal inferences. Despite these limitations, this study serves as a critical first step in exploring the role of economic incentives in promoting sustainability within the freight transportation sector.

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Figures

Figure 3.1.1: Scatter Plot with Color-coded Countries (Impact of Tax Rate on ESG Scores by Country)

Figure 1.1 presents the Scatter Plot with Color-coded Countries. The scatter plot shows individual data points for ESG scores against tax rates, with each country represented by a unique color and marker style. This highlights the distribution of ESG scores and tax rates for each country.

Figure 3.1.2: Trend Lines by Country

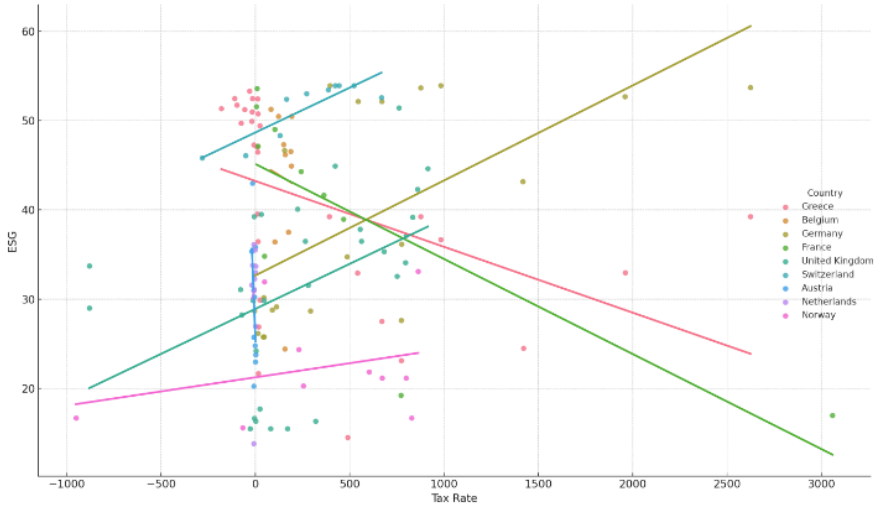

Figure 1.2 presents the trend Lines by Country. The trend lines indicate the general relationship between tax rates and ESG scores for each country. Some countries show a positive relationship (e.g., Belgium), while others display a negative trend (e.g., Germany), which could imply that the regulatory tax environment influences ESG practices differently across countries.

