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The Role of Supply Chain Collaboration in Achieving Carbon Neutrality

Evidence from Global Logistics Companies

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ABSTRACT:
The paper examines the importance of supply chain collaboration in attaining carbon neutrality in the logistics industry using evidence of global logistics firms. The study discusses the increased significance of minimizing carbon emissions in supply chains especially since transportation, warehousing, and distribution of logistics operations are major sources of greenhouse gas emissions on the earth. Although the need to be sustainable and collaborative is mentioned in the previous literature, the practicality of the logistics companies to work with the supply chain partners to attain carbon-neutral results is still not well comprehended empirically.

This research adopts a qualitative mono-method design by adopting an interpretivist research philosophy and a deductive approach. Semi-structured interviews conducted with four Finnish, Australian and Sri Lankan logistics professionals were used to collect the data. A qualitative thematic analysis was used to analyze the data collected.

The results demonstrate that logistics firms are at the center of coordination to mitigate supply chain emissions by collaborating in several practices that include shipment consolidation, route optimization, demand planning, and information sharing. They found digital tools, such as Transportation Management Systems (TMS) and Warehouse Management Systems (WMS) as primary enablers of transparency and coordination. Nevertheless, the article also reveals that there are numerous obstacles to successful cooperation, such as the absence of data transparency, the incompatibility of sustainability objectives, financial limitations, and technological disparities between partners.

The study also shows that carbon neutrality in logistics is not possible through individual organizational actions but must be carried out by joint, data-driven actions at all levels of the supply chain. The research adds to the literature in the field by offering practical information on collaboration mechanisms, difficulties and facilitating factors in the logistics perspective. It also has managerial implications as it highlights that better collaboration between partners in reducing carbon requires that they should be standardized in the data system, stronger partnerships, and increased investment in sustainable technologies.

KEYWORDS: Supply Chain Collaboration, Sustainable Supply Chain Management, Carbon Neutrality, Global Logistics Companies, Data Transparency, Digital Technologies

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Abbreviations

CO_2 – Carbon Dioxide

GHG – Greenhouse Gas

SSCM – Sustainable Supply Chain Management

GSCM – Green Supply Chain Management

TBL – Triple Bottom Line

LSP – Logistics Service Provider

TMS – Transportation Management System

WMS – Warehouse Management System

SCC – Supply Chain Collaboration

1 Introduction

The growing importance of mitigating climate change globally led businesses to adopt ambitious environmental targets, such as carbon neutrality where net green-house gas emissions are brought to zero (Tetteh et al., 2025). The logistics sector ranks among the largest contributors to the energy resources globally and can be called one of the major contributors to the CO2 emissions. (Rashidi & Cullinane, 2019). In order to ensure the pollution caused by logistics is kept in check, there is a must to have an effective environmental management system to ensure the environment is healthy and green. The increased globalization leads to the fact that the logistics industry turns global and as a result, it contributes to the raising of the volume of trade and, therefore, to the CO2 emissions (Sharma et al., 2021). Hence, the logistics companies are under pressure to enhance the carbon management structure that is needed to intensify the efficiency of the logistics. Popescu, C.-A. (2024) stated that the logistic operations like freight movement, warehousing and distribution etc. do not only make direct contributions to the emissions but also affect the emission in the wider supply chain, meaning that the sector plays a critical role in controlling climate change.

Carbon neutrality cannot be achieved by merely making changes in internal operations that imply coordination and collaboration between a variety of actors in the supply chain. It has been identified that sustainable supply chain practices lead to the minimization of carbon footprint when logistics and transportation planning is integrated with a clear environmental objective (Luqman et al., 2024). Sustainability efforts in operations cannot only be unilateral (within an individual firm) but require more inter-organizational coordination, particularly in the indirect emissions, which can be the most significant part of a firm carbon footprint in general (Matthews et al., 2008). This systemic viewpoint emphasizes the fact that reducing emissions in the logistics requires concerted efforts that go beyond the boundaries of individual firms. Scholarly literature has recognized that the cooperation between logistics service providers and the supply chain partners including suppliers, customers, and carriers etc. is crucial in promoting sustainability goals(Jum’a et al., 2025). Further author has mentioned that sustainable

supply chain management recommends that collaborative practices, including shared planning, joint decision making, and inter-firm communication could lead to better green innovation, and enhance sustainability performance (Jum'a et al., 2025). Supplier and customer partnerships have also been found to lead to sustainability efforts in most manufacturing and supply settings, like improvement in energy efficiency and decreased environmental footprint through aligned efforts (Vachon & Klassen, 2008). Whereas these results are mostly in the production and larger supply chain angles, they support the view that inter-organizational cooperation can have a positive impact on environmental results. Although this was theoretically understood, the existing supply chain sustainability literature has centered on innovation and performance results instead of the practical processes of cooperation in supply chain logistics situations (Golicic & Smith, 2013). Additionally, the literature like Mubarik et al. (2025) that explores supply chain innovation, and collaboration points out that collaboration in itself might not necessarily result in decarbonization unless accompanied by complementary measures like supply chain mapping and visibility initiatives. This indicates that collaborations have potential, but to be successful in terms of logistics, they must be structurally and information-ally integrated between partners (Mubarik et al., 2025).

Logistics companies, especially, are at the intersection of supply chain operations, and can potentially affect the result of carbon through their strategic relationships with partners. Partnering logistics systems, where carriers, shippers, and other parties co-design and coordinate their efforts have been recognized as a potential solution to enhancing environmental sustainability through more efficient resource use and minimization of redundancies across supply chains (Creazza et al., 2024). Such systems include a focus on joint planning, information sharing in real-time, and combined decision-making, which is able to facilitate more efficient and less-emission logistics operations. Even though the importance of supply chain partnership and green practices in the sustainability performance are disclosed in academic sources (Acquaye et al., 2014), the qualitative information about the concrete way logistics companies collaborate with their supply chain partners to become carbon neutral remains

incomplete. Most of the empirical studies have examined collaboration under an overall supply chain context or have focused on innovation performance (Leuschner et al., 2013).

Despite the fact that previous studies have determined that supply chain collaboration is significant in environmental sustainability, its efficiency in carbon neutrality in the logistics context is not fully comprehended. The available literature mainly analyses collaboration as a genericized concept and tends to presume a direct positive correlation between collaborative practices and environmental performance (Rashidi & Cullinane, 2019 and Lintukangas et al., 2023). Nevertheless, logistics businesses bring together fragmented emission sources through transportation and warehousing/distribution. chains, with carbon reduction results being strongly contingent on inter-organizational coordination. According to Qian. (2023), collaboration might be insufficient to provide meaningful decarbonization results unless it is accompanied by facilitating practices, including supply chain transparency, data sharing, and visibility mechanisms.

The majority of the existing literature is based on quantitative research and secondary data which provide very little information on the practical issues, decision making, and coordination approaches that logistics companies face in reality (Mubarik et al., 2025, Abbasi and Nilsson, 2016). Moreover, the study of carbon neutrality has been mostly concerned with manufacturing and with focal firms, whereas logistics service providers have not been represented in the sustainability and decarbonization research. This raises a serious knowledge gap about how logistics firms interact with their supply chain partners to control emissions that spread across organizational boundaries (Qian, 2023). Consequently, managers are not clearly advised on how collaborative strategies can be designed and implemented to achieve carbon neutrality goals in logistics operations. Rahman et al. (2024) have called for further research is needed into the intricate relationships among stakeholders in the pursuit of carbon neutrality and net-zero emissions. Chen, Lim, Yeo, and Tseng (2024) state that in the future, the performance results associated with the aggregate performance should be superseded by the

discussion of interactions, negotiations, and possible conflicts between the internal and external stakeholders participating in the decarbonization efforts.

Additionally, Chen et al. (2024) and Seroka-Stolka, O. (2023) emphasizes the significance of investigating the low-carbon values among the major stakeholders like the suppliers, consumers, investors and government because these values are a major factor in determining the effectiveness and uptake of the carbon reduction measures. Although these proposed future research directions highlight the importance of enhancing the understanding of the dynamics of stakeholder interactions, there is a shortage of empirical data on how such interactions are practiced, especially in the logistics environment (Evangelista et al., 2018). The logistics companies are at the crossroads of various stakeholders and have to collaborate with the partners of the supply chains that might have diverse interests, capabilities and environmental concerns (Beske-Janssen et al., 2015). For instance, the current research meets the research agenda defined by Chen et al. (2024) and addresses the outlined gap in the literature by exploring the collaboration practices, challenges, and enabling mechanisms through the lenses of the logistics professionals and addressing the need to expand and deepen the current understanding of collaborative decarbonization activities with supply chain partners. Therefore, a thorough qualitative study on how logistics companies cooperate with their partners in the supply chain to strive towards carbon neutrality, the difficulties they face, and the practices that facilitate the cooperation to transform into the real reduction of emissions is required.

Although the importance of supply chain collaboration in enabling environmental sustainability is increasingly being realized, little is known on how this collaboration is actually being put into practice by the logistics firms in the quest to ensure that they become carbon neutral. The literature currently available is majorly on general supply chain performance, innovation performance, or based on quantitative and secondary data, which does not provide much information on how coordination works in the real world, how decisions are made by logistics companies, and what challenges are evident

in these firms. Specifically, the qualitative and practice-based evidence of how logistics firms can cooperate with various supply chain partners to decrease emissions that are dispersed across organizational borders is lacking. Therfore, the key research research problem in the current study is the lack of empirical knowledge regarding the operationalization of supply chain collaboration by logistics companies to become carbon neutral and what mechanisms, challenges, and practices contribute to the efficiency of such collaborative activities.

1.1 Research Question and Objective

The following main research question will be used in order to answer the research problem.

“How do logistics companies collaborate in the Supply chain to achieve carbon neutrality?”

In order to address this question in more detail, following three sub questions are expected to be investigated.

1. Which practices, mechanisms, and tools do Logistics companies apply to facilitate efficient carbon-neutral cooperation with their supply chain partners?
2. What are the challenges and issues facing logistics companies when adopting collaborative carbon reduction initiatives?
3. What can logistics firms do to enhance their collaborative approaches to attain more effective carbon-neutral results?

The aim of the research is to examine how logistics companies collaborate in the supply chain in order to achieve carbon neutrality. It recognizes the mechanisms, tools, and practices that support productive collaborative carbon reduction and investigate the challenges and barriers by which logistics firms find it difficult to achieve decarbonization by partnering and also practical recommendations to improve the collaborative strategies, which will help the logistics companies attain more efficient and effective carbon-neutral results throughout their supply chains.

1.2 Thesis Structure

This thesis is structured as follows. Chapter one presents the background of the research, problem statement, gaps in the research, objectives and research questions. Chapter two provides a literature review on existing literature pertaining to carbon neutrality, sustainable supply chain management, the role played by logistics companies and supply chain collaboration etc. with the theoretical and conceptual basis of the study. Chapter three provides the research methodology, which includes the qualitative research design, data collection techniques, and the data analysis method. In chapter four, it provides the findings based on the interview data using thematic analysis. Lastly, Chapter Five explains the implications of the findings relative to the existing literature, the contributions of the study, as well as the conclusion, limitations, and the directions needed in future research.

2 Literature Review

2.1 Sustainability in Supply Chain Management

Environmental challenges, scarcity of resources and social expectations have become a primary issue in the business practice and thus sustainable operation has become a major issue of concern to business organizations (Carter & Rogers, 2008). Due to the realization by companies that their activities touch on the environment and social aspects, and not just in the internal processes of the company, sustainability has become synonymous with supply chain management. Supply chains are made up of networked organizations that engage in activities like sourcing, production, transportation, warehousing, and distribution (Sánchez-Flores et al., 2020). Due to the fact that these activities have a cumulative effect in creating environmental and social-level impacts, the sustained management of sustainability can only be achieved in a well-coordinated manner throughout the entire network of supply chain activities. This has seen the creation of Sustainable Supply Chain Management (SSCM) as an important research field where environmental and social concerns are incorporated in the conventional practices of supply chain management (Seuring and Muller, 2008).

The broad definition of sustainable supply chain management implies the management of material, information, and financial flows across supply chains and at the same time considering the economic, environmental, and social objectives. According to Carter and Rogers (2008), SSCM refers to the process of integrating environmental and social objectives in supply chain operations to enhance economic, in the long-run, performance, and reducing environmental and social effects. In this view, sustainability does not represent a one-off initiative but a fundamental part of supply chain strategy and decision-making (Seuring and Muller, 2008). To effectively tackle the environmental challenges, Logistics companies should manage the sustainability programs with the suppliers, distributors, and customers etc.

The theory of sustainable supply chain management is more or less linked to the Triple Bottom Line (TBL) framework that suggests the performance of the organization should be measured in three aspects: economic performance, environmental performance, and social performance. The TBL framework as originally proposed by Elkington (1997) explains that companies have to balance profitability, environmental protection, and social responsibility to enable them to attain sustainable development. Applying this to supply chains, it becomes evident that companies may not only have to take care of the financial performance but also the environmental effects (carbon emissions and use of resources), the social concerns (such as labor practices and the community welfare). Studies indicate that a combination of these three dimensions into supply chain decision making would help organizations sustain themselves in the long-term as well as stay at par with competition (Carter and Rogers, 2008).

The idea of Green Supply Chain Management (GSCM) has acquired a lot of literature in the wider context of SSCM. Green supply chain management lays a lot of emphasis on the environmental component of supply chain operations that comprise resource efficiency, pollution prevention, waste reduction, as well as carbon emission reduction (Sarkis, Zhu & Lai, 2011). GSCM is a process that seeks to include environmental considerations in different phases of the supply chain which include product design, procurement, manufacturing, logistics and reverse logistics processes (Srivastava, 2007). Through incorporation of environmentally responsible activities in the supply chain, logistics companies are able to lower the impact of pollution on the environment besides increasing their operational efficiency and resource utilization (Zhu, Sarkis & Lai, 2008)

According to another study, sustainable adoption of the supply chain practices usually entails cooperation and coordination between the supply chain partners. Individual organizations cannot effectively solve the challenges to the environment like climate change and resource scarcity. Rather, the supply chain stakeholders need to collaborate and introduce sustainability programs that cut across borders. Seuring and Muller (2008) note that SSCM is the management of supply chain relationships in a manner that

enhances environmental and social responsibility among all the participating organizations. This can involve setting sustainability standards to suppliers, involving partners in environmental betterment programs and ensuring that there is transparency in the sustainability reporting (Sarkis, Zhu & Lai, 2011).

And one more feature of sustainable supply chain management is the incorporation of sustainability into operational decision-making processes. In the past, cost efficiency, service quality, and operational reliability were the main concerns of supply chain management (Pagell & Wu, 2009). Nevertheless, the growing environmental consciousness has prompted businesses to consider sustainability factors in making various decisions like who to choose as a supplier, how to plan their transportation and how to design their logistics networks. Indicatively, firms can use more factors than just cost and quality to choose the suppliers, considering their environmental impacts and adherence to sustainability efforts (Pagell & Wu, 2009). With the incorporation of sustainability in operational choices, organizations would achieve a lesser environmental effect and an increase in the resilience of supply chains over time.

Another scholarly article emphasizes that strategic benefits can also be created by the supply chain management which is strategic in nature. Sustainability efforts in supply chains can have a beneficial impact on corporate image, relationship with stakeholders, and efficiency of operations due to optimization of resources (Touboulic & Walker, 2015). Further research indicates that logistics firms using sustainable supply chain models tend to have a better innovation potential and competitive edge over organizations that have been relying on conventional supply chain approaches (Touboulic & Walker, 2015). These gains indicate that sustainability and economic performance do not, in fact, need to be opposing goals but can reinforce each other in case they are combined successfully.

Moreover, sustainable supply chain management is relevant in solving climate change as well as corporate carbon reduction policies. Much of the corporate emissions are also associated with supply chain operations like transportation, distribution services and

supplier production processes (Benjaafar, Li & Daskin, 2013). This has led to sustainability being incorporated into the supply chain management as a prominent approach towards attaining wider environmental objectives like carbon neutrality and low-carbon supply chains. Logistics service providers that embrace the use of SSCM practices are able to detect the hotspots of emissions in the organization, work together with partners to undertake carbon cutting programs as well as enhance the general performance of the organization in the supply chain network (Dekker, Bloemhof & Mallidis, 2012).