Figure 3.2: Scatterplot Matrix for Key Variables in the First Hypothesis

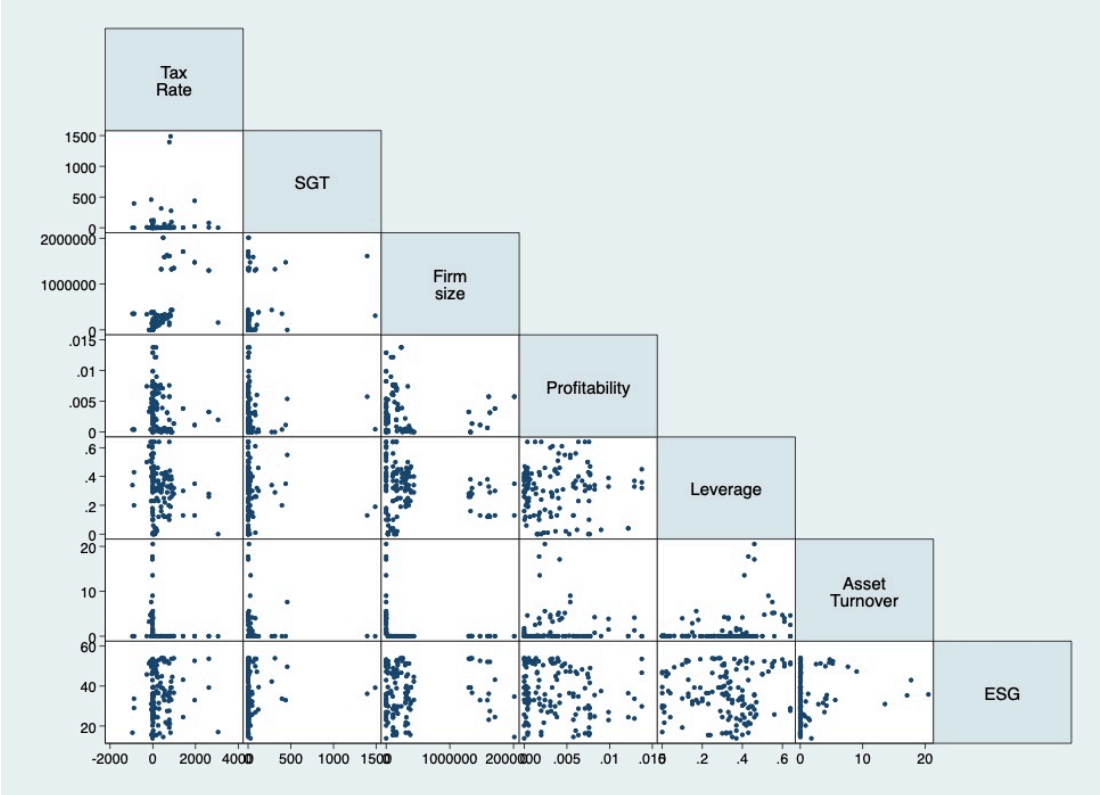

Figure 2 presents the scatterplot matrix and provides a visual representation of the relationships between the variables included in the first model, such as Tax Rate, SGT (Subsidies for Green Technologies), Firm Size, Profitability, Leverage, Asset Turnover, and ESG (Environmental, Social, and Governance performance). This matrix offers insights into how these key economic, financial, and environmental variables interact with one another, helping to identify potential patterns or correlations.

Figure 3.2: Scatterplot Matrix for Key Variables in the Second Hypothesis

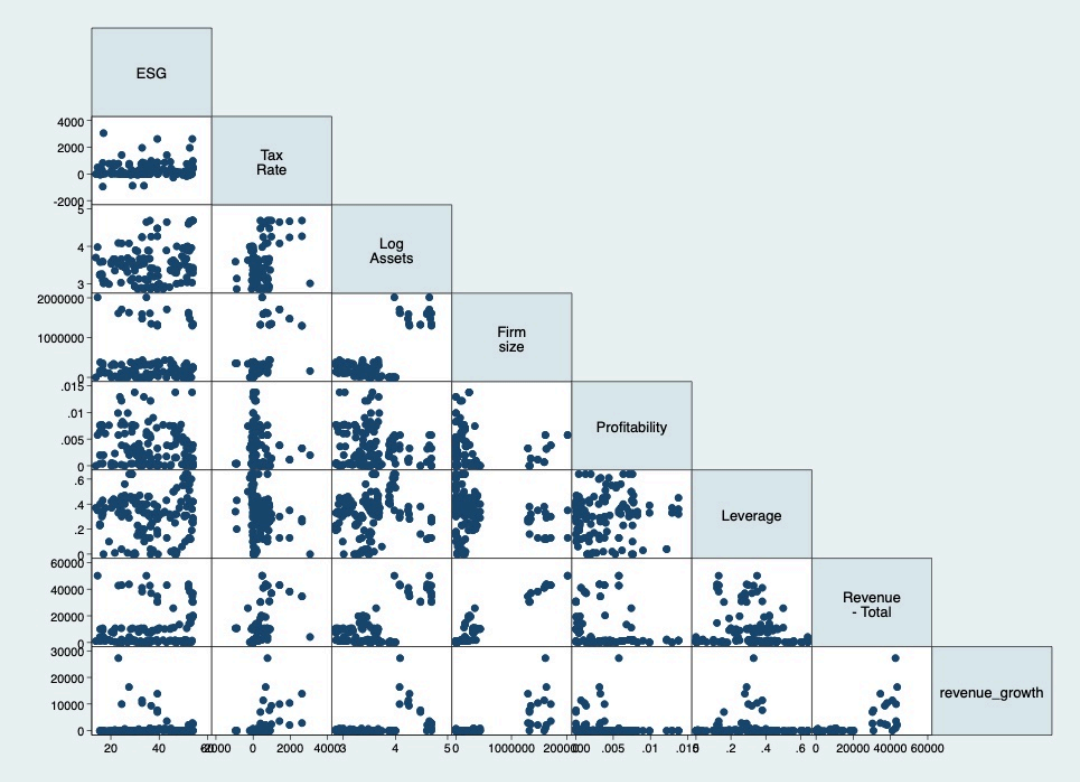

Figure 3 represents the scatterplot matrix and a visual representation of the relationships between key variables in the second model, including Tax Rate, Firm Size, Profitability, Leverage, Revenue Total (Market Share), and revenue_growth (Growth Opportunities). This matrix helps to identify potential linear or non-linear correlations between the variables, allowing for a more intuitive understanding of how they interact.

Figure 3.3: Scatterplot Matrix for Key Variables in the Third Hypothesis

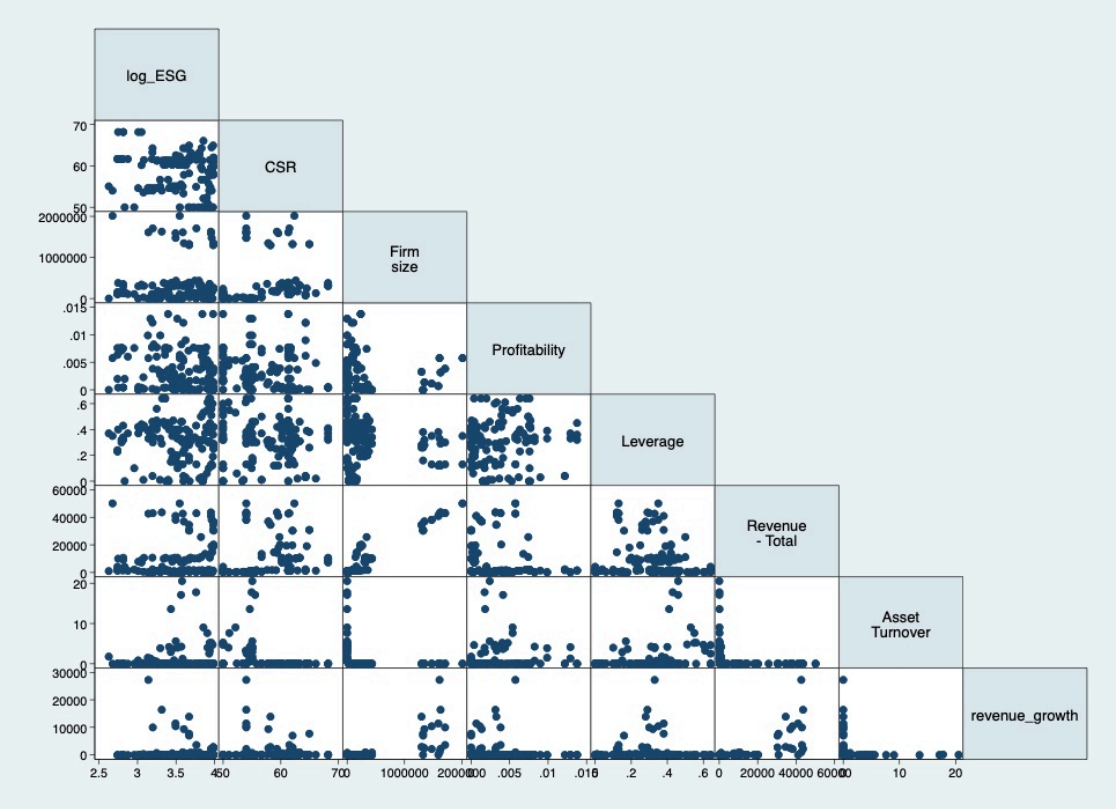

Figure 4 represents the scatterplot matrix and provides a visual representation of the relationships between key variables in the third model, including log_ESG (Overall Sustainability), Environmental Impact (CSR), Firm Size, Profitability, Leverage, Revenue Total, Asset Turnover, and revenue_growth (Growth Opportunities). This matrix assists in identifying potential linear or non-linear correlations between the variables, offering an intuitive way to observe how these financial, operational, and sustainability-related factors interact.