2.2 Carbon Neutrality in Supply Chain

Climate change has become one of the most significant worldwide issues of the 21st century whereby governments, organizations and industries have incorporated strategies that can minimize greenhouse emissions (GHGs). Moktadir and Ren (2025) explains that, with the growing level of globalization, awareness on issues relating to the environment, companies are faced with increased pressure by regulators, investors and consumers to embrace sustainability measures and minimize their environmental impacts. Carbon neutrality is considered one of the most noticeable projects in the framework of corporate sustainability planning, meaning that the total volume of carbon dioxide emissions released by an organization is minimized to zero due to the emission reduction process and carbon offsetting principles (Liu et al., 2023). Carbon neutrality has thus emerged as a key goal among organizations aiming to make their operations meet global climate reduction goals and sustainability made commitments (Chen et al., 2024).

The two ideas of carbon neutrality and net-zero emissions are more or less similar in meaning but have slight differences in the scope and application. Carbon neutrality is usually centered on equilibrating the carbon dioxide emissions by reducing the emissions and carbon offsetting. However, net-zero emissions are an attempt to reduce the total amount of greenhouse emissions in the operations and value chain of an organization to the greatest extent possible and then using offset mechanisms (Chen et al., 2024). These are becoming more and more embedded into corporate sustainability

plans as companies are trying to react to climate policies and international treaties like the Paris Climate Agreement. With the rise in the number of companies making carbon reduction commitments, there arises a need to think beyond their internal operations of their operations and look at the emissions being caused by their extended supply chains (Guntuka et al., 2024).

The Greenhouse Gas Protocol is the most commonly employed international standard of carbon accounting and will classify corporate greenhouse gas emissions into three scopes. The term scope 1 emissions denotes those resulting from the sources that are owned or controlled by an organization, including fuel burning in the facilities of the company or its transporting fleet. Scope 2 is a result of indirect emissions that occur due to purchased electricity, heating, or cooling consumed in the operating processes. Scope 3 emissions are the indirect emissions which take place in the value chain such as supplier emissions, logistics, transportation, product usage, and end-of-life treatment (Hettler and Graf-Vlachy, 2024; Klaaassen and Stoll, 2021). The worst emissions to quantify are usually scope 3 emissions since the emissions are not under the immediate control of the focal firm but regularly constitute most of the carbon footprint of a company. Studies have shown that Scope 3 emissions may comprise between 48-74 percent of total emissions in complex supply chains, and hence the need to consider regulations of emissions outside the organization (Hettler and Graf-Vlachy, 2024; Klaaassen and Stoll, 2021).

The issue related to supply chains is extremely important to global greenhouse gas emissions due to the inter-relationship of various activities that it entails, including sourcing, manufacturing, transportation, warehousing, and distribution. With the growth of the global trade and the growing complexity and geographical dispersion of supply chains, the environmental effects of logistics and transportation have grown dramatically. Researchers hold that supply-chain level of emission management is therefore a crucial source of effective mitigation of climate effects since a large portion of the emissions takes place in between the supplier chain and in their logistics (Stenzel

and Waichman, 2023; Benjaafar, Li and Daskin, 2013). Furthermore, the literature about sustainable supply chain management emphasizes that the issue of climate change necessitates the concerted efforts of several parties, such as suppliers, logistics agencies, producers, and distributors (Borchardt et al., 2025).

The logistics industry is especially significant in decarbonization of supply chains. Freight transportation, warehousing, and distribution logistics activities are some of the major consumers of energy and greenhouse gas emissions in the world since they involve a high level of fossil fuel consumption. The empirical data prove that the energy and fuel use in logistics operations impact the environment significantly, and the sector is one of the major targets of the emission reduction efforts (Popescu, 2024). Logistics service providers are not only impacting on the environmental outcomes by their activities, but also by setting up transportation networks and distribution systems within the supply chains over which they coordinate. Consequently, it is believed that a stronger environmental performance of supply chain logistics systems is the key to carbon-neutral supply chains (Borchardt et al., 2025).

Along with operational enhancement, the proper carbon management would demand the transparency and precise quantification of the supply chain emissions. The difficulty in quantifying the emissions in a complex global supply chain has been cited as a problem to many organizations since not all the data is available and standardized reporting systems are not in place (Stenzel & Waichman, 2023). The studies have emphasized that enhanced data sharing and emissions monitoring systems are necessary in the determination of the emission hotspots and also the application of specific decarbonization measures within the supply chain networks (Stenzel & Waichman, 2023). Organizations might have difficulties in coordinating carbon reduction efforts across their supply chain without access to clear environmental information and systems of joint reporting.

Although the focus on decarbonization of the supply chain is increasing, it is still a complicated task that organizations have to struggle to accomplish carbon neutrality. The supply chains have various independent actors with diverse capabilities, priorities and resources (Guntuka et al., 2024). Such distinctions tend to position obstacles to information exchange, coordination as well as investment in sustainable technologies. According to scholars, the solution to these issues is collaborative strategies and sound governance systems to make sure that sustainability efforts can be introduced regularly throughout supply chain networks (Routroy & Behera, 2025).

2.3 Supply Chain Collaboration

Supply chain co-operation has emerged as a crucial organizational strategy, especially to the logistics firms that would like to enhance performance and deal with the complicated issues such as environmental management and sustainability (Kumar et al., 2018). The growing globalization and complexity in the supply chain have motivated the logistics service providers and other supply chain players to shift out of the customary transactional relationship with their supply chain partners and to more integrated and integrated relationships within the supply chain networks (Wu et al., 2014). In the case of logistics companies, collaboration facilitates transportation, warehousing and distribution operations while also enabling supply chain partners to share resources and co-create solutions that improve operational performance as well as the environmental performance (Barratt, 2004). The supply chain collaboration can be loosely defined as a process where the independent organizations combine their efforts to plan, manage, and carry out supply chain transactions to achieve a common objective. In the case of logistics companies, it may be seen that collaboration is usually associated with close coordination of activities with suppliers, manufacturers, and distributors to enhance the work of logistics and service performance. Cao and Zhang (2011) state that collaboration entails exchange of information, risks and rewards between partners in the supply chain. Their study shows that collaborative relationships create collaborative advantage, which means the companies that cooperate with each other are able to accomplish the results which they could not do individually.

Co-operation in supply chains can occur in various forms with much of the co-operation involving logistics companies and logistics service providers. Vertical collaboration involves organizations working at different levels of the supply chain which include suppliers, manufacturers, distributors and logistics providers. In the case of logistics companies, vertical collaboration allows a better coordination of the transportation and distribution operations thanks to information sharing and collaboration with related upstream and downstream partners. Horizontal collaboration, conversely, takes place between organizations which are on the same tier of the supply chain, for example, sharing of transportation resources and infrastructure by logistics providers (Barratt, 2004). Horizontal integration between logistic companies can be very effective in providing logistics efficiency by streamlining the transport routes, maximizing load utilization, and minimizing the movement of empty vehicles (Cruijssen et al., 2007).

Trust is one of the most acknowledged elements of effective supply chain cooperation, especially in the case of logistics partnerships when the coordination of several participants is needed. Lack of trust could make logistics companies and supply chain partners less willing to share sensitive information in the operation and invest in the collaborative efforts (Flynn et al., 2010). A study has shown that trusted-based relationships promote the supply chain members to exchange operational information and enter into long-term strategic alliances (Fawcett et al., 2008). In the case of logistics companies, trust hence minimizes the risks involved in logistics partnership and helps to build stable and sustainable supply chain relations.

Collaboration also requires a high level of effective communication and information sharing, particularly in the case of logistics companies, which organize a network of complex transportation and distribution, among others. To organize the activities of the supply chain efficiently, the partners of the supply chain are required to communicate on the information related to the demand forecasts, production plans, inventory availability, and logistics activities (Laari et al., 2016). Logistically, information exchange

in a timely manner allows the logistics providers to enhance the planning of transport routes, warehouse capacity, and delivery schedules. Research indicates that sharing of information enhances visibility of supply chain and allows organizations to be more responsive to disruption and market transformation (Flynn et al., 2010).

The coordination mechanisms also facilitate the relationships in the supply chain through alignment of decision-making processes among the supply chain partners. In the case of logistics companies, coordinated decision-making aids in connecting logistics operations and further supply chain planning. According to Simatupang and Sridharan (2005), coordination entails the coordination of operational activities and matching incentives of partners. Their study recognizes three important elements of collaboration including sharing of information, simultaneity of decisions and alignment of incentives. The mechanisms guarantee that the partners in the supply chain such as the logistics firms work towards achieving common objectives as opposed to having conflicting objectives.

Enhanced sustainability performance has also been linked to supply chain collaboration massively. The environmental issues like climate change demand concerted efforts on the part of various stakeholders within the supply chains including the logistics companies that have the responsibility of conducting their transportation and distribution operations. And also, it indicates that through joint efforts in environmental activities, organizations can minimize emissions, enhance efficiency of resources and employ sustainable logistic activities (Vachon & Klassen, 2008). In the eyes of the logistics firms, the work with supply chain partners can facilitate the efforts to use green transportation methods, practice freight consolidation, and align the logistics planning to minimize the negative effects on the environment. Therefore, teamwork has proven to be a vital skill required by logistics firms that aim to adopt the concept of sustainability and those that aim to contribute to the process of carbon mitigation in the supply chain systems.

2.4 Collaboration for Environmental Sustainability

The issue of environmental sustainability has emerged to be a strategic focus of logistics firms as the issues regarding the environment, challenges posed by regulations, and the expectations of the various stakeholders keep rising. Since the environmental effects spread throughout the supply chain networks, partnership between the logistics companies and other players within the supply chain has become the key to attainability of the sustainability objectives (Gold et al., 2010). Single companies do not have the resources and capabilities to face the elaborate environmental issues without assistance. In the case of logistics companies whose operations imply transportation activities, warehousing, and distribution, which have a high level of emissions, the cooperation with suppliers, manufacturers, and customers is a significant aspect of the environmental performance in supply chains (Delmas & Toffel, 2008). Collaboration helps to sustain through one of the major mechanisms, which is joint environmental initiatives. Such initiatives mean that logistics companies are collaborating with supply chain partners to lessen the environmental impacts by taking concerted efforts. Such cases are joint waste minimization initiatives, collective recycling, and collective investments in renewable energy sources within the logistics and distribution networks (Testa et al., 2016). Research indicates that the joint sustainability projects allow companies to utilize their complementary capabilities and resources and thus enhance their capacity to combat environmental issues (Pagell & Shevchenko, 2014).

The other dimension of collaboration that is essential to sustainability is the formulation of collective environmental plans between the supply chain partners that include logistics firms. The alignment between organizations is a common feature of sustainability strategies since it is necessary to implement environmental goals throughout the chain of supply. In the view of the logistics companies, alignment of sustainability strategy with manufacturers, suppliers, and customers assists in incorporating the environmental considerations in the logistics processes like the transportation planning and the distribution management. The studies show that firms that adopt collaborative sustainability strategies have higher chances of realizing high

levels of environmental advances than those which operate independently (Gold et al., 2010). Partnering also ensures sharing of knowledge and being innovative towards environmental sustainability. The logistics firms and supply chain partners are usually endowed with varying levels of technological capacity and environmental savvy. By collaborating, logistics businesses have the opportunity to share the knowledge with the partners and create innovative solutions in addition to the quicker implementation of environmentally friendly technologies in the logistics activities. It has been found out that knowledge exchange among supply chain partners facilitates the creation of sustainable production processes and low-carbon logistics systems (Zhu et al., 2012).

Partner involvement in the reduction of carbon is also another significant factor of environmental collaboration. The number of emissions that take place during the processes of suppliers, logistics is great, and, therefore, the logistics companies have to engage the partners in the supply chain in the process of sustainability activities. To logistics firms, it is necessary to involve suppliers, customers, and transport partners in order to minimize the number of emissions caused by transportation and distribution processes. Studies indicate that the companies that involve their supply chain members in environmental programs are likely to achieve a substantial decrease in supply chain emissions, as well as enhance sustainability performance (Lee, 2008). Collaboration also enhances transparency as well as environmental data sharing within the supply chains. By sharing the data with the environment performance with the supply chain partners logistics companies can locate the sources of emissions in logistics processes and apply specific carbon minimization measures. These initiatives have been further enhanced by the use of digital technologies including carbon tracking systems and the supply chain visibility platforms, which already allow logistics companies and their partners to track environmental performance on supply chain networks.

Although these advantages exist, collaborative sustainability projects are also faced with some challenges that include lack of trust, discrepancy in organizational goals, and finances. In the case of logistics companies, achieving sustainability usually involves

major investment in the low-carbon transportation technologies, energy-saving logistical infrastructure, and digital monitoring systems. These efforts are also associated with long-term engagements by the supply chain partners to align sustainability plans across the logistics and distribution networks. Nonetheless, studies report that logistics providers and supply chain participants that succeed in overcoming these obstacles can realize considerable environmental and economic rewards by collaborative sustainability initiatives.

2.5 Role of Logistics Companies

The logistics firms are significant in developing the environmental performance of contemporary supply chains. With the increased global trade, transportation, warehousing, packing, and distribution services are logistics services that move into the sustainability outcome of supply chain networks (Karaman, Ellili & Uyar, 2024). Freight transportation alone accounts for a significant portion of greenhouse gas emissions of the world, which puts a lot of burden on logistics suppliers to implement environmentally friendly approaches (Dekker et al., 2012). Since logistics companies can control the flow of products in supply chains, they have the advantage of making environmental changes that lower the emissions and enhance the efficiency of resources (Zhu, Sarkis & Lai, 2013). A major concept that has emerged in the literature is green logistics that is regarded to be the incorporation of environmental consideration in logistics management and operations. Green logistics activities involve optimal routes, a modal change that replaces road with rail or sea transport, enhanced vehicle utilization and alternative fuel or electric vehicle. Research shows that these practices can save a lot of fuel and carbon emissions and enhance the efficiency of logistics (Sbihi & Eglese, 2010). The following environmental improvements show that logistics firms can simultaneously realize both operational and environmental performance improvement when sustainability is incorporated into logistics strategies.

Logistics service providers (LSPs) are also involved in supporting sustainability across the supply chains by coordinating and collaborating with other supply chain actors. Studies

indicate that LSPs serve as the mediators between manufacturers, suppliers, and distributors, and this aspect allows them to affect the environmental performance of various organizations at the same time (Marchet et al., 2014). By planning transportation coordination, providing common logistics facilities, and having common distribution chains, logistics providers can decrease inefficiencies in transportation and decrease total emissions of a supply chain. One more important task of logistics companies is the support of sustainable transport systems. A significant percentage of emissions related to logistics are transport activities, and hence, this area is a main target of sustainability efforts. Research has revealed that measures like freight consolidation, intermodal transport system, and better load factors may go a long way in cutting down the emissions caused by freight transportation (McKinnon et al., 2015). In particular, intermodal transport has been generally accepted to be a viable method of minimizing environmental influence through integrating various transportation methods to enhance efficiency and fuel savings.

The role of logistics companies in sustainable supply chains is another aspect that is changing due to the use of digital technologies. The new technologies in the logistics industry, including transport management systems, real-time vehicle tracking, and sophisticated data analytics enable the providers of logistics to make the most of the transportation routes, minimize empty runs, and enhance the usage of the fleet. These digital platforms are used to allow companies to track emissions in logistics and take action based on sustainability strategies with data (Benjaafar et al., 2013). Moreover, supply chain visibility systems enable companies to exchange environmental information with their partners, which enhances coordination and facilitates joint sustainability efforts.

In addition to the operational effectiveness, the logistics companies are offering sustainability-oriented logistics services as well. According to research, a number of logistics providers have adopted environmental-focused services including carbon footprint, sustainable packaging solutions, and carbon offset programs (Perotti et al.,

2012). These services allow supply chain partners to have a better insight into their environmental impact and initiate carbon cut programs in the logistics activities.

Nevertheless, the logistics companies also have some challenges related to the implementation of green logistics practices despite the existing opportunities to enhance sustainability. These obstacles are high cost of investment in low-emission technologies, insufficient infrastructure in alternative transportation systems, and the inability to coordinate environmental efforts in a variety of actors of the supply chain (Abbasi and Nilsson, 2016). It, therefore, implies that to establish sustainable logistics systems, there must be a close cooperation between logistics providers, manufacturers, policy makers, and technology developers.

2.6 Mechanisms and Tools Supporting Collaborative Carbon Reduction

To be carbon neutral in the supply chain, it is necessary to coordinate the efforts of various stakeholders, especially logistics companies and their suppliers in the supply chain. The logistics companies are at the center of supply chain operations since logistic operations, namely transportation, warehousing, and distribution, are major contributors of greenhouse gas emissions across the globe (Wijethilake, Munir & Appuhami, 2017). Due to this, logistics companies become more closely linked with their supply chain partners to introduce mechanisms and tools, which will help reduce carbon initiatives. The literature mentions a number of mechanisms, which facilitate collaborative carbon reduction, which have a logistics point of view, such as strategic alliances between logistics organizations and supply chain participants, digital technologies to monitor emissions, systems to measure environmental performance, and processes of knowledge sharing (Golicic & Smith, 2013).