Tables

Table 3.1. Descriptive Statistics of Key Variables

Descriptive Statistics					
Observations			140		
	mean	min	max	p50	p75
ESG	36.549	13.822	53.938	36.143	47.294
Tax Rate	302.654	-950.161	3,058.556	95.794	531.279
SGT	44.631	0.006	1,488.000	1.952	9.020
Firm size	353,773.200	144.065	2,012,329.000	163,513.100	340,843.000
Profitability	0.004	0.000	0.014	0.002	0.006
Leverage	0.310	0.000	0.640	0.325	0.420
Asset Turnover	1.168	0.001	20.532	0.014	0.088
Tax Incentives	22.868	0.000	256.685	5.120	20.068
Upfront Costs	529.125	83.333	5,667.000	180.424	306.850
Economic Incentives	347.285	-949.385	3,060.163	114.020	552.866
Liabilities - Total	338,044.700	35.887	1,957,919.000	160,830.200	324,476.000
Pretax Income	542.549	-6,805.000	3,883.000	656.075	1,227.000
Market share	9,478.860	61.842	50,092.000	1,849.963	10,686.000
Income Taxes - Total	325.522	-842.000	3,059.000	97.959	535.000
Log Assets	3.558	2.860	4.690	3.515	3.805
Capital	5,140.635	398.760	44,770.700	2,432.830	4,972.865
Environmental Impact/CSR	58.033	50.000	68.200	59.475	61.430
Prima	0.469	0.000	0.956	0.519	0.667

Table 1 provides the descriptive statistics for the key variables used in the study, covering the period from 2012 to 2021. The table includes 140 observations and reports each variable's mean, minimum, maximum, median (P50), and 75th percentile (P75). The data have been winsorized at the 1st and 99th percentiles to reduce the influence of outliers. The variables cover various financial and operational metrics such as environmental performance (ESG), tax rates, subsidies for green technologies (SGT), firm size, profitability, leverage, asset turnover, tax incentives, upfront costs, as well as broader indicators like liabilities, pretax income, revenue, stockholders' equity, CSR, and Prima. This provides an overall view of these variables' distribution and central tendencies within the sample.

Table 3.2. Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) ESG	1															
(2) Tax Rate	0.060	1														
(3) SGT	0.053	0.122	1													
(4) Firm Size	0.063	0.559***	0.187*	1												
(5) Profitability	-0.147	-0.190*	-0.072	-0.180*	1											
(6) Leverage	0.005	-0.170*	-0.082	-0.135	0.025	1										
(7) Asset Turnover	0.088	-0.206*	-0.021	-0.249**	0.015	0.268**	1									
(8) Tax Incentives	0.014	-0.071	-0.010	-0.089	-0.294***	0.265**	0.046	1								
(9) Upfront Costs	-0.034	-0.073	-0.034	-0.146	0.019	-0.619***	-0.124	-0.167*	1							
(10) Economic Incentives	0.071	0.955***	0.412***	0.569***	-0.196*	-0.181*	-0.196*	-0.068	-0.077	1						
(11) Liabilities Total	0.057	0.556***	0.187*	1.000***	-0.174*	-0.135	-0.248**	-0.091	-0.145	0.566***	1					
(12) Pretax Income	0.144	0.292***	0.040	-0.030	0.085	0.0251	-0.097	0.042	-0.032	0.280***	-0.033	1				
(13) Market Share	0.127	0.555***	0.184*	0.961***	-0.235**	-0.109	-0.247**	-0.076	-0.167*	0.564***	0.958***	-0.0255	1			
(14) Capital	0.259**	0.432***	0.174*	0.714***	-0.164	-0.004	0.049	-0.086	-0.142	0.449***	0.711***	-0.0101	0.659***	1		
(15) CSR	-0.262**	0.051	0.055	0.167*	-0.155	-0.040	-0.301***	0.125	-0.060	0.063	0.163	0.0956	0.187*	0.056	1	
(16) Prima	-0.064	-0.165	-0.035	-0.122	0.752***	0.023	0.360***	-0.231**	0.037	-0.162	-0.116	-0.162	-0.179*	-0.063	-0.311***	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2 presents the pairwise correlation coefficients for the variables included in the analysis, spanning the period from 2012 to 2021, with 140 observations. The variables assessed in this table include ESG, Tax Rate, Subsidies for Green Technologies (SGT), Firm Size, Profitability, Leverage, Asset Turnover, Tax Incentives, Upfront Costs, Economic Incentives, Liabilities, Pretax Income, Revenue, Capital, CSR, and Prima. Statistical significance is denoted by *, **, and ***, representing the 5%, 1%, and 0.1% levels, respectively. The variables are winsorized at the 1% and 99% levels to minimize the effect of outliers. Bonferroni adjustments were applied to the significance levels.