As per Lee et al. (2025), it is common knowledge that the cooperation between shippers and logistics service providers (LSPs) is a significant mechanism to enhance the performance of environmental sustainability in supply chains. The logistics firms have specialized skills and operational assets that enable them to optimize the transport

routes, enhance the vehicle use, and be able to apply sustainable logistics solutions. In the view of logistics companies, cooperation with supply chain partners helps to incorporate the sustainability objectives in the logistics planning and operational decisions. Research indicates that strategic alliances between the logistics firms and supply chain members allow firms to make logistics plans and operational decisions incorporating the sustainability goals (Evangelista, Colicchia & Creazza, 2023). These collaborative relationships usually encompass some long-term contracts and collective sustainability aim that favors the execution of carbon cut-down measures through logistics systems.

Another significant tool has been the digital technologies, which have provided the logistics companies with more opportunities to work collaboratively with their partners within the supply chain regarding sustainable initiatives. Transport management systems (TMS), warehouse management systems (WMS), and supply chain analytics platforms are technologies that enable the logistics companies to track logistics processes and determine the hotspots of emissions in the transportation and distribution processes (Amui et al., 2017). Real-time data exchange allows the logistics firms and their supply chain stakeholders to coordination of transportation operation, minimize idle vehicle movements, and consolidation of freights (Benjaafar, Li and Daskin, 2013). Efficient digital environments also enable the exchange of environmental information within the supply chain networks, enhancing transparency and allowing logistics firms to monitor carbon emissions during the logistics processes.

One more valuable mechanism in the context of the logistics companies is the environmental performance measurement systems. Environmental performance measurement will help logistics firms and their supply chain partners to assess the effectiveness of sustainability programs adopted by the firm in its logistics business (Testa et al., 2016). The usual indicators are carbon emission, energy usage and energy efficiency in transportation and distribution operations. Nonetheless, the presence of contradictory measurement systems in organizations usually poses a problem in

measuring their overall environmental performance. It has been studied that standardized environmental reporting systems are necessary which will enable the logistics companies and supply chain partners to compare their sustainability performance and adopt concerted measures to reduce carbon (Hervani, Helms and Sarkis, 2005).

The exchange of knowledge and the development of capabilities is also significant when it comes to collaborative carbon reduction efforts that involve logistics companies. The introduction of sustainable logistics can often presuppose specific expertise in the field of environmental technologies, low-carbon transport sector, and regulatory aspects. Joint workshops, teams of projects, and cross-organizational training programs can be discussed as the possible collaborative processes that allow logistics companies and their supply chain partners to share their knowledge and come up with new solutions that can be used to minimize emissions in the logistics networks (Gold, Seuring & Beske, 2010). These programs assist logistics firms and supply chain stakeholders to develop the capabilities needed in order to initiate green logistics practice and enhance environmental performance.

The green logistics practices in their turn can be viewed as a very important mechanism of operation helping to reduce carbon in the eyes of logistics companies. These are route optimization, intermodal transport system, freight consolidation and the use of alternate fuels in transportation activities. Research has shown that adoption of these practices has the potential of greatly diminishing the emissions of logistics and transportation operations and their efficiency in logistics can still be achieved (Dekker, Bloemhof & Mallidis, 2012). The joint logistics efforts like common distribution channels and coordinated transport planning also contribute to improved environmental outcomes of green logistics practices as they allow logistics firms and their supply chain collaborators to collectively decrease emissions due to transportation.

2.7 Barriers and Challenges in Collaborative Carbon Neutrality

Although a joint carbon cutting program can have a number of advantages, there are a number of obstacles that the logistics companies may encounter in their application of sustainability programs in the supply chains. The supply chains in which logistics companies work are not simple and entail the participation of various organizations with diverse priorities, resources, and capabilities (Walker, Di Sisto & McBain, 2008). Consequently, it may be difficult to harmonize the environmental initiatives and synchronize the carbon cutting efforts between the logistics companies and the companies they serve in the supply chain. Past studies have established some of the major challenges to joint carbon neutrality to include mistrust, mismatch of sustainability objectives, budget cuts, and insufficient data openness amid supply chain participants (Govindan et al., 2014).

The lack of trust between supply chain partners can be viewed as one of the greatest obstacles in the way of logistics companies when it comes to the implementation of collaborative sustainability projects. Successful carbon cutting efforts usually involve the logistics firms sharing operational information, environmental performance information and strategies with the shippers, suppliers and other logistics clients. Nevertheless, logistic companies and other organizations might not be eager to provide sensitive information because of the fear that they will lose their competitive edge or can act opportunistically. Research has shown that the lack of trust may inhibit the desire by organizations to participate in joint environmental processes and may result in transactional and not strategic alliances (Walker, Di Sisto & McBain, 2008). Trust can also be a key determinant of the effectiveness of collaborative carbon neutrality efforts in logistics firms that rely on coordination and information sharing with supply chain partners.

Another problem which identified by previous scholars is the lack of alignment of sustainability objectives of the supply chain participants such as logistics firms and their suppliers. Supply chain organizations can vary in terms of their environmental concerns,

financial strengths, and regulation (Govindan et al., 2014). Proactive sustainability measures that could be taken by some logistics companies to minimize transportation emissions and short-term economic performance that is considered as the most important factor by other supply chain partners may be the cause of this. Such disparities have the potential to cause conflicts among logistics firms when they seek to adopt collaborative carbon cutting efforts with supply chain partners. Depending on the studies, the inability to have consistent environmental objectives of both partners may severely diminish the success of joint sustainability measures (Govindan et al., 2014).

Financial problems also constitute a significant barrier for joint carbon reduction efforts as perceived by the logistics companies. Green logistics technologies like alternative fuel vehicles, renewable energy systems or carbon monitoring platforms may involve huge financial investments to implement (Popescu, C.-A. (2024). The logistic industries, especially the small and medium-sized logistics, might not have the financial capabilities to invest in sustainability projects. Since logistics firms have limited operational margins, the risk of not knowing the financial payoff of green supply chain initiatives may deter them out of incorporating green supply chain practices. A previous study indicates that lack of clarity on the financial returns of sustainability investments is a major reason why organizations are not willing to use green supply chains (Abbasi and Nilsson, 2016).

The issue of data transparency and information sharing also makes it difficult to collaborate in carbon reduction efforts with the involvement of logistics companies. Proper environmental management entails proper data in emissions, energy use, and utilization of resources within supply chain networks, which is of primary interest to transportation and distribution processes of logistics firms. Nevertheless, the disparity in data gathering requirements and reporting criteria frequently leads to the situations when the logistics firms and their supply chain associates struggle to benchmark environmental performance. Low transparency can also be a barrier to locating areas of hotspots in emissions in logistics networks and supply chain activities (Busse et al., 2017). There are also institutional and technological constraints that can affect collaborative

sustainability programs involving the logistics companies. As an example, the logistics companies in the areas where environmental regulations are relatively weak may be less motivated to invest in the sustainability programs (Whipple et al., 2010). Moreover, the lack of technological ability can make logistics businesses unable to use the sophisticated carbon tracking mechanisms or electronic logistics systems that can facilitate joint carbon cut-downs.

According to Whipple, Lynch and Nyaga (2010), some of the difficulties can be solved by good governance structures, trust-building programs, and designing uniform environmental reporting systems by logistics firms and their supply chain partners. Besides that, they state that collaborative relations among supply chain partners are associated with the ability to coordinate, share information and long-term performance than transactional relations. In the case of logistics companies, collaborative models that can be used to align sustainability objectives and allocate costs and benefits to partners can be effective in enhancing the success of carbon reduction efforts and facilitating the shift to carbon-neutral supply chains.

Moreover, the article by Lee et al. (2025) recaps that barriers can be surmounted by logistics companies more effectively and sustainably with multiple solutions being strategic. Table 01 shown below illustrates the different barriers and the strategies to overcome them as defined in the study by the above authors. When these barriers are overcome and the recommended solutions are effectively instated, the ability of the logistics companies and other supply chain participants to share information and data collaboratively can establish a synergistic environment that will enable the overall performance of the supply chain to improve and provide sustainable logistics operations.

Table 1. Barriers and Solutions to overcome Information sharing (Adapted from Lee et al., 2025)

Barrier Category	Specific Barriers	Solutions to Overcome
Cultural and Organizational	- Misaligned objectives between stakeholders (e.g., cost efficiency vs. throughput). - Resistance to change within organizations. - Lack of leadership in driving collaboration.	- Develop joint strategic goals to align priorities. - Conduct cross-stakeholder training and workshops to build a collaborative culture. - Encourage leadership involvement in collaboration.
Technological	- Lack of standardization in systems and protocols. - Gaps in technology adoption, especially among smaller players. - High implementation and maintenance costs of IT systems.	- Implement standardized platforms like Port Community Systems (PCS). - Provide subsidies or incentives for technology adoption by smaller firms. - Offer cloud-based cost-efficient solutions.
Regulatory	- Inconsistent regulations across regions. - Bureaucratic hurdles in data sharing approvals. - Overlapping jurisdiction among port authorities and government agencies.	- Harmonize international regulations to streamline collaboration. - Establish policies to simplify data-sharing agreements. - Create unified governance frameworks for port operations.
Trust Deficit	- Fear of data misuse or exploitation by competitors. - Lack of transparency in collaborative practices. - Past incidents of data breaches undermining trust	- Use blockchain technology for secure and transparent data sharing. - Establish legal frameworks and agreements to ensure fair use of shared information. - Increase stakeholder communication.
Economic	- Financial constraints on implementing collaborative systems. - Unequal cost-sharing among stakeholders. - Limited access to funding for smaller players.	- Create public–private partnerships to share infrastructure costs. - Introduce tax benefits or grants for stakeholders investing in collaborative systems. - Explore shared cost models.
Data Security and Privacy	- Concerns over data breaches and cyberattacks. - Limited technical expertise in data security management. - Ambiguity in data ownership and control rights.	- Enhance cybersecurity measures and implement data encryption. - Provide training in data security practices. - Define data ownership policies in contracts.
Operational	- Inefficiencies in aligning schedules among stakeholders. - Capacity constraints at ports and terminals. - Poor integration of multimodal transport systems.	- Use AI and machine learning for predictive scheduling. - Optimize terminal layouts and operations for higher capacity. - Develop interconnected transport systems for seamless operations. - Adoption of quantum-inspired computing technology for flexibility and operational agility.

2.8 Theoretical and Conceptual Framework

In this study, theoretical framework is based on Supply Chain Collaboration (SCC). This theory describes the collaboration of logistics companies and other members of the supply chain towards the attainment of common environmental goals (Cao & Zhang, 2011). Supply chain collaboration entails inter-relationships between supply chain partners in which there is sharing of information, shared decision making and coordinated operations. According to Singh, Garg and Sachdeva (2018), the paradigm of

supply chain collaboration has experienced massive growth in the world, and the collaboration between supply chain partners has become the major theme in the supply chain research in the last ten years. In the view of logistics firms, partnership with supply chain partners will allow the company to combine logistics with the overall supply chain sustainability strategies. Collaboration helps organizations combine resources and capabilities through supply chain networks and enhance their efficiency as well as get in a position to solve complex issues which are not solvable individually (Singh et al., 2018).

It has been indicated in the research that supply chain collaboration need involves trust, transparency and sharing of information between the partners in the supply chain including logistics firms. Barratt (2004) notes that collaboration entails well-planned coordination, sharing of information and coordinated goals among organizations. These collaborative processes enable the logistics firms and their partners to enhance the coordination of the transportation, warehousing, and distribution processes. On the same note, Cao and Zhang (2011) also show that supply chain collaboration may generate collaborative advantage whereby organizations can generate outcomes that would be tricky to realize without collaboration.

Within the framework of the environmental sustainability, coordination among the supply chain players is critical towards the minimization of carbon emissions and the adoption of sustainable business practices within logistics networks. The carbon emissions are often interdependent, especially the transportation and logistics operations, which are operated by the logistics companies. This means that the organizations need to organize their sustainability efforts within the supply chain networks to help reduce emissions effectively. Research carried out in the past has shown that the partnership between supply chain partners can have a profound positive environmental impact and help in adopting the green supply chain practices (Vachon & Klassen, 2008). Collaboration is especially significant in the case of logistics companies since logistics providers organize transportation, warehousing, and distribution operations within and between supply chain networks. By working together with supply

chain members, the logistics firms are able to undertake sustainable activities like route optimization, freight consolidation, and low-carbon transportation initiatives. Such efforts usually entail exchange of information, integrated plans of logistics, and collective investment in green technologies along logistics networks (Vachon & Klassen, 2008).

Overall, Supply Chain Collaboration Theory creates an all-encompassing theoretical basis of the study. Further, it describes how logistics firms coordinate with supply chain partners in order to meet carbon reduction objectives. This theory justifies the conceptual framework applied in the current study that investigates the roles of collaboration mechanisms, sustainability practices, barriers, and institutional settings in determining the capacity of logistics firms to play a role in ensuring that supply chains are carbon neutral.

The conceptual framework that was created in the current research describes the way logistics companies cooperate with supply chain partners to become carbon neutral and is based on the literature reviewed in Section 2.1 to Section 2.8, with the Supply Chain Collaboration Theory being the main theoretical background. This framework is designed to indicate a linear flow of sustainability drivers to collaboration, enabling mechanisms, operational practices and eventually the outcome of carbon neutrality whilst acknowledging the moderating effect of barriers and challenges at various phase of the process.

The initial element of the framework is sustainability in the supply chain, which is the increasing consciousness and strains to minimize environmental impact on supply chain activities. The growing concern about the problem of climate change and emissions in the world has prompted organizations to be more sustainable and find collaborative solutions in dealing with the environment. This forms the basis on which logistics companies are being urged to collaboratively work towards minimizing emissions along the supply chain.

Developing on this, the second constituent is the supply chain collaboration that is the key mechanism in the framework. Collaboration entails sharing of information, making decisions together, trust, and coordination of activities between partners in the supply chain including suppliers, manufacturers, transport providers and customers. Cao and Zhang (2011) note that collaboration improves the efficiency of operations and the environmental performance of firms because the firms are able to operate jointly as opposed to when they operate independently. Collaboration is crucial in logistics scenarios, where emissions are a result of many activities that are interrelated, including transportation, warehousing, and distribution, and therefore no single entity can go carbon-neutral. As such, logistics companies are important coordinators of inter-organizational interaction along the supply chain.

Collaboration mechanisms and tools are the third part of the framework and are enablers of effective collaboration. These are digital systems like Transportation Management Systems (TMS), Warehouse Management Systems (WMS), real-time tracking systems, and carbon monitoring systems. These tools enhance visibility, transparency, and real-time data-sharing among partners within the supply chain to enable better coordination and informed decision-making. Digital integration is a key to successful teamwork, as it helps to align the actions and improve the overall supply chain performance, as pointed out by Gunasekaran et al. (2017). In the absence of these mechanisms, collaboration would be less effective and fragmented in the attainment of sustainability outcomes.

The fourth element is sustainability and carbon-neutral practices, which can be seen as the operational aspect of collaborative work. Such practices are optimization of routes, freight consolidation, warehousing that is energy efficient, the use of alternative fuels, and intermodal transportation. McKinnon (2018) argues that logistics activities are a substantial source of carbon emission, yet there are immense possibilities to curb carbon emission through efficiency gains. By collaborating, logistics companies are in a position to implement these practices within multiple partners such that sustainability initiatives

are applied across the whole supply chain, as opposed to segments. This emphasises the importance of logistics companies as facilitators, enablers of sustainable operations.

Nevertheless, the framework acknowledges the existence of barriers and challenges, which affect various steps in the process, as demonstrated by their relationships to supply chain collaboration, collaboration mechanisms, and sustainability practices. Such obstacles are lack of trust, goal misalignment, high implementation costs, and issues of data sharing and transparency. According to Barratt (2004), collaboration involves openness and trust most of the time, which is rarely attained because of competitive issues. On the same note, Simatupang and Sridharan (2005) point out that inefficient coordination and improper incentives may diminish collaboration effectiveness. These issues are moderating factors that undermine the power of collaboration and constrain the effective execution of sustainability practices.

The last element of the framework is the carbon neutrality as the final product of the research. Carbon neutrality is the process of decreasing and balancing emissions on the supply chain activities in a coordinated and collaborative effort. To reach this result, it is necessary to not only improve operational efficiency but also the concerted efforts of all of the supply chain partners. The Intergovernmental Panel on Climate Change (2025) also says that to reach net-zero emissions, it needs systemic and coordinated solutions, especially in Scope 3 emissions that are found throughout the supply chain. This supports the concept that carbon neutrality is not a personal organizational measure but a collective measure that is achieved through quality cooperation.

In general, the conceptual framework illustrates a well-defined and systematic process where sustainability pressures push supply chain collaboration, which is facilitated by enabling mechanisms and converted into operational sustainability practices and finally resulting in carbon neutrality, which is affected by major barriers and challenges throughout the process.

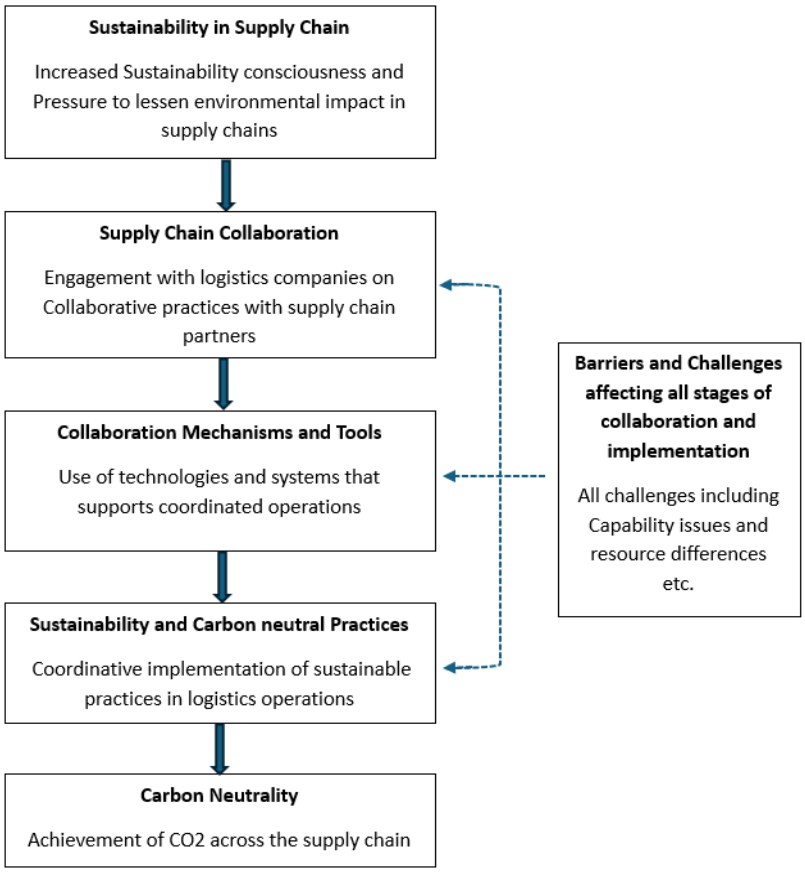

Figure 1. Conceptual Framework (Source: Author's own illustration, 2026.)

3 Methodology

This chapter outlines the methodology of this study. It describes the research design which includes research philosophy, research approach, research method and research strategy adopted. It also explains the sampling and participants, data collection methods and data analysis techniques. Moreover, reliability, validity, and ethical concerns are addressed in the latter part.

3.1 Research design

The Research Onion by Saunders et al. (2007) is a widely used model of research methodology design because it offers researchers a six-level logical structure that allows them to discover such aspects as research philosophy, general techniques and methods, and the application of particular practices. Individual layers indicate a choice that has to be made: Philosophy, Approach, Methodological choice, Strategy, Time horizon and Data collection. This principle is straightforward yet mighty and the decisions made at the outer layers influence the choices that are available in the inner layers. This is a step-by-step procedure that makes the study consistent. The research onion used in the study is illustrated by Figure 02 as below.

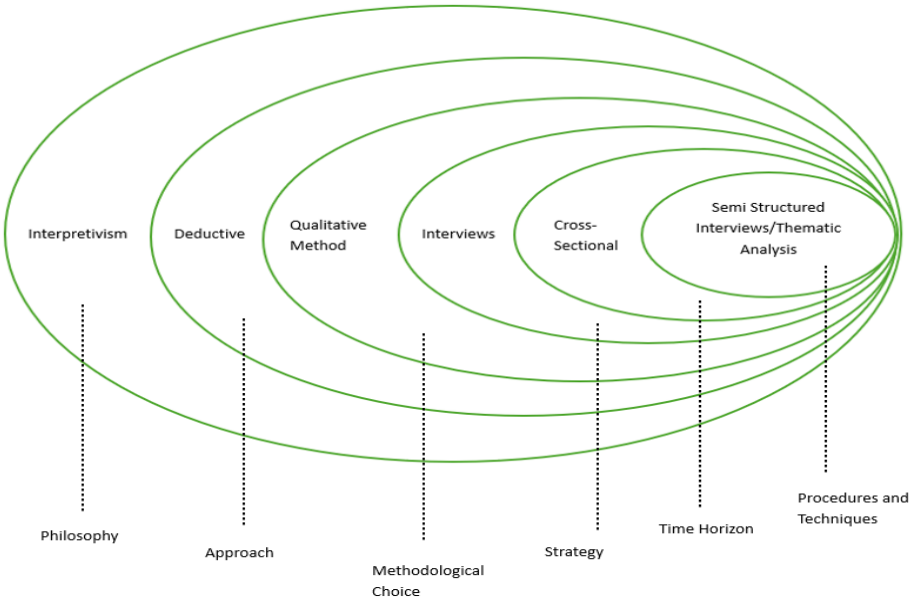

Figure 2. Research Onion: Adopted from Saunders et al. (2023)

3.1.1 Research Approach

This study is characterized by a deductive research approach, which is informed by the already available theoretical frameworks and seeks to investigate their relevance in a given research situation. Deductive reasoning is a process of general theory to particular observation, which enables the researcher to organize the investigation and explain the empirical observations with the help of previously known concepts (Saunders et al., 2019). Research in this study extends the Supply Chain Collaboration Theory and literature on sustainability issues, which form the basis of the understanding of how the collaboration between supply chain partners can help in reaching carbon neutrality. Instead of formulating new theory, the research uses these two theoretical viewpoints that already exist to investigate how the logistics companies liaise with the supply chain partners and the effect of such liaison on sustainability results.

The deductive research style is appropriate to this study since it allows the researcher to apply pre-determined theoretical constructs, including collaboration, coordination mechanisms, and sustainability practices, in data collection and data analysis. The interview questions will be structured on concepts which are based on the literature and there will be no mismatch between theory and empirical research. This enables the research to determine the extent to which current theories can be used to explain the actual practices in logistics and supply chain operations.

The study does not entail a formal hypothesis test but rather follows a deductive logic by analyzing empirical evidence in comparison to the theoretical expectations. The results are assessed in the frames of Supply Chain Collaboration Theory that allows the researcher to substantiate, elaborate, or deepen theoretical knowledge in the framework of carbon-neutral supply chains.

Moreover, the deductive method is suitable to study complex phenomena like supply chain collaboration and sustainability, because it offers a systematic guideline to define the connection between theory and practice. By applying theoretical concepts across

different organizational contexts, the study offers insights into how collaboration mechanisms operate in real-world logistics environments while maintaining a strong connection to established academic knowledge.

3.1.2 Research Philosophy

The research philosophy adopted in this study is an interpretivist research philosophy, which suits well the investigation of the role played by logistics companies to work closely with their supply chain partners in attaining carbon neutrality. The idea behind interpretivism is that reality is created by humans and knowledge is created through the interpretation of the experience, perception, and interaction of individuals (Saunders, Lewis and Thornhill, 2019). Within the scope of this study, collaboration towards carbon-cutting is not necessarily a technical or quantifiable practice but is influenced by the organizational relationships, stakeholder expectations, and institutional contexts of supply chains. The interpretivist method allows the researcher to understand the perception of sustainability practices, collaboration mechanisms, and environmental responsibilities by logistics professionals in the real-life situations. This is especially applicable because the logistics companies work in complex networks where trust, communication, and outside pressures affect the decision-making process. In contrast to positivism, which is concerned with objective measurement and testing hypothesis, and pragmatism, which is concerned with practical solutions and mixed approach, interpretivism provides an opportunity to understand these contextual and subjective factors in-depth.

3.1.3 Research method

The study used a mono-method qualitative research approach which suited the exploration of how logistics companies can be involved in partnering with the supply chain partners to attain a carbon neutral environment. In a qualitative approach, the complex social and organizational phenomena are studied by examining the experiences, perceptions, and interactions of the participants, which makes it relevant in this case

(Saunders, Lewis and Thornhill, 2019). The aspects of human behavior, relations and institutional factors in sustainability collaboration which were examined in the context of this study cannot be adequately described by quantitative measures only. And also, the qualitative method will allow the researcher to understand the depth of the implementation of sustainability practices by the logistics companies, their coordination with the supply chain partners, and reaction to the environmental pressure. It can be used to investigate the collaboration mechanisms, barriers, and contextual differences in more detail within different organizations. It is especially applicable in the context of the exploratory character of the research and the paucity of the empirical studies that specifically concentrate on the collaborative role of logistics companies in carbon neutrality.

The selection of mono-method qualitative design can also be explained by the fact that data collection strategy consisted of semi-structured interviews with logistics companies in Finland, Australia and Sri Lanka. The approach offers detailed information that is rich and assists in the further comprehension of the sustainability practices in various institutional settings.

3.1.4 Research Strategy

The research strategy in this study was qualitative interview-based research strategy to examine how logistics firms integrate with supply chain partners to become carbon neutral. A research strategy is a plan on how the research can be carried out and the collection and analysis of data to answer the research questions (Saunders, Lewis and Thornhill, 2019). Since this research is exploratory and needed to focus on real-life practices and experience, qualitative approach is deemed to be appropriate. The proposed research applied to the method of semi-structured interviews as the main research technique which gives the freedom to explore the views of the participants in detail and ensure that the main themes remain consistent. And also, the most suitable method of data collection was semi-structured interviews because they enable a balance between structured framework of predetermined questions and the freedom to develop emerging themes during the interview. The approach is also known to be efficient in

terms of in-depth insights, experiences, and perspectives of the participants, especially in the context of exploratory research (Saunders et al., 2019; Kallio et al., 2016). It allows the researcher to dig deeper on pertinent issues and to be consistent throughout the interviews. In this way, the researcher is able to study the views of logistics professionals on the mechanism of collaboration, sustainability practices, and issues surrounding carbon reduction in supply chains. To create the interview guide, the most prominent themes outlined in the literature review, such as Sustainability practices, Carbon neutrality, Supply chain collaboration, Technological enablers, and Barriers to implementation etc. were considered. The semi-structured nature of the format meant that the respondents could expound on their experiences and at the same time, all areas of interest to the research were addressed.

The study plan also has been reinforced by the fact that Finnish, Australian and Sri Lankan logistics companies were included in the study, to capture various perspectives in terms of sustainability practices of the companies operating in various institutional settings. This strategy facilitated a better comprehension of the role of environmental policies, the state of the market, and organizational strengths in joint carbon reduction efforts.

3.1.5 Time Horizon

In this research, the time horizon adopted was cross-sectional because the data will be gathered at one time. A time horizon is the temporal aspect of the study, and it can either mean that data were collected over time or at a single point of time (Saunders, Lewis and Thornhill, 2019). The semi-structured interviews in this study were carried out with the logistics companies over a specified period, and their present experiences and views on collaboration and carbon reduction practices will be taken. The cross-sectional type of research applied in the current study is relevant due to studying the existing sustainability practices, collaboration, and challenges the logistics companies experience in the supply chains. The research is not intended to investigate the evolution of the situation but to present the picture of the existing practices in various institutional

environments. This applies especially well as this research includes several operational contexts as the logistics companies of Finland and Sri Lanka are included, and it allows learning the ways in which the collaboration towards carbon neutrality is implemented across various logistics environments.

3.2 Sampling and Participants

This study aimed to examine the role of Logistics companies in collaborating with Supply chain partners to achieve Carbon neutrality. As the research mainly address the role of Logistics companies, their collaborating practices and mechanisms with supply chain partners, their insights on achieving carbon neutrality, the sampling design included the views of Logistics companies in Finland, Australia and Sri Lanka who has direct experience in the topic.

The research employed purposive sampling method which is common in qualitative research so that the researchers can pick the participants who have the relevant knowledge and experience concerning the research topic. In this way, the researcher can select the logistics professionals purposely to include the professionals that have direct engagement in the sustainability and supply chain collaboration practice, hence providing a rich and meaningful data. (Palinkas et al., 2015; Etikan et al., 2016). Four interviews were carried out with the professionals. The selected participants were from four different logistics companies. These respondents were selected because they were directly involved in logistics activities and were well acquainted with sustainability programs and thus were the right individuals to offer abundant and valuable data to the research.

This study included four key participants,

1. A representative from company A from Finland
2. A representative from company B from Australia
3. A representative from company C from Sri Lanka
4. A representative from company D from Sri Lanka

All participants have discussed about their practical experience on how to coordinate with supply chain partners, operational decision-making, and initiatives in the area of sustainability. This has guaranteed that the data gathered is abundant, pertinent, and based on real-life logistics practices which is crucial in responding to the research objectives. The selection of firms with international backgrounds such as Finland, Australia, and Sri Lanka was not random and it is to ensure a wide-ranging operational view in the logistics industry. Finland and Australia can be considered as the developed logistics setting, with fairly developed technological infrastructure and sustainability programs, whereas Sri Lanka can shed some light on the developing logistics environment with resource constraints and different degrees of technological adoption potentially impacting collaboration and sustainability practices. This variety enables the research to examine the functioning of supply chain collaboration within various organizational and work environments, without directly performing an analysis of comparative countries.

3.3 Data Collection

The qualitative data used in this study were gathered using semi-structured interviews that were carried out during the research period. The main purpose of these interviews was to investigate how logistics companies can support supply chain cooperation towards carbon neutrality, and learn more about the practices, challenges, and opportunities in the context of real-life logistics activities.

All the interviews were in English and conducted with the consent of the participants to make sure that they are accurate and to record all the information. Out of four interviews, three were conducted online, while one was conducted in person. The length of every interview was about 15-40 minutes. The recorded interviews were then transcribed word to word in order to analyze them in detail. Furthermore, field notes were also recorded during and right after the interviews to record contextual insights and first impressions, which helped to interpret the data.

Table 2. Interviewee Information

Participant	Position	Industry	Country	Online /In person	Length of the Interview	Trans-cribe pages
Company A	Transportation Manager	Road transportation	Finland	In person	00:39:26	11
Company B	Senior Executive - Documentation	Freight forwarding and logistics	Sri Lanka	Online	00:20:25	10
Company C	Shipping Documentation officer	Freight Forwarding and Shipping	Australia	Online	00:17:40	08
Company D	Assistant Manager	Freight Forwarding and Warehousing	Sri Lanka	Online	00:20:48	09

Further, data collection focused on gaining more practical understanding of the way logistics companies partner with supply chain participants in order to reduce the carbon footprint, tools and mechanisms that they use, and what challenges they face. This strategy helped to keep the gathered information in a close relationship to the research goals and added to a multi-faceted comprehension of supply chain collaboration to become carbon neutral.

3.4 Data Analysis

Interpretation of the interview data was done using thematic analysis. In accordance with the procedure described by Erlingsson and Brysiewicz (2017), transcripts of all interviews were read several times in order to become familiar with the data. The themes indicated some vital areas like carbon reduction practices, supply chain cooperation, technology enablers, implementation barriers and future improvement opportunities. The thematic analysis helped the researcher to go beyond the mere descriptions and come up with some meaningful insights into the organizational behaviors and strategies in the logistics industry (Dubois and Gadde, 2002). Transcription, coding, categorization and theme development were done manually. Meaning units -

phrases or sentences that are pertinent to the research objectives were found and summarized without losing the essence. These meaning units that were condensed were then allotted codes. The codes were then categorized in groups according to similarities and patterns. This procedure helped to organize the data systematically and identified the patterns that recur in the context of sustainability practices, the systems of collaboration, and operational issues in the logistics. The codes and categories were further expanded and broken down into general themes that encompassed important patterns in the dataset, in accordance with the framework suggested by Braun and Clarke (2006). This enabled the researcher to be in close contact with the data and guaranteed a sensitive interpretation of the responses of the participants. To substantiate the results, quotes of the participants are anonymized and shown in the findings chapter, which depicts the main themes and maintains the originality of the participants' opinions. On the whole, thematic analysis offered a holistic and systematic way of analyzing the data, allowing the systematic categorization of the research findings and the in-depth interpretation of the research results. Below is an example of coding in this study (See Appendix 2. Code Table to find the whole code table).