Table 3.3. Generalized Linear Multi-Regression Results

Model 1							
Dependent variable: ESG (Environmental Impact)							
	Intercept	***log_TaxRate***	***SGT***	***log_Firmsize***	***Profitability***	***Leverage***	***AssetTurnover***
Intercept	3.353	-0.019	-2.561	0.042	-20.190	-0.374	0.011
	(0.000***)	(-0.463)	(0.986)	(0.194)	(0.046*)	(0.068)	(0.541)
AIC (Akaike Information Criterion): 7.80493							
BIC (Bayesian Information Criterion): 12,466.38							
Observation: 131							
Model 2							
Dependent variable: ESG (Adoption of Sustainable Practice)							
	Intercept	***Tax Incentives***	***Upfront Cost***	***Firmsize***	***Profitability***	***Leverage***	***GrowthOpportunities***
Intercept	38.814	-0.020	-0.000	5.995	-579.569	1.108	-0.000
	(0.000***)	(0.380)	(0.786)	(0.054)	(0.059)	(0.890)	(0.014*)
AIC (Akaike Information Criterion): 7.714146							
BIC (Bayesian Information Criterion): 14833.62							
Observation: 131							
Model 3							
Dependent variable: ESG (Overall sustainability)							
	Intercept	***Economic Incentives/CSR***	***Firmsize***	***Profitability***	***Leverage***	***MarketShare***	***AssetTurnover***	***GrowthOpportunities***
Intercept	5.454	-0.032	-2.261	-14.056	-0.033	0.000	0.003	-0.000
	(0.000***)	(0.000***)	(0.260)	(0.074)	(0.831)	(0.004**)	(0.643)	(0.000***)
AIC (Akaike Information Criterion): 0.413663								
BIC (Bayesian Information Criterion): -589.3832								
Observation: 131								

Table 3 presents the results of the Generalized Linear Model (GLM) regression for the third model, focusing on overall sustainability. This model examines the relationship between ESG (Overall Sustainability) as the dependent variable and several independent variables: Economic Incentives/CSR, Firm Size, Profitability, Leverage, Market Share, Asset Turnover, and Growth Opportunities. The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values provide an assessment of model fit, showing how well the model captures the data. The model is based on 131 observations. The analysis indicates that Economic Incentives/CSR and Market Share exhibit significant relationships with ESG (Overall Sustainability), as indicated by their highly significant p-values. Although some other variables like Profitability and Leverage have weaker significance levels, they still play a role in the overall sustainability equation. The model uses Bonferroni adjustment to correct for multiple comparisons and winsorizes the data at the 1% and 99% levels to mitigate the influence of outliers. The reported t-statistics and coefficients are derived from robust standard errors that account for autocorrelation. Statistical significance is denoted by ∗, ∗∗, and ∗∗∗, representing the 1%, 5%, and 10% levels, respectively. The table provides coefficients and t-statistics, with all standard errors and p-values displayed in parentheses.

Table 3.4. Robustness Regression Results (Heteroskedasticity Robust Standard Errors)

Robustness Regression Results								
Heteroskedasticity Robust Standard Errors								
Dependent variable: ESG								
	Intercept	***Tax Incentives***	***Prima***	***Capital***	***Profitability***	***Leverage***	***Growth Opportunities***	***CSR***
Intercept	38.310	-0.013	-0.134	0.000	-542.430	-0.305	-0.000	-0.034
	(0.000***)	(0.543)	(0.976)	(0.000***)	(0196)	(0.956)	(0.000***)	(0.000***)
R-Squared: 0.1410								
Root MSE: 10.845								
Observation: 131								

Table 4 reports the robustness regression results using heteroskedasticity-robust standard errors. The dependent variable is ESG, and the independent variables include Tax Incentives, Prima, Capital, Profitability, Leverage, Growth Opportunities, and CSR. The table provides the coefficients, standard errors, and p-values for each variable. The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values are reported to assess model fit, with 131 observations included in the analysis. All variables are winsorized at the 1% and 99% levels to minimize the influence of outliers. Bonferroni adjustments are applied to the significance levels, and the t-statistics are derived from robust standard errors that account for heteroskedasticity. The significance levels are represented by ∗, ∗∗, and ∗∗∗, corresponding to the 1%, 5%, and 10% levels, respectively. Coefficients and t-statistics are presented, with all standard errors and p-values reported in parentheses.

Table 3.5. Robustness Regression Results (Panel Data with Clustered Standard Errors)

Robustness Regression Results

Panel Data with Clustered Standard Errors

Dependent variable: ESG

	Intercept	***Tax Incentives***	***PreTax Income***	***Liability***	***Profitability***	***Leverage***	***MarketShare***	***GrowthOpportunities***	***CSR***
Intercept	5.495	0.032	0.000	5.281	-842.846	9.741	0.000	-0.001	-0.816
	(0.000***)	(0.073)	(0.165)	(0.978)	(0.021*)	(0.167)	(0487)	(0.004**)	(0.012*)
Sigma_u: 9.522									
Sigma_e: 6.976									
Rho: 0.650									
Observation: 131									

Table 5 presents the robustness regression results for the dependent variable ESG using panel data with clustered standard errors. The model includes key independent variables such as Tax Incentives, Pretax Income, Liability, Profitability, Leverage, Market Share, Growth Opportunities, and CSR. The results indicate that the model effectively controls for the effects of these variables on ESG performance, with adjustments for potential heteroskedasticity and autocorrelation through the use of clustered standard errors. Significant predictors in the model include Profitability, Growth Opportunities, and CSR, highlighting their impact on ESG outcomes. All variables are winsorized at the 1% and 99% levels to minimize the influence of outliers. Bonferroni adjustments are applied to the significance levels, and t-statistics are derived from robust standard errors. Significance levels are represented by ∗, ∗∗, and ∗∗∗, corresponding to the 1%, 5%, and 10% levels, respectively. Coefficients and t-statistics are presented, with standard errors and p-values reported in parentheses.

Appendix

Appendix A. Descriptions, Definitions, and Sources of Data

Variables	Descriptions and Definitions	Source
Environmental Impact (ESG)	Dependent variable measured through metrics such as carbon emissions reduction and energy consumption.	Derived from ESG data in Datastream, Orbis company sustainability reports, and relevant environmental metrics.
Tax Rate	Level of taxes imposed on freight activities.	Authors' own calculation; Sourced from national and regional tax databases available in Datastream.
Subsidies for Green Technologies (SGT)	Proxied by the capital expenditures allocated towards environmental projects, representing the financial investments made by firms or governments to adopt and support green technologies.	Sourced from financial statements in Datastream and Orbis.
Adoption of Sustainable Practices	Extent to which businesses implement green technologies and practices.	Derived from ESG data and company reports in Datastream.
Tax Incentives	Represents the deferred tax liabilities, reflecting future tax benefits or obligations resulting from timing differences in tax payments.	Sourced from financial reports and ESG data in Datastream.
Upfront Costs	Total value of assets owned by a company, used as a proxy for the initial capital required to adopt sustainable practices.	Sourced from financial reports and ESG data in Datastream.
Firm Size	Logarithmic measure of the firm's size.	Sourced from financial statements in Datastream and Orbis.
Profitability	Profit margins or net income to revenue ratio of firms.	Derived from company financial statements in Datastream and Orbis.
Leverage	Financial leverage, calculated as the ratio of a company's total debt to its equity.	Derived from company financial statements in Datastream and Orbis.
Market Share	Represents the total revenue generated by a company, reflecting its overall market share and financial performance within the industry.	Derived from company financial reports in Datastream.
Asset Turnover	Ratio of a firm's revenue to its assets, indicating how efficiently assets are used to generate revenue.	Derived from company financial reports in Datastream.
Growth Opportunities	Represents the growth potential of firms, measured by the *Revenue Growth Rate.*	Derived from company financial reports in Datastream.
Corporate Social Responsibility (CSR)	CSR initiatives measured through ESG data, reflecting the firm's social and governance practices.	Derived from ESG data in Datastream, and Orbis company sustainability reports.
Overall Sustainability (ESG)	Represents the overall sustainability performance of firms, measured as the *log of ESG* score	Author's calculation.

Conclusion

This thesis has examined the diverse factors shaping sustainability in the European freight transportation sector through three distinct yet interconnected lenses: central bank regulations, sustainable accounting practices, and economic incentives. Each of these dimensions provides a unique perspective on the complex landscape of sustainability, revealing both the challenges and opportunities faced by the freight industry as it seeks to balance economic growth with environmental stewardship. By analyzing central bank regulations, sustainable accounting frameworks, and fiscal policies, this research provides a comprehensive overview of the mechanisms driving and occasionally hindering sustainability in this critical sector. This conclusion will summarize the findings of each essay, discuss their implications, and offer recommendations for future research and policy development.