Table 3. Example of Code table

Theme	**Code Name**	**Code No.**	**Full Verbatim Description (from Transcripts)**
Role of Logistics Companies	Coordinator identity	RL02	"Simply, we are coordinators in the supply chain." (Company B)
Key Sources of Carbon Emissions	Transportation as main emission source	SE01	"Definitely that is Transportation. Particularly long-haul ocean freight and last mile trucking." (Company B)
Carbon Reduction Practices	Slower shipping for fuel reduction	CR05	"We also advise clients to use slower shipping methods where possible since faster shipping tends to use more fuel." (Company B)

3.5 Reliability, Validity, and Trustworthiness

The rigor of qualitative research must be considered in terms of reliability, validity, and trustworthiness. In contrast to a quantitative study, qualitative research focuses on the credibility, dependability, confirmability, and transferability as essential factors in the assessment of the research quality (Lincoln and Guba, 1985; Nowell et al., 2017).

3.5.1 Reliability

Dependability can be defined as the reliability and clarity of the research process. A systematic and well-defined research design allowed establishing reliability in this study. Audio recordings of all interviews were transcribed verbatim and analyzed through a structured process of coding. Thematic analysis served to enhance consistency in data interpretation. Also, the transparency and reproducibility of the analysis process were improved by having a clear audit trail of coding decisions and theme development (Nowell et al., 2017).

3.5.2 Validity

Credibility is connected with the correctness and veracity of the results. A methodological triangulation was designed with the aim of increasing validity by using qualitative thematic analysis in this study. This method enabled the data to be analyzed both descriptively and interpretatively, enhancing the strength of the results. Moreover, the questions to be asked during the interview were thoroughly formulated according to the themes revealed in the literature review and they were aligned with the theory and empirical study. Whenever possible, the participants were allowed to explain their answers during the interviews, which helped in the collection of accurate and valuable data. This also supports the credibility of the findings as the use of direct participant quotations enables the reader to evaluate the relationship between the data and the interpretations (Creswell and Poth, 2018).

3.5.3 Reflexivity

Reflexivity recognizes the role of the researcher in the process of the research and interpretation of the data. The researcher was conscious of possible biases and kept a non-partisan position in the data collection and analysis. There was an attempt to make interpretations based on the answers of the study participants and not assumptions made by individuals. Critical evaluation of decisions and interpretations was carried out with reflective notes being kept throughout the research process, which increased the study integrity (Berger, 2015).

3.5.4 Trustworthiness

The general credibility of the research was promoted by considering the four main criteria namely credibility, transferability, dependability and confirmability (Lincoln and Guba, 1985). Systematic data collection, triangulation, and participant quotes were used to attain credibility. Transferability was facilitated through the availability of detailed description of the research context, participants and methods which enabled the readers to determine the applicability of the results in other settings. A clear and documented research process was used to ensure the dependability. Finally, the confirmability was also improved as the findings were based on the data and objectivity was observed during the analysis. Through the combination of these measures, the study will be robust, credible and methodologically sound.

3.6 Ethical Considerations

One of the core considerations that are involved in the process of conducting qualitative research, especially in cases involving human subjects, is the aspect of ethics. This research conformed to the accepted ethical standards in order to safeguard, rights and well-being of all the individuals in the course of the research (Orb et al., 2001). All the participants were informed about the study and gave informed consent before the data was collected. All respondents were made well aware of the study purpose, the type of involvement, and the use of the data. Participation was voluntary and the respondents

were assured that they could discontinue their participation in the study at any point without any adverse effects. This meant that there was free will and transparency in participation.

Anonymity and confidentiality were observed. The study did not reveal the names of the participants and their organizations. Rather, when reporting findings, anonymized labels like (Company A, Company B..etc) were used. The transcription process, to preserve the privacy of the participants, eliminated any identifying information. This methodology is in line with ethical research practices that focus on protecting the identity of participants and sensitive data (Saunders et al., 2019). All interviews were carried out with the previous agreement of the participants to audio or video recording. The tapes and transcripts were well locked and could only be accessed by the researcher. The information was not provided to any third parties and was only used academically. Proper data management practices were followed to ensure data security and confidentiality throughout the research process (Creswell & Poth, 2018).

Also, the researcher was neutral and respectful in interviewing because the participants were not exposed to any form of discomfort, pressure, and harm. The questions were asked to address professional experiences as opposed to personal or sensitive experiences, hence reducing any ethical risks. The research was also developed in the principle of integrity by making sure that all the findings were reported in an honest and accurate manner. No data was made up and distorted and the interpretations were based on the answers given by the participants. Ethical principles of academic honesty and prevention of plagiarism were observed to the letter. In general, the research study made sure that ethical considerations were maintained throughout the research process, data collection, data analysis, and data reporting. These actions helped in the credibility and trust of the research.

4 Findings

This chapter provides the results of the empirical research based on the semi-structured interviews with the logistics professionals, and the purpose of answering the key research question. The structured interview protocol informed the data collection process and included essential themes that encompass carbon neutrality, sustainability practices, supply chain collaboration, technological enablers and barriers to implementation. All interviews were able to offer profound insights into how logistics companies view their role in cutting down on emissions, the kind of collaborative practices they are involved in, and the real-life challenges they face in performing carbon reduction initiatives. The interviews were done with the strategic points of view and the experiences of operations at the operational level, which enabled the investigation of the phenomenon in a holistic way.

First, the transcripts of the interviews were meticulously examined and coded in order to determine meaningful units in reference to the research objectives. The results are in thematic form instead of a case-by-case comparison of separate firms. Such a strategy aligns with the aim of the study to draw generalizable findings and trends in the logistics organizations and does not aim to draw organizational differences. All participants and their respective organizations have been anonymized to maintain confidentiality and comply with ethical research practices, and are identified as Company A, Company B, Company C and Company D in this chapter.

The chapter is organized into nine key themes that emerged from the data analysis.

1. Understanding Carbon Neutrality in Logistics.
2. Key Sources of Carbon Emissions.
3. Carbon Reduction Practices in Logistics Operations.
4. Role of Logistics Companies in Supply Chain Collaboration.
5. Types of Supply Chain Collaboration.
6. Mechanisms and Tools Supporting Collaboration.
7. Data Transparency in Supply Chain Collaboration.

8. Barriers and Challenges in the process.
9. Improvements and Future Role of Logistics Companies in Achieving Carbon Neutrality.

These themes are not isolated but are interrelated and collectively explain how supply chain collaboration contributes to achieving carbon neutrality in logistics. The first theme, Understanding of Carbon Neutrality in Logistics, provides the foundational perspective that shapes how organizations approach sustainability. This understanding is closely linked to the Key Sources of Carbon Emissions, which identify the primary areas where emissions occur, particularly in transportation and logistics operations. These emission sources directly influence the Carbon Reduction Practices in Logistics Operations, as organizations adopt efficiency-driven strategies to minimize their environmental impact.

The Role of Logistics Companies in Supply Chain Collaboration and Types of Supply Chain Collaboration further explain how collaboration is structured and implemented across different stakeholders. These collaborative efforts are supported by Mechanisms and Tools Supporting Collaboration, such as digital systems and platforms, which enable coordination and operational efficiency. In this context, Data Transparency in Supply Chain Collaboration plays a critical role in facilitating information sharing and improving decision-making.

However, the effectiveness of these collaborative practices is influenced by Barriers and Challenges in the process, including issues related to trust, cost, and technological limitations. These challenges highlight the gaps between current practices and desired outcomes. Finally, the theme of Improvements and Future Role of Logistics Companies in Achieving Carbon Neutrality builds upon these challenges by identifying potential solutions and outlining how logistics companies are expected to evolve as sustainability enablers and coordinators within supply chains.

4.1 Understanding of Carbon Neutrality in Logistics

In all the interviews, carbon neutrality was always interpreted to mean a process of minimizing the number of emissions produced in the course of logistics activities and control or offset of unavoidable environmental effects. The main interpretation of carbon neutrality by the participants is the practical logistics like transportation, warehousing and handling. As an illustration, one respondent said: *"So actually Carbon neutrality in logistics operations means balancing carbon emissions generated from the activities like warehousing or transportation and handling with the actions to reduce those emissions."* (Company C, CN01). Equally, the other participant defined carbon neutrality as: *"In our view, carbon neutrality means that we should minimize the emissions produced in the course of logistics operations and then compensate the rest of the emissions."* (Company B, CN02). These answers show that carbon neutrality is not understood as a total removal of the emissions, but a continuous process of balance between the reduction and compensation. This is also supported by those respondents who emphasized the practical reduced possibilities of full carbon neutrality. As an example, one participant mentioned: *"It's kind of hard-to-reach carbon neutrality as we have long-distance transport mostly by road. So, our options are very few."* (Company A, CN03). This underscores the limitation of operations of logistics enterprises especially in long-haul transportation in which they are unable to completely eradicate emissions.

The focus on operational efficiency became one of the key elements of the interpretation of carbon neutrality. The participants were always associated with the emission reduction and enhanced logistics planning, decreased fuel consumption, and enhanced use of transport capacity. As an illustration, one of the participants explained: *"when we are planning shipments, we can try to reduce unnecessary movements, like avoiding sending half-empty containers or reducing multiple trips. Instead, we try to consolidate cargo as much as possible."* (Company D, CN04). Equally, another participant added the importance of fuel efficiency and minimizing inefficiency: *"We try to reduce fuel consumption and also, one thing you can think about is to reduce empty driving when you drive between places*." (Company A, CN05). These answers indicate that the concept

of carbon neutrality is operationalized in terms of efficiency-based practices, in which environmental gains are made through the optimization of logistics processes, instead of using advanced technologies to sustainability.

The other key lesson that the data reveals is that the logistics companies have an indirect role to play in the management of emissions. The respondents admitted that in most instances; they do not produce emissions directly but affect the results of emissions through planning and coordination. One interviewee said: *"If I speak honestly, we can't control these emissions alone because we don't operate any transport vehicles, but our role is indirect. We can tell other parties how to work sustainably."* (Company D, CN06). This demonstrates the interdependent form of supply chains whereby logistics companies are coordinators and support sustainable practices.

Although there was a common vision of carbon neutrality, disparities were noted in how much the concept of sustainability is established in the organizational strategies. Certain organizations said that they had formal sustainability goals. As an example, one participant replied: *"Yes, our organization has formal sustainability and carbon reduction objectives. So, we are focusing on improving operation efficiency, reducing the fuel consumption and promoting the use of energy efficient systems within the warehouses and minimizing waste across logistics processes."* (Company C, CN07). Nonetheless, other participants pointed out that sustainability activities are less institutionalized and do not have clearly defined targets. One participant noted: "*Finally, I have to say is we don't have clear goals, but we have above practices which support carbon neutrality."* (Company D, CN08). Likewise, another interviewee said: *"We have some that are stated in our code of Conduct, but I don't know if they are not so specific. It's most like stated that we try to reduce, but we have no clear goals in numbers."* (Company A, CN09). These results indicate that although sustainability is identified as a key factor, a large part of logistics firms adheres to informal or practice-based systems, instead of formal carbon management systems.

Overall, the results indicate that the concept of carbon neutrality is viewed with a pragmatic and experience-based approach among logistics professionals and is mostly based on reducing emissions by focusing on operational efficiency and coordination. The degree of strategic integration, however, varies among organizations. Some companies have started formalizing sustainability, but others still depend on the incremental operational practices. This shows that the issue of carbon neutrality in the logistics industry remains dynamic, shifting the focus of operational consciousness to more systematic and strategic action.

4.2 Key Sources of Carbon Emissions

Transportation was found to be the major contributor to carbon emission in all interviews. Respondents stressed that road transportation, ocean shipping, and air transportation are very fuel-intensive types of logistics, which are crucial to logistics operations. Indicatively, one of the participants said explicitly: *"Definitely that is Transportation. Particularly long-haul ocean freight and last mile trucking."* (Company B, SE01)

On the same note, one more respondent emphasized that transportation emissions are the most prominent in their operations: *"I would say it's clearly the transportation part."* (Company A, SE02). These answers reveal that there is a high level of agreement that transportation operations, especially the long-distance movements, produce the greatest number of emissions in the logistics operations. This is mainly because of the use of fossil fuels and long distances that are used in the international supply chains.

Participants also explained the contribution of fuel consumption to the emission. High reliance on vehicles that are run using diesel was cited as among the main factors, especially in transport operations that are long-haul. One participant explained: *"These days we are only have diesel trucks, and I don't see so many possibilities to use some electric trucks or anything like that because of the long distances."* (Company A, SE03). This underscores technological and infrastructural constraints that hinder the use of

cleaner alternatives, hence cementing the traditional fuel-based transport systems hegemony in logistics. Along with long-haul transportation, inefficiencies in transportation processes were also found to be some of the factors that led to high emissions. There were such problems highlighted by the participants like empty driving, route planning, and unwarranted movements. For instance, one participant noted: *"So-called unnecessary driving to drive empty, so it's better to drive with loads."* (Company A, SE04). Moreover, the representatives of other organizations also noted the operational inefficiencies as a cause of emissions. As an example, *"when we are planning shipments, we can try to reduce unnecessary movements, like avoiding sending half-empty containers or reducing multiple trips."* (Company D, SE09). It means that inefficiencies in operations may considerably raise the fuel consumption and emissions even in existing transport systems.

Although transportation was found to be the dominant source of the emissions, some of the participants also noted that warehousing activities were also a source of emission. Nevertheless, these emissions were less likely to be seen as troublemakers compared to them. One participant explained: *"Although warehousing is a factor, the overwhelming amount of fuel used in trans-Pacific or European routes is the major factor."* (Company B, SE05).

This indicates that although warehousing is a contributor of emissions in the form of energy use like electricity, the overall effect is relatively small to the transportation-related emissions. Moreover, respondents emphasized that the logistics operations design could affect the level of emissions. When there is direct transportation of goods between their origin and destination without any intermediary handling of the goods, warehousing emissions are reduced. As an example, one of the participants claimed: *"mostly our trucks deliver straight from place A to place B, so there is mostly no middle handling in some warehouse or something like that."* (Company A, SE06). This is indicative of the role of operational models, like direct transportation, in minimizing other sources of emissions like storage and handling. The other observation that is

important is that not only physical activities produce emissions but also planning decisions and supply chain configurations have an impact. As reported by the participants, the decisions made with regard to the mode of transport, the routes and the timing of transport have a direct effect on the level of emission. This supports the premise that both the operational implementation and decision-making are in close relation to emission sources in logistics.

As a whole, the results indicate that transportation is the leading cause of carbon emissions in the logistics processes, which are caused by the use of fuel, long-term transport, and the use of traditional forms of transportation. Warehousing and other operations have some effect on emissions, but their effect is relatively minimal. There are further inefficiencies in the transport operations and planning which also increase the level of emission. These lessons underscore the urgent requirement of interventions in the transportation systems to realize significant carbon reduction in the logistics.

4.3 Carbon Reduction Practices in Logistics Operations

Interview findings highlight that most of the participants stressed that reduction of carbon is mainly through the optimization of logistics operations. Shipment consolidation was one of the most frequently recognized practices that minimized the amount of transport movements that was necessary. For example, one participant explained: *“one key practice, we use is ‘shipment consolidation’. So, here we do not make several small shipments and dispatch them in different containers. Instead, we connect all of them as one into one container and this decreases the number of trips to be made.”* (Company B, CR01). In the same vein, another respondent emphasized the same strategy in a team-based situation: *“Instead of 3 half-empty containers, we merge them into one as one container when dispatching. Then we can cut emissions immediately.”* (Company B, CR02). In line with this, another participant pointed out similar operational practices: *“when we are planning shipments, we can try to reduce unnecessary movements, like avoiding sending half-empty containers or reducing multiple trips. Instead, we try to consolidate cargo as much as possible.”* (Company D, CR09). These answers suggest that

one of the key strategies in decreasing emissions in logistics activities is the reduction of trips by increasing the use of transport capacity.

In addition to consolidation, route optimization was identified as another key practice for minimizing fuel consumption and emissions. Participants emphasized the importance of selecting efficient transport routes and avoiding unnecessary movements. One participant stated: *"the other example is route optimization, where we are planning the best transport routes to ensure we do not waste more fuel"* (Company B, CR03). This shows the importance of planning and decision making in the realization of carbon reduction with efficient routing as a direct contribution to fuel consumption.

The necessity to find the most efficient transportation channels and eliminate unnecessary movements also became one of the highlighted points by the respondents. One Interviewee explained: *"We try to reduce fuel consumption and also, one thing you can think about is to reduce empty driving when you drive between places."* (Company A, CR04). This shows that through better load management and coordination; much efficiency and emission reduction can be achieved. Moreover, the organizational aspects of sustainability were also emphasized: *"So we are focusing on improving operation efficiency, reducing the fuel consumption and promoting the use of energy efficient systems within the warehouses and minimizing waste across logistics processes."* (Company C, CR10).

The participants also emphasized the importance of implementing alternative ways of operations including the use of slower means of transport to minimize the use of fuel. One participant mentioned: *"We also advise clients to use slower shipping methods where possible since faster shipping tends to use more fuel."* (Company B, CR05). This implies that the trade-offs between speed and sustainability are becoming more a part of logistics decision-making, and slower methods of transport have potential environmental benefits.

Besides transport-related practices, a few participants noted measures undertaken to enhance energy efficiency in warehousing and operational plants. These involve utilization of energy saving systems and minimization of waste. As an example, One participant stated: *"we are focusing on improving operation efficiency, reducing the fuel consumption and promoting the use of energy efficient systems within the warehouses and minimizing waste across logistics processes."* (Company C, CR06). It means that transportation is still a major concern, but organizations are also making efforts to enhance sustainability in the supporting logistics operations.

The digitalization and decreasing physical documentation were also named as valuable practices that facilitate carbon reduction. Respondents pointed out the environmental advantages of switching to electronic systems. As an example, one participant explained: *"Mostly digital systems help reduce paperwork and improve efficiency. For example, using electronic bills of lading reduces the need for physical documents."* (Company B, CR07). This is an indication of how digital transformation may indirectly lead to sustainability through a decrease in resource usage and an increase in operational efficiency. Moreover, respondents highlighted the relevance of equipments and operational enhancements in the reduction of emissions. To illustrate, one participant mentioned that *"we are trying also is to have longer road trains… they take like two trailers at the same truck and go down. So, we can reduce a little bit of emission."* (Company A, CR08). This shows the potential of innovations in transport formation and use of equipment to reduce emissions, even in the current technological limitations.

In general, the results suggest that the reduction of carbon in the logistics is mainly operational and efficiency oriented. Businesses are working on maximizing the use of transport, better route planning, minimizing the inefficiencies like empty trips and implementing gradual sustainability steps. Although there are organizations that are starting to implement energy-efficient systems and digital solutions, uptake of advanced low-carbon technologies is still minimal. This implies that the present carbon reduction

initiatives in the logistics mainly focus on optimizing the processes which are already present and do not involve the adoption of transformative sustainability initiatives.

4.4 Role of Logistics Companies in Supply Chain Collaboration

The information taken from the interviews shows that logistics firms are majorly coordinators and intermediaries in the supply chain, which allows various stakeholders to cooperate and indirectly impact emissions reduction by planning and decision making.

In all interviews, the participants were consistent in stating that logistics companies are key coordinators of a supply chain. Instead of producing goods or emissions directly, as they do, they enable the flow of goods by integrating various stakeholders. To illustrate this, one participant stated: *"We basically connect different parties in the supply chain such as exporters, importers, shipping lines, transport companies. We don't physically produce goods, but we manage goods to move from one point to another efficiently. Actually, in simple terms, we act coordinators of the supply chain."* (Company B, RL01). Likewise, another respondent supported this view by saying: *"Simply, we are coordinators in the supply chain."* (Company B, RL02). These responses underscore the fact that logistics firms act as mediators, as they organize the actions of various actors, as opposed to owning operational resources.

A notable discovery is that logistics firms are directly but indirectly associated with carbon emissions. Although they might not be involved in driving transport vehicles or holding emission generating properties, they affect the manner in which logistics operations are developed and implemented. One respondent had a response such as *"If I speak honestly, we can't control these emissions alone because we don't operate any transport vehicles, but our role is indirect. We can tell other parties how to work sustainably."* (Company D, RL03).

It was noted through Interviews that logistics businesses contribute to reducing emissions by planning and optimization of their operations. They can greatly influence

total supply chain emissions by controlling the shipment schedules, transport mode choice, and coordination of cargo flows. This role was explained by one participant in the frames of collaboration: *"By collaborating, we can consolidate cargo. Instead of 3 half-empty containers, we merge them into one as one container when dispatching. Then we can cut emissions immediately."* (Company B, RL04). This illustrates that logistics firms are facilitators of efficiency, and they leverage their coordination position to adopt measures that lower emissions.

Logistics companies are also vital in information flow and communication in the supply chain. They enable information exchange between the stakeholders concerning the operations and the sustainability issues and allow making decisions. One participant explained: *"I will make sure that any documentation is in line with the Australian regulations and as well as that of the destination country. And also, interact with clients, transport providers, and port authorities and make sure that everything goes smoothly."* (Company B, RL05). This indicates the value of communication and coordination in making sure that logistics operations are efficient and compliant.

Moreover, respondents revealed that the logistics companies are also involved in sustainability by affecting stakeholder behavior. Their recommendations to clients, choice of providers of transport and their operations can promote more sustainable practices. As an example, one interviewee said: *"We also work together with customers by motivating them to plan better shipments. Accurate predictions and flexible schedules by the clients will allow us to consolidate deliveries and improve routes that will help in reducing emissions."* (Company B, RL06). This is the influence that logistics companies have as the decision makers in the whole supply chain in order to realize an improved environmental performance.

Nonetheless, the results also indicate that logistics companies have a constrained impact due to their location in the supply chain. They lack full control over all the stakeholders hence their power to impose sustainability practices relies on the collaboration and

mutual agreement. This supports the essence of coordination and collaboration in meeting carbon reduction objectives. The results, in general, indicate that logistics firms have a key centralizing and facilitating role in supply chain cooperation. They serve as a connector between the stakeholders, affect the results of the emissions indirectly by planning and making decisions, and improve communication and collaboration along the supply chain. Their ability to control emissions is minimal, but they are in a strategic position to play an important role in carbon reduction initiatives through coordination, optimization, and engagement of stakeholders.

4.5 Types of Supply Chain Collaboration

Collaboration with transport companies such as shipping lines and trucking companies is one of the most outstanding types of collaboration discovered during the interviews. Respondents highlighted the importance of coordination with such partners to maximize routes, minimize delays, and enhance fuel efficiency. One of the participants explained as an example: *"In the case of the transport providers such as the trucking companies, we cooperate with them to arrange the pickup and delivery times on time. This can prevent unnecessary waiting time, empty trips, and better fuel consumption."* (Company B, SC01). This underscores the role of cooperation with transport providers in the direct reduction of inefficiencies and emissions in the logistics processes.

Besides this, the participants also emphasized the cooperation with shipping lines as a valuable tool to enhance sustainability results. Logistics companies are vital in identifying carriers and scheduling to maximize efficiency. One participant stated: *"In shipping lines, we manage the schedule of vessels, availability of containers and planning routes. The fact that selecting the right carriers that perform effective operations can contribute to the delays and fuel usage reduction."* (Company B, SC02). This shows that cooperation on a carrier level helps to improve the operational performance and also helps to reduce emissions.

The other important type of collaboration that is observed is the collaboration with the customers, especially as applies to the shipment planning and demand forecasting. Respondents also highlighted that customer collaboration is essential in facilitating effective logistic operation. As an example, one respondent mentioned: *"We also work together with customers by motivating them to plan better shipments. Accurate predictions and flexible schedules by the clients will allow us to consolidate deliveries and improve routes that will help in reducing emissions."* (Company B, SC03). This was also supported by another participant who noted: *"we work together with customers to plan shipments better."* (Company D, SC07). It shows that customers actively participate in the sustainability processes, and their readiness to change planning processes has a substantial impact on the results of the emission.

Moreover, the participants emphasized that collaborative decision-making is one of the key factors in the process of emissions reduction. This is through close collaboration with various stakeholders in order to maximize the logistics process. A respondent with a partner related it as follows: *"We have recently joined with an Australian retailer and a shipping line to try out a 'Carbon-Optimized Route'."* (Company B, SC04). This case illustrates how cooperation among various supply chain stakeholders can result in new ways of reducing emissions.

The need to work in collaboration with different stakeholders was also highlighted by participants as engaging diverse stakeholders like customs agents, government authorities, and logistics partners. A participant said: *"We work with various stakeholders such as shipping lines, trucking firms, customs agents, clients and government etc." (Company B and Company C, SC05).* This underscores the intricacy of logistics activities and the necessity of collaboration between various organizations to attain sustainability goals. Besides operational cooperation, participants also found the significance of information sharing and real-time coordination. The exchange of data with partners allows to plan better and minimizes inefficiencies. For example, one participant noted: *"shipment tracking systems enable all parties to receive real-time*

updates. So, this enhances coordination and minimizes delays." (Company B, SC06). This shows how the cooperation with the help of information exchange can enhance the efficiency of operations and decrease emissions.

Generally, the results suggest that supply chain collaboration in the logistics is operational and coordination-based and that numerous stakeholders are involved in the supply chain. The cooperation with transport providers, shipping lines and customers is critical to enhance the efficiency and minimize emissions. Along with this, sharing of information and real time systems also enhances teamwork. These results point to the fact that successful cooperation is the key to carbon neutrality in the logistics since it allows taking coordinated action throughout the whole supply chain.

4.6 Mechanisms and Tools Supporting Collaboration

One of the mechanisms that have been observed in all the interviews is the application of Transportation Management Systems (TMS) and other online platforms to coordinate logistics processes and facilitate the tracking of emissions. One respondent described: *"We use a specialized Transportation Management System (TMS) which integrated with carbon calculators. We also rely on data provided by shipping lines and truck companies regarding fuel efficiency."* (Company B, MT01). This underscores the effectiveness of integrated systems in helping organizations keep track of emissions and make sound decisions based on the fuel efficiency information.

Conversely, other respondents had to use more rudimentary and manual methods of quantifying carbon emissions. To demonstrate this, one respondent mentioned: *"We have a quite simple system here… It's quite easily calculated on a sum in Excel. Like, calculate the estimated fuel consumption and what kind Emissions per kilometer."* (Company A, MT02). It means that although the emission measurement is considered a significant instrument, not every organization can use sophisticated digital instruments, which contribute to the discrepancy in the data quality and analytical capacities.

Another aspect that was pointed out by the participants was the application of digital communication platforms and logistics systems to coordinate supply chain partners. One of the participants has elaborated on the situation: *"The information is primarily exchanged using digital platforms, emails, and logistics systems. As an example, shipment tracking systems enable all parties to receive real-time updates."* (Company B, MT03). This shows that digital communication tools are critical in the exchange of timely information and coordination among various stakeholders. The other valuable mechanism that has been identified is the adoption of real-time tracking systems, which increase visibility and minimize inefficiencies in the logistics processes. One participant reported: *"real-time tracking helps avoid unnecessary delays, which can lead to fuel wastage."* (Company B, MT04). This means that better visibility with the use of digital systems has a direct impact of minimizing operational inefficiencies and emissions.

Besides the operational systems, participants also highlighted the role of digital documentation, paperless processes in facilitating efficiency and sustainability. One participant explained: *"For example, using electronic bills of lading reduces the need for physical documents. Then the time taken to negotiate with shipping lines and shippers will be minimized and also the vehicle fuel cost to move those documents will also be reduced."* (Company B, MT05). This points to the fact that in addition to enhancing operational effectiveness, digitalization leads to a smaller reduction in emissions through the consumption of fewer resources.

Nonetheless, the results also unveil shortcomings of the existing application of technological tools. According to some respondents, current systems are not well developed to facilitate full tracking of emissions or data sharing. One participant stated: *"our transport management system that we use here is not so very modern. So, it has nothing to calculate, it doesn't even calculate the kilometers or anything."* (Company A, MT06). This implies that old systems may both be a burden to proper measurement of emissions and restrict the possibilities of making data-based decisions.

Moreover, participants identified issues associated with data sharing capacity of digital systems. In other instances, companies cannot provide the partner with the data on emissions because of the limitations of the system. One participant explained: *"we are not able to share this data with the clients now."* (Company A, MT07)

This is an indication of lack of data accessibility, despite the availability of data, and thus it may impede the collaborative approach to sustainability. On the whole, the results show that technological systems and tools are essential in facilitating supply chain partnership and aiding in carbon reduction. High-tech tools like TMS with built-in carbon calculators can be used as important sources of decision-making information, and the communication mechanisms and monitoring systems can be used to improve coordination and efficiency. Nevertheless, technological differences and the inability to exchange data indicate the necessity to have better systems and become more digital throughout the supply chain.

4.7 Data Transparency in Supply Chain Collaboration

Throughout the interviews, the participants were always keen to stress the significance of data sharing in enhancing the process of coordination and decision-making in the supply chain. The digital communication systems and logistics were named as the main channels where the information about operations and emissions could be exchanged. As an example, one of the participants described it as follows: *"The information is primarily exchanged using digital platforms, emails, and logistics systems. As an example, shipment tracking systems enable all parties to receive real-time updates."* (Company B, DT01). This underscores how digital systems facilitate the flow of information in real-time, thus improving coordination and minimizing operational inefficiencies.

Besides communication, participants also stressed the need to have transparency in instilling trust among the partners in the supply chain. One respondent mentioned:

“When it comes to data transparency, it is mandatory. If a partner doesn't trust our data, they won't invest in more expensive, sustainable shipping options.” (Company B, DT02). It means that transparency is not a technical issue only but one of the key factors contributing to stakeholder behavior and their readiness to use sustainable practices. Nevertheless, even though it is noted to be important, participants indicated that the data sharing is very sparse and not carried out in a systematic manner. Data on emissions and performance are often shared on demand in most instances. Another participant explained: *“It's like only presented by request, if they don't ask, we don't make any reports or that kind of stuff.”* (Company A, DT03). This implies data sharing practice is reactive than proactive and this restricts the robustness of collaboration towards attaining sustainability objectives.

In addition, the participants emphasized that there were no standardized ways of measuring and reporting the emissions, which poses a problem in maintaining consistency and reliability of collective information. One among them said: *“they are aware of how we are calculating… it's like average for fuel consumption and the kilometers.”* (Company A, DT04). It means that calculations of emissions can be usually made on the basis of estimates and assumptions, and it can decrease the confidence in the correctness of the information. The other critical problem that is being identified is that the current digital systems do not have the ability to facilitate data sharing. Other organizations do not have the technology to share the emission data directly with partners. As an illustration, one of the Interviwee said: *“we are not able to share this data with the clients now.”* (Company A, DT05). This is indicative of disparity between data creation and data availability, which may impede successful cooperation and openness.

Moreover, participants also noted that various organizations implement various systems and methods, which results in discrepancies in data reporting. This integration deficiency also makes it more difficult to share and interpret the data on emissions along the supply chain. Irrespective of these issues, a few participants reported that there is an attempt

to enhance transparency through keeping partners updated on the pertinent information. Representative from company B indicated: *"we are trying our best to keep our partners up to date on relevant emission information."* (Company B, DT06). This shows an increasing awareness of the need to be transparent although this has not been widely enforced.

In general, the results suggest that data sharing and transparency are key facilitators of supply chain collaboration toward carbon neutrality. Although information exchange is facilitated by digital platforms and tracking systems, the existing practices are usually disjointed, reactionary, and limited by technology. The inefficiency of transparency initiatives is further constrained by the absence of standardized methodologies of measurement and the low level of integration of systems. These results point to the necessity to be more organized, proactive, and standard in data sharing in logistics so as to properly facilitate collaborative sustainability actions.

4.8 Barriers and Challenges

Cost is one of the most conspicuous issues found during the interviews. Respondents repeatedly highlighted how sustainable and carbon-neutral solutions are costly in terms of financial resources, which are not always justifiable in a highly competitive environment with small profit margins. Indicatively, one respondent mentioned: *"One major challenge is cost. Sustainable and carbon neutral options are always expensive and not all customers willing to pay extra."* (Company B, BC01). On the same note, another participant pointed out financial risks of sustainability investments: *"if you need to invest in something, it's not so easy because… margins are very slim within the transportation business."* (Company A, BC02). These comments suggest that the price is a significant obstacle that curbs the implementation of more environmentally friendly technologies and practices, in those cases when the customers are not ready to spend more money.