The first essay explored the role of central bank regulations in shaping sustainable practices within the freight transportation industry. Central banks, as key monetary policymakers, have a unique ability to influence corporate behavior through their regulatory frameworks, including liquidity requirements, return-on-equity (ROE) expectations, and broader financial stability mandates. While central banks are increasingly adopting sustainable finance objectives, this study highlights an inherent tension between traditional command-and-control regulations and sustainability goals. The findings of this essay reveal a counterintuitive relationship: while central banks' regulations are intended to promote long-term stability and economic sustainability, they may inadvertently restrict companies' ability to invest in green technologies and adopt sustainable practices (Breitenfellner, Andreas; Pointner, Wolfgang; Schuberth, 2019). Specifically, the analysis demonstrates that high ROE expectations and stringent regulatory compliance can limit the financial resources available to transportation firms for sustainable investments. This negative association suggests that overly rigid regulatory frameworks may stifle innovation and reduce the flexibility needed for companies to pursue environmentally friendly initiatives (Kennedy et al., 2005). These findings have important implications for policymakers. To support sustainability in freight transportation, central banks may need to adopt a more balanced regulatory approach that allows firms to align their financial goals with environmental objectives (Cecchetti, 2000). This could include integrating flexibility into compliance measures, offering incentives for sustainable investments, or adjusting liquidity requirements to account for green investments. Ultimately, the

study underscores the need for central banks to reconsider their approach to sustainable finance, emphasizing the importance of harmonizing regulatory goals with sustainability targets to promote a more resilient and environmentally responsible freight transportation sector.

The second essay focused on the integration of sustainability into accounting practices within the freight transportation industry, highlighting the need for robust frameworks that capture environmental, social, and governance (ESG) metrics (Jones, 2010). While accounting has traditionally centered on financial data, the increasing importance of sustainability in business has necessitated a shift toward incorporating non-financial metrics that reflect corporate responsibility and environmental impact. Through a systematic literature review, this essay reveals a significant gap in the existing literature: there is a lack of cohesive frameworks that integrate sustainability metrics into accounting practices, particularly in freight transportation. Although the field has witnessed an increase in scholarly interest in ESG metrics, the practical application of these metrics within accounting systems remains underdeveloped (Piatkowski et al., 2015). This poses challenges for practitioners who need reliable tools to track and report sustainability metrics and for stakeholders who rely on transparent reporting to assess corporate responsibility. The essay highlights the potential benefits of a conceptual framework based on substitution dynamics tracking shifts in transportation modes, trip chains, and destination preferences as part of a sustainable accounting model. By adopting such a framework, companies could measure and report the environmental and social impacts of their logistics decisions more accurately. This approach would also enhance transparency, allowing stakeholders to assess the sustainability of freight companies and make informed decisions based on reliable ESG data (Edwards et al., 2021). The implications of this essay extend beyond freight transportation to the broader accounting profession. For the accounting industry to support sustainable development, it must develop standardized frameworks that accurately capture non-financial data and account for the unique environmental impacts of each sector. This essay advocates for further research into sustainable accounting frameworks tailored to the specific needs of freight transportation, as well as the establishment of industry-wide standards that promote accountability and transparency (Carter & Rogers, 2008).

The third essay examined the effectiveness of economic incentives, including taxation policies and financial subsidies, in promoting sustainability in the European freight transportation sector. Economic incentives play a crucial role in shaping corporate behavior, especially in high-capital industries like transportation, where the adoption of green technologies can require significant

investment (Yip & Bocken, 2018). However, the analysis reveals a nuanced picture of the effectiveness of these incentives. Using generalized linear models, the study finds that while tax incentives and subsidies can help reduce financial barriers, their direct impact on sustainability outcomes is limited. Instead, the analysis suggests that firm characteristics, such as size, market share, and profitability, are more decisive in determining a company's commitment to sustainable practices. Larger firms and those with greater market power are better positioned to adopt sustainable technologies and make long-term investments in environmental initiatives (Ajeigbe et al., 2023). In contrast, smaller companies may struggle to balance profitability with environmental goals, particularly when economic growth is prioritized over sustainability. These findings highlight the complexity of promoting sustainability through economic incentives alone. For policymakers, the implications are clear: a one-size-fits-all approach to economic incentives may not be sufficient to drive sustainable practices across the freight transportation sector. Instead, policies should be tailored to account for firm characteristics and market dynamics, with targeted subsidies for smaller firms and incentives that reward sustainability efforts regardless of firm size. This essay underscores the need for a nuanced policy approach that aligns economic and environmental priorities, creating a supportive framework that encourages sustainable investment without compromising corporate profitability.

Collectively, the findings from these three essays provide a comprehensive understanding of the factors influencing sustainability in European freight transportation. By analyzing regulatory, accounting, and economic mechanisms, this thesis offers a multi-dimensional perspective on the sustainability challenges and opportunities in the sector. While each essay addresses a specific aspect of sustainability, the insights converge to emphasize the need for an integrated approach that harmonizes financial, regulatory, and operational objectives. One key theme that emerges across the essays is the importance of flexibility in regulatory and economic frameworks. As shown in the first essay, rigid central bank regulations may hinder companies' ability to invest in green technologies, suggesting that central banks must adopt a more adaptive approach that considers the unique needs of sustainable industries. The second essay highlights the critical role of transparency and accountability in promoting sustainability, advocating for accounting frameworks that integrate ESG metrics and reflect the true environmental impact of corporate actions (Pamucar et al., 2022). Finally, the third essay underscores the importance of economic incentives that are responsive to firm characteristics, recommending a tailored approach that supports small and large companies in their pursuit of sustainability.

The findings of this thesis have several important implications for policymakers, industry leaders, and researchers. First, central banks should explore regulatory approaches that align financial stability with sustainability goals. This may involve introducing sustainable finance guidelines that offer flexibility in meeting ROE requirements or provide incentives for green investments. By fostering a regulatory environment that encourages sustainability, central banks can play a more proactive role in supporting the environmental transition of the freight sector. Second, there is a pressing need for the accounting profession to establish standardized frameworks for sustainable accounting, particularly in high-impact sectors like freight transportation. Industry associations, regulatory bodies, and academic institutions should collaborate to develop guidelines that integrate ESG metrics into accounting practices, ensuring that companies have the tools to measure and report their environmental performance effectively (Seuring, 2013). Third, economic incentives for sustainability should be carefully calibrated to address the diverse needs of firms within the freight transportation sector. Policymakers should consider providing targeted subsidies and tax incentives to smaller companies that may lack the financial resources of larger competitors, creating an equitable policy environment that promotes sustainability across the industry. At the same time, incentive structures should reward companies for sustained environmental performance rather than short-term compliance, encouraging long-term commitment to green practices.

This thesis also points to several areas for future research. The relationship between central bank regulations and sustainable transportation warrants further investigation, particularly in exploring alternative regulatory models that support green investments. Future studies could examine how specific regulatory adjustments, such as flexible liquidity requirements or ESG-linked financial products, might promote sustainability within the freight industry (Masud et al., 2017). In the realm of sustainable accounting, further research is needed to refine and validate frameworks that integrate non-financial metrics into corporate reporting. Empirical studies could evaluate the effectiveness of proposed frameworks, exploring how the inclusion of ESG metrics impacts corporate behavior and stakeholder perceptions in the freight sector. Lastly, the effectiveness of economic incentives in promoting sustainability remains a complex area of study. Future research could investigate the long-term impacts of tailored subsidies on sustainability outcomes and analyze the comparative effectiveness of various incentive structures across different industry contexts (Rodríguez-Espíndola et al., 2022; Uddin et al., 2023). By exploring these avenues, researchers can contribute to a more nuanced understanding of the financial, regulatory, and operational dynamics that shape sustainability in freight transportation.

This thesis underscores the intricate interplay between finance, regulation, and corporate behavior in promoting sustainability within European freight transportation. The findings highlight the need for a flexible, transparent, and contextually aware approach to policy development, emphasizing that sustainability requires not only regulatory support but also robust accounting systems and thoughtfully designed economic incentives. As the European Union moves closer to achieving its ambitious environmental goals, this research contributes to a growing body of knowledge that can inform policy and practice in the freight transportation sector, laying the groundwork for a more sustainable and resilient future.

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