The other major challenge observed is the difference in capabilities among supply chain partners. The participants observed that although there are advanced tools and systems to measure and manage emissions in some organizations, some organizations do not have the technological capabilities. One participant explained: *"Some big shipping lines have the ability to measure carbon and work according to carbon neutral practices, but some local transport companies don't have the right tools to measure or adapt these practices."* (Company B, BC03). This gap poses challenges in ensuring uniform and integrated sustainability activities throughout the supply chain.

Besides the difference in capability, technological and infrastructure bottlenecks were also cited as a major challenge. The participants emphasized the lack of alternative fuels, electric cars, and multimodal transportation. As an illustration, one of the interviewees said: *"We haven't seen that here and we don't have any possibility to do that with the kind of transport that we are doing."* (Company A, BC04). Another participant emphasized the challenges associated with long-distance transport: *"It's kind of hard-to-reach carbon neutrality as we have long-distance transport mostly by road. So, our options are very few."* (Company A, BC05). These results imply that the structural and infrastructural barriers restrict the possibility of implementing low-carbon alternatives in logistics operations.

The challenges in the supply chain to which the participants pointed to include commitment and collaboration. Sustainable partnership involves a long-term commitment of all the stakeholders which is not always assured. One interviewee remarked: *"If we start to collaborate sustainably with our partners in the supply chain, we can't quit easily."* (Company B, BC06). This analyses that sustainability efforts must be a long-term endeavor and commitment, which is not always easy to sustain in the dynamic and competitive business environments.

The other significant obstacle is associated with the problem of data sharing and trust. As observed in the preceding section, transparency and standardized data sharing

practices may be lacking, which may impede cooperation. Stakeholders might not be keen on investing in sustainability activities without reliable data. Moreover, they referred to regulatory and external environmental factors as affecting the sustainability efforts. Regional variations in regulations and infrastructure may provide disparities in implementation. One of the participants stated: *"Some countries have better infrastructure and regulations for sustainable logistics, while others don't."* (Company B, BC07). The other respondent noted that global standardization is lacking saying: *"it's hard to do it all over the world because there isn't a universal carbon tax."* (Company B, BC08). These reactions reveal that the outside influences like regulatory systems and access to infrastructure are important determinants of sustainability practices.

Altogether, the results indicate that the possibility of supply chain collaboration to achieve carbon neutrality is limited by a set of internal and external issues. Financial constraints, disparities in capabilities, technology constraints, and absence of standardized regulations are reasons that make the adoption of sustainable practices difficult. These are some of the barriers that underscore the importance of coordinated efforts, investment in technology, and facilitating policy frameworks to facilitate successful collaboration to reduce carbon in logistics.

4.9 Improvements and Future Role of Logistics Companies in Achieving Carbon Neutrality

Among the themes that are prominent in the interviews is the necessity to engage in more sharing and transparency of data. The participants stated that the lack of data on emissions is a significant limitation to the possibility of finding potential areas of improvement. To illustrate this, the participant of Company D stated, "*First is better data sharing and transparency. As I have mentioned before, businesses do not actually present more detailed information. They do not provide many details on emissions. It is extremely hard to determine where improvements are required without appropriate data.*" (IM01, Company D). This implies that insufficient data availability is a major constraint that

constrains greatly the extent of cooperation, which must be an evidence-based decision making.

The necessity to make systems and processes more standardized is also a close issue in relation to this topic. Interviewees observed that lack of consistency in various organizations poses challenges to measuring and comparing emissions, *"Having more standardized systems and readiness to share data among partners is extremely important."* (IM02, Company D). This is indicative of a larger problem of disjointed systems and lack of consistency in reporting that makes it difficult to work with other systems.

The other area that can be identified as critical to be improved is the significance of trust and long-term relationship between supply chain partners. The participants insisted on the fact that without a good base of trust, collaboration is not possible. According to one of the interviewees, *"There is no way that collaboration will be effective when companies are unwilling to share information or collaborate. There must be extended relationships as opposed to transactional relationships."* (IM03, Company D). This brings out the fact that the cooperation in logistics is not merely transaction based but relationship based.

The results also indicate the increasing significance of the digitalization and technological integration in facilitating collaboration. The participants stressed the necessity to have more sophisticated digital systems that could track the emissions and allow making real-time decisions. Participant from company C said, *"strong data standardization and transparency is needed across all partners along with the better integration of digital systems to enable real time visibility of the performance and the emissions"* (IM04, Company C). This implies that digital tools can be instrumental in improving the visibility and coordination of the supply chains.

Besides digital systems, interviewees emphasized investing in green technologies and infrastructure. One of the participants mentioned that *"investments in green*

technologies might be a major need in future" (IM05, Company B), which implies that carbon neutrality cannot be achieved without investment and technological solutions.

The other significant theme is connected with the innovation of transport and operational advancement. The interviewees pointed out that alternative forms of transport and fuel were necessary to minimize emissions. The representative from Company A said, *"we would need more options for Multimodal transports… also like these alternative fuels"* (IM06, Company A). This underscores the fact that the existing transport systems cannot accommodate carbon-neutral operations.

The results also demonstrate the significance of shared responsibility and collaboration with stakeholders. Participants highlighted that carbon neutrality can only be achieved through concerted efforts of all players in the supply chain. According to Company B, *"I don't think that a single company can reach for Carbon Neutrality alone. Continuous effort and sustainable collaboration with other supply chain partners can achieve these long-term environmental goals."* (IM07, Company B). Correspondingly, company C emphasized the need to have a strategic alignment of stakeholders as *"alignment with sustainability goals, shared KPIs and joint planning between suppliers, logistic providers and custom also essential."* (IM08, Company C). That implies that cooperation should go beyond operational coordination to strategic integration among supply chain partners.

Lastly, the results give information about how logistics firms will be utilized in carbon-neutral supply chains in future. Interviewees continually pointed out that logistics companies are supposed to change roles and cease being service providers to more strategic roles. According to the Company C, *"the role of logistics companies will evolve from being service providers to becoming sustainability enablers and coordinators as well."* (IM09, Company C).

Moreover, logistics companies are expected to take a central role in driving sustainability initiatives. As one participant explained, they can "*play a centered role by leveraging*

digitalization, improving operation efficiency and promoting sustainable and carbon neutral practices across supply chain." (IM10, Company C). This underscores the increasing role of logistics firms in terms of helping to collaborate and facilitate carbon mitigation.

In general, the results indicate that data transparency, standardization, trust, technological integration, and stakeholder collaboration are necessary to reach carbon neutrality. Meanwhile, logistics firms are transforming into important agents of sustainability within supply chains, and they are at the center of facilitating collaborative and carbon-neutral operations.

4.10 Synthesis of Findings

The results show that the logistics companies have a largely operational concept of carbon neutrality, which aims at minimizing emissions by enhancing efficiency but is not based on an overall strategic framework. To a large extent, carbon neutrality is seen as the reduction of emissions produced due to the logistic activities and the control of the unavoidable effects. This realization is strongly connected to the character of the logistics operations, with transportation being found as the main contributor to emissions. Other factors like fuel consumption, long distance transportation, and use of standard methods of transport are major contributors of emissions.

Logistics companies respond by taking on carbon reduction practices that are largely driven by efficiency. Shipment consolidation, route optimization, empty driving reduction, and digitalization are some examples of practices that show a high concentration on the optimization of current processes. These results imply that carbon mitigation in logistics is more of an incremental than a transformational change. One important lesson of the research is that the main facilitator of supply chain cooperation is the logistics companies. Logistics companies are coordinators and intermediaries, and they link various stakeholders, who include customers, transport providers, and regulatory bodies. Even though they are not the direct owners of the assets that produce

the emissions, they have an effect on the emission results through planning, coordinating, and making decisions.

The research also indicates that the collaboration takes place at various levels, such as customers, transport providers and other stakeholders. Such interactions contribute towards better planning, enhanced resource utilization and coordination, which will result into a reduction in emissions. Nevertheless, collaboration is effective based on the ability and involvement of the stakeholders. Mechanisms and tools and especially digital systems, in the form of Transportation Management Systems (TMS) and tracking platforms, are determined as one of the critical facilitators of collaboration. The adoption of these systems is however constrained by the differences in the levels of technological maturity. On the same note, data sharing and transparency is considered very important, but the current practices are usually reactive, and not standardized, which makes them less effective. This has been found to have a number of barriers and challenges such as cost constraints, ability differences, technological limitations, and regulatory standardization. These obstacles point to the fact that carbon neutrality will only be achieved through coordinated efforts outside of individual organizations. On the whole, the results indicate that logistics firms are slowly transforming themselves into the providers of operational services to sustainable supply chains and play a key role in facilitating collaboration and assisting the carbon neutrality.

Summary of key findings and Interrelationships as follows.

Table 4. Summary of key findings and Interrelationships

Theme No.	Theme	Key Insight	Relationship to Other Themes
01	Understanding of Carbon Neutrality	Carbon neutrality is viewed operationally rather than strategically	Influences carbon reduction practices (Theme 3)
02	Key Sources of Emissions	Emissions mainly arise from transport and fuel consumption	Drives need for reduction practices (Theme 3)

03	Carbon Reduction Practices	Focus on efficiency (route optimization, consolidation)	Enabled through collaboration (Theme 4 & 5)
04	Role of Logistics Companies	Logistics firms act as coordinators and facilitators	Central to all collaboration activities
05	Types of Collaboration	Collaboration occurs with customers, transport providers, and stakeholders	Supports implementation of practices
06	Mechanisms & Tools	Digital systems (TMS, tracking) enable coordination	Supports data sharing (Theme 7)
07	Data Transparency	Data sharing is limited and non-standardized	Affects collaboration effectiveness
08	Barriers & Challenges	Trust, cost, and technology gaps limit collaboration	Restricts all collaborative efforts
09	Improvements & Future Role	Need for data, trust, and digital systems; logistics evolving as enablers	Addresses barriers and strengthens collaboration

5 Discussion

5.1 Theoretical Contribution

This research paper adds to the existing literature in that it answers the research questions based on empirical findings of logistics firms. The study, by relating results to the research questions, offers a systematic interpretation of how logistics companies implement collaborative practices, challenges they encounter, and what they need to do to attain a carbon-neutral result.

In relation to the first research question, the results indicate that logistics firms are mainly dependent on operational, collaborative, and digital solutions to enable carbon-neutral collaboration. The main practices that are discovered are; route optimization, shipment consolidation and reduction of empty driving that is meant to help in efficiency and reduction of emissions. The practices show that carbon reduction is in many ways inbuilt in the daily operations of the activities rather than as a result of independent sustainability efforts. On mechanisms, the results indicate that central to collaboration is coordination and information exchange by the stakeholders. Logistics companies interact with their customers, transport providers, and other partners in order to enhance planning and align operations. This justifies the concepts of SCC theory which stresses shared decision making and coordinated action (Cao and Zhang 2011; Barratt, 2004). Moreover, the research traces the significance of the digital tools, like Transportation Management Systems (TMS) and tracking platforms, in facilitation. The tools increase visibility, enhance communication and assist in decision making that is data driven. Nevertheless, the results also indicate that the applicability of these tools is constrained by the lack of system integration and different degrees of technological capacity. Theoretically, this builds upon current literature, by showing that carbon-neutral collaboration can be promoted via a blend of operational practices, relational mechanisms, and technological tools, which does not rely on one approach. It also notes that digital systems can be the catalysts to collaboration, although their effectiveness is determined by the degree of integration and adoption throughout the supply chain.

In response to research question two, the results of the study reveal that there are a number of challenges that impede effective implementation of collaborative carbon reduction initiatives. Some of the key issues are lack of data transparency, standardized system, lack of trust amongst partners and technological constraints. All these obstacles inhibit the capacity of logistics companies to work in cooperation and attain carbon-neutral results. An important point in the results is that these issues are not independent but are related to each other. To illustrate, sharing of limited data will lead to lack of transparency, which undermines trust among partners and eventually impacts on collaboration. Equally, without any standardized measurement system, performance is hard to compare and also benchmark sustainability objectives within organizations. These results correspond with the existing literature that places trust and coordination in the supply chain cooperation as essential (Govindan et al., 2014). Nonetheless, the current research is an addition to the existing literature as it illustrates the interplay between these issues in practice, which compounds obstacles to collaboration. This implies that it might not be adequate to solve personal issues in isolation, but a more comprehensive approach is needed. Theoretically, this adds to the fact that the success of collaboration in the supply chain is reliant on the interplay of technological, organizational, and relational variables. It also shows a disconnect between theory of smooth cooperation and reality of logistics companies.

Regarding the third research question, the results indicate that there are a number of ways in which logistics firms should improve in order to achieve more successful carbon-neutral results and improve collaboration. These are enhancing the transparency of data, using standardized systems, enhancing stakeholder relations, and investing in digital technologies and green infrastructure. One of the identified areas of the improvement is the necessity to provide a more advanced data exchange and unified reporting, which could lead to an increased level of transparency and allow making more efficient decisions. Also, the need to build trust and establish long-term relationships was mentioned as a key to enhancing collaboration. The research also highlights the need to

integrate digitally, with advanced systems having the capability to provide real-time access to emissions and performance. This implies that collaboration is a vital enabler by technology development. In addition, the paper points to the change in the future role of the logistics companies that are likely to become sustainability facilitators and orchestrators rather than service providers. It means that logistics companies will be even more strategic in promoting collaborative efforts and enhancing carbon reduction throughout supply chains. Theoretically, it builds on existing literature by showing that successful collaboration necessitates implementation of not only practices but also system, relationship, and strategic goal alignment. It also supports the notion that logistics firms are key facilitators in promoting sustainable supply chain results.

These contributions help get a more detailed and realistic picture of the way supply chain collaboration can help achieve carbon neutrality in logistics settings. Moreover, the contributions provide a more realistic and situation-specific insight into the way supply chain collaboration works in practice, thus contributing to the theoretical knowledge base of sustainable logistics.

5.2 Managarial Implications

The results obtained from the study have several implications for logistics managers who strive to create better collaboration between supply chain actors while striving for carbon neutrality. First of all, the study results have shown that operational efficiency is the most effective path forward when it comes to reducing emissions. Shipment consolidation, route optimization, and minimization of empty miles are common practices adopted by the respondents. Thus, logistics managers should concentrate on making the most of their operational capabilities instead of adopting advanced technologies and solutions until they manage to streamline and optimize their operations.

Secondly, one cannot underestimate the importance of working together with both transport providers and customers. According to the findings of the research, logistics

managers should collaborate with customers to plan and forecast their demands and make sure that they have flexible schedules in terms of deliveries. Similarly, logistics managers should develop their cooperation with transporters, as they should be involved in any sustainable actions.

Thirdly, Logistics managers should acknowledge their role as a logistics managers and how they play in coordinating activities of various stakeholders. It is essential that logistics managers become coordinators, guiding the efforts of other actors and pushing them toward sustainable practices, rather than focusing purely on operations. For example, it might be useful for managers to select transport providers based on their environmental friendliness.

Fourth, the study indicates the need to use technology to facilitate collaboration. Digital technologies such as TMS and transport management solutions are necessary tools used to facilitate logistics and reduce emissions. At the same time, it is necessary to consider that there might be a digital maturity gap in supply chains, thus managers should pay particular attention to enhancing interoperability.

Fifth, logistics managers should consider information sharing as a key step towards collaboration. It is evident that sharing practices are usually reactive in nature and fail to establish standardized ways of information exchange. Hence, it is important for logistics managers to create proactive and standardized mechanisms of data exchange among participants to enhance the levels of collaboration.

Finally, logistics managers should pay attention to some common barriers, such as lack of funds and differences in capabilities between partners. It might be useful to use collaborative approaches such as cost-sharing or joint development of new capabilities.

5.3 Limitations

This paper faces several limitations that need to be highlighted. First, the sample size of the study consists of only four participants. Nevertheless, this limitation is characteristic of qualitative studies where in-depth understanding of the topic prevails over its broader coverage. This study has been successful in uncovering the nuances associated with collaboration practices. Future work could employ larger sample sizes in order to generalize findings to a wider population. Another issue that needs to be raised is related to the use of self-reported data based on interviews. The respondents' answers might have been distorted due to the desire to portray themselves positively by mentioning sustainable practices and activities. As a result, this might negatively affect the validity of the study findings. Moreover, this research employs cross-sectional design implying collection of data at a certain point in time. Due to the fact that carbon neutrality is a long-term goal, organizational collaboration practices and strategies can change with time. This means that the dynamic nature of organizational collaboration practices will not be captured through a cross-sectional approach. Furthermore, this study takes the point of view of logistics organizations, and there was no attempt to consult with representatives of other actors involved in collaborative practices. These stakeholders could include customers, suppliers, as well as governmental bodies. Finally, the findings reveal differences between technological capabilities without offering detailed technological analyses or quantitative assessment of emission levels.

5.4 Suggestions for Future Research

Expanding upon the findings from this paper, which also had some limitations, there are numerous areas where future research should go. First, further investigations will have to include more subjects from various logistics companies within diverse sectors. This will allow obtaining the findings that can be generalized on the collaboration in the studied sphere. It is also crucial to consider the multi-stakeholder approach and incorporate the opinions of the company’s employees, clients, transportation providers, and policymakers. This way, the researcher will understand collaboration in all its

complexity and find out whether such collaboration can help achieve carbon neutrality in the sector. Longitudinal analysis could be useful to monitor the dynamics of collaboration strategies and sustainable practices over time. In addition, due to the lack of digitalization in logistics and the potential provided by innovative technologies, future studies may focus on how artificial intelligence, blockchain, and IoT technology can promote collaboration and track greenhouse gases. Moreover, further quantitative and mixed research methods should be used to evaluate the impact of collaboration on reducing carbon emission within the industry. Lastly, future research should investigate the role of policies in promoting collaborative projects geared towards developing carbon-neutral supply chains.

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Appendices

Appendix 1. Interview Questions

Part 1: **Background Information**

1. Can you explain your job role and duties in the organization?
2. How many years of experience do you have in logistics and supply chain management?
3. What role does your company play within the logistics or supply chain?
4.

Part 2: **Carbon Neutrality and Sustainability**

1. What is carbon neutrality to your company within the context of logistics operations?
2. Does your organization have formal sustainability or carbon-reduction objectives? If yes, please describe them briefly.
3. Which logistics activities (Eg:- Transportation, warehousing, distribution etc) generate the highest emissions in your organization?
4. What key practices or initiatives are implemented to reduce carbon emissions?

Part 3: **Role of Logistics Companies in Supply Chain Collaboration**

1. In your opinion, what role do logistics companies play in reducing overall supply chain emissions?
2. What types of partnerships or collaborations do your company have with supply chain partners to achieve sustainability goals?
3. Would you be able to provide some examples of successful collaboration on the reduction of carbon?

Part 4: **Mechanisms and Tools**

1. What technologies or tools does your organization use to measure and manage carbon emissions?

2. How is information such as emissions data, performance metrics shared with partners, and how important is data transparency in this process?
3. How do digital systems (Eg:- Transportation Management System, tracking systems) support collaboration and sustainability efforts?

Part 5: **Barriers and Challenges**

1. What are the main challenges your company faces when collaborating with supply chain partners on carbon reduction initiatives (Eg:- Trust, cost, data sharing, capability differences)?
2. Are there any country-specific or business-specific barriers that influence above discussed efforts?
3. How do government regulations and policies influence your company's sustainability practices, and how do approaches differ across countries?

Part 6: **Improvements, future Outlook and closing**

1. What improvements are needed to enhance Supply chain collaboration for achieving carbon neutrality and how do you see the role of logistics companies evolving in future carbon neutral supply chains?
2. Do you have any final thoughts or suggestions to add ?

Appendix 2. Code Table

Theme	Code Name	Code No.	Full Verbatim Description (from Transcripts)
Understanding of Carbon Neutrality	Emission balancing concept	CN01	"So actually, Carbon neutrality in logistics operations means balancing carbon emissions generated from the activities like warehousing or transportation and handling with the actions to reduce those emissions." (Company C)
Understanding of Carbon Neutrality	Emission reduction and compensation	CN02	"In our view, carbon neutrality means that we should minimize the emissions produced in the course of logistics operations and then compensate the rest of the emissions." (Company B)
Understanding of Carbon Neutrality	Practical limitation of carbon neutrality	CN03	"It's kind of hard-to-reach carbon neutrality as we have long-distance transport mostly by road. So, our options are very few." (Company A)
Understanding of Carbon Neutrality	Operational planning for emission reduction	CN04	"When we are planning shipments, we can try to reduce unnecessary movements, like avoiding sending half-empty containers or reducing multiple trips. Instead, we try to consolidate cargo as much as possible." (Company D)
Understanding of Carbon Neutrality	Fuel efficiency and reducing empty trips	CN05	"We try to reduce fuel consumption and also, one thing you can think about is to reduce empty driving when you drive between places." (Company A)
Understanding of Carbon Neutrality	Indirect role in emission control	CN06	"If I speak honestly, we can't control these emissions alone because we don't operate any transport vehicles, but our role is indirect. We can tell other parties how to work sustainably." (Company D)

Understanding of Carbon Neutrality	Formal sustainability objectives	CN07	“Yes, our organization has formal sustainability and carbon reduction objectives. So, we are focusing on improving operation efficiency, reducing the fuel consumption and promoting the use of energy efficient systems within the warehouses and minimizing waste across logistics processes.” (Company C)
Understanding of Carbon Neutrality	Lack of clear sustainability goals	CN08	“Finally, I have to say is we don’t have clear goals, but we have above practices which support carbon neutrality.” (Company D)
Understanding of Carbon Neutrality	Non-specific sustainability targets	CN09	“We have some that are stated in our code of Conduct, but I don't know if they are not so specific. It's most like stated that we try to reduce, but we have no clear goals in numbers or that kind of stuff.” (Company A)
Key Sources of Carbon Emissions	Transportation as main emission source	SE01	“Definitely that is Transportation. Particularly long-haul ocean freight and last mile trucking.” (Company B)
Key Sources of Carbon Emissions	Dominance of transportation emissions	SE02	“I would say it's clearly the transportation part.” (Company A)
Key Sources of Carbon Emissions	Fuel-intensive logistics operations	SE03	“These days we are only have diesel trucks, and I don't see so many possibilities to use some electric trucks or anything like that because of the long distances.” (Company A)
Key Sources of Carbon Emissions	Impact of long-distance transport	SE04	“It's kind of hard-to-reach carbon neutrality as we have long-distance transport mostly by road.” (Company A)
Key Sources of Carbon Emissions	Warehousing as minor emission source	SE05	“Although warehousing is a factor, the overwhelming amount of fuel used in trans-Pacific or European routes is the major factor.” (Company B)

Key Sources of Carbon Emissions	Direct transport reduces warehouse impact	SE06	“Mostly our trucks deliver straight from place A to place B, so There is mostly no middle handling in some warehouse or something like that.” (Company A)
Key Sources of Carbon Emissions	Inefficiency due to empty trips	SE07	“So-called unnecessary driving to drive empty, so it's better to drive with loads.” (Company A)
Key Sources of Carbon Emissions	Transport modes contributing to emissions	SE08	“In logistics, transportation such as ships, trucks and also air freight is contributing to the majority of the emissions.” (Company B)
Key Sources of Carbon Emissions	Inefficient shipment planning and underutilization	SE09	“When we are planning shipments, we can try to reduce unnecessary movements, like avoiding sending half-empty containers or reducing multiple trips.” (Company D)
Carbon Reduction Practices	Shipment consolidation practice	CR01	“One key practice, we use is ‘shipment consolidation’. So, here we do not make several small shipments and dispatch them in different containers. Instead, we connect all of them as one into one container and this decreases the number of trips to be made.” (Company B)
Carbon Reduction Practices	Consolidation for emission reduction	CR02	“Instead of 3 half-empty containers, we merge them into one as one container when dispatching. Then we can cut emissions immediately.” (Company B)
Carbon Reduction Practices	Route optimization	CR03	“The other example is route optimization, where we are planning the best transport routes to, uh, ensure we, uh, to ensure we do not waste more fuel” (Company B)
Carbon Reduction Practices	Reducing empty driving	CR04	“We try to reduce fuel consumption and also, one thing you can think about is to reduce

			empty driving when you drive between places." (Company A)
Carbon Reduction Practices	Slower shipping for fuel reduction	CR05	"We also advise clients to use slower shipping methods where possible since faster shipping tends to use more fuel." (Company B)
Carbon Reduction Practices	Energy-efficient operations	CR06	"Yes, our organization has formal sustainability and carbon reduction objectives. So, we are focusing on improving operation efficiency, reducing the fuel consumption and promoting the use of energy efficient systems within the warehouses and minimizing waste across logistics processes." (Company C)
Carbon Reduction Practices	Digitalization and paper reduction	CR07	"Mostly digital systems help reduce paperwork and improve efficiency. For example, using electronic bills of lading reduces the need for physical documents." (Company B)
Carbon Reduction Practices	Transport efficiency (longer road trains)	CR08	"We are trying also is to have longer road trains… they take like two trailers at the same truck and go down. So, we can reduce a little bit of emission." (Company A)
Carbon Reduction Practices	Reducing unnecessary movements and consolidating shipments	CR09	"When we are planning shipments, we can try to reduce unnecessary movements, like avoiding sending half-empty containers or reducing multiple trips." (Company D)
Role of Logistics Companies	Supply chain coordination role	RL01	"We basically connect different parties in the supply chain such as exporters, importers, shipping lines, transport companies. We don't physically produce goods, but we manage goods to move from one point to another efficiently. Actually, in simple terms, we act coordinators of the supply chain." (Company B)

Role of Logistics Companies	Coordinator identity	RL02	"Simply, we are coordinators in the supply chain." (Company B)
Role of Logistics Companies	Indirect emission influence	RL03	"If I speak honestly, we can't control these emissions alone because we don't operate any transport vehicles, but our role is indirect. We can tell other parties how to work sustainably." (Company D)
Role of Logistics Companies	Collaboration for emission reduction	RL04	"By collaborating, we can consolidate cargo. Instead of 3 half-empty containers, we merge them into one as one container when dispatching. Then we can cut emissions immediately." (Company B)
Role of Logistics Companies	Operational coordination and communication	RL05	"I will make sure that any documentation is in line with the Australian regulations and as well as that of the destination country. And also, interact with clients, transport providers, and port authorities and make sure that everything goes smoothly." (Company B)
Role of Logistics Companies	Influencing customer behavior	RL06	"We also work together with customers by motivating them to plan better shipments. Accurate predictions and flexible schedules by the clients will allow us to consolidate deliveries and improve routes that will help in reducing emissions." (Company B)
Types of Supply Chain Collaboration	Collaboration with transport providers	SC01	"In the case of the transport providers such as the trucking companies, we cooperate with them to arrange the pickup and delivery times on time. This can prevent unnecessary waiting time, empty trips, and better fuel consumption." (Company B)

Types of Supply Chain Collaboration	Collaboration with shipping lines	SC02	"In shipping lines, we manage the schedule of vessels, availability of containers and planning routes. The fact that selecting the right carriers that perform effective operations can contribute to the delays and fuel usage reduction." (Company B)
Types of Supply Chain Collaboration	Collaboration with customers	SC03	"We also work together with customers by motivating them to plan better shipments. Accurate predictions and flexible schedules by the clients will allow us to consolidate deliveries and improve routes that will help in reducing emissions." (Company B)
Types of Supply Chain Collaboration	Collaborative emission reduction initiative	SC04	"We have recently joined with an Australian retailer and a shipping line to try out a 'Carbon-Optimized Route'." (Company B)
Types of Supply Chain Collaboration	Multi-stakeholder collaboration	SC05	"We work with various stakeholders such as shipping lines, trucking firms, customs agents, clients and government etc." (Company B)
Types of Supply Chain Collaboration	Real-time coordination and tracking	SC06	"Shipment tracking systems enable all parties to receive real-time updates. So, this enhances coordination and minimizes delays." (Company B)
Mechanisms and Tools	TMS with carbon tracking	MT01	"We use a specialized Transportation Management System (TMS) which integrated with carbon calculators. We also rely on data provided by shipping lines and truck companies regarding fuel efficiency." (Company B)
Mechanisms and Tools	Manual emission calculation (Excel)	MT02	"We have a quite simple system here… It's quite easily calculated on a sum in Excel. Like, calculate the estimated fuel consumption

			and what kind Emissions per kilometer.” (Company A)
Mechanisms and Tools	Digital communication platforms	MT03	“The information is primarily exchanged using digital platforms, emails, and logistics systems. As an example, shipment tracking systems enable all parties to receive real-time updates.” (Company B)
Mechanisms and Tools	Real-time tracking systems	MT04	“real-time tracking helps avoid unnecessary delays, which can lead to fuel wastage.” (Company B)
Mechanisms and Tools	Digital documentation (paperless)	MT05	“For example, using electronic bills of lading reduces the need for physical documents. Then the time taken to negotiate with shipping lines and shippers will be minimized and also the vehicle fuel cost to move those documents will also be reduced.” (Company B)
Mechanisms and Tools	Outdated system limitations	MT06	“Our transport management system that we use here is not so very modern. So, it has nothing to calculate, it doesn't even calculate the kilometers or anything.” (Company A)
Mechanisms and Tools	Lack of data sharing capability	MT07	“We are not able to share this data with the clients now.” (Company A)
Data Sharing and Transparency	Digital information exchange	DT01	“The information is primarily exchanged using digital platforms, emails, and logistics systems. As an example, shipment tracking systems enable all parties to receive real-time updates.” (Company B)
Data Sharing and Transparency	Importance of transparency for trust	DT02	“When it comes to data transparency, it is mandatory. If a partner doesn't trust our data, they won't invest in more expensive, sustainable shipping options.” (Company B)

Data Sharing and Transparency	Reactive data sharing	DT03	“It's like only presented by request, if they don't ask, we don't make any reports or that kind of stuff.” (Company A)
Data Sharing and Transparency	Emission calculation based on estimates	DT04	“They are aware of how we are calculating… it's like average for fuel consumption and the kilometers.” (Company A)
Data Sharing and Transparency	Lack of data sharing capability	DT05	“We are not able to share this data with the clients now.” (Company A)
Data Sharing and Transparency	Effort to maintain transparency	DT06	“We are trying our best to keep our partners up to date on relevant emission information.” (Company B)
Barriers and Challenges	High cost of sustainability	BC01	“One major challenge is cost. Sustainable and carbon neutral options are always expensive and not all customers willing to pay extra.” (Company B)
Barriers and Challenges	Financial constraints and low margins	BC02	“If you need to invest in something, it's not so easy because… margins are very Slim within the transportation business.” (Company A)
Barriers and Challenges	Capability differences among partners	BC03	“Some big shipping lines have the ability to measure carbon and work according to carbon neutral practices, but some local transport companies don’t have the right tools to measure or adapt these practices.” (Company B)
Barriers and Challenges	Lack of alternative transport options	BC04	“We haven't seen that we don't have any possibility to do that with the kind of transport that we are doing.” (Company A)
Barriers and Challenges	Long-distance transport limitation	BC05	“It's kind of hard-to-reach carbon neutrality as we have long-distance transport mostly by road. So, our options are very few.” (Company A)

Barriers and Challenges	Commitment challenges in collaboration	BC06	“If we start to collaborate sustainably with our partners in the supply chain, we can’t quit easily.” (Company B)
Barriers and Challenges	Differences in infrastructure and regulations	BC07	“Some countries have better infrastructure and regulations for sustainable logistics, while others don’t.” (Company B)
Barriers and Challenges	Lack of global regulatory standardization	BC08	“it's hard to do it all over the world because there isn't a universal carbon tax.” (Company B)
Improvements and Future Role	Data transparency	IM01	“First is better data sharing and transparency… It is extremely hard to determine where improvements are required without appropriate data.” (Company D)
Improvements and Future Role	Standardization	IM02	“Having more standardized systems and readiness to share data among partners is extremely important.” (Company D)
Improvements and Future Role	Trust and relationships	IM03	“There is no way that collaboration will be effective when companies are unwilling to share information… There must be extended relationships as opposed to transactional relationships.” (Company D)
Improvements and Future Role	Digital integration	IM04	“Strong data standardization and transparency is needed across all partners along with the better integration of digital systems to enable real time visibility of the performance and the emissions” (Company C)
Improvements and Future Role	Green investment	IM05	“Investments in green technologies might be a major need in future” (Company B)
Improvements and Future Role	Transport innovation	IM06	“We would need more options for Multimodal transports… also like these alternative fuels” (Company A)

Improvements and Future Role	Collective responsibility	IM07	"I don't think that a single company can reach for Carbon Neutrality alone. Continuous effort and sustainable collaboration with other supply chain partners can achieve these long-term environmental goals." (Company B)
Improvements and Future Role	Strategic alignment	IM08	"Alignment with sustainability goals, shared KPIs and joint planning between suppliers, logistic providers and custom also essential." (Company C)
Improvements and Future Role	Future role shift	IM09	"The role of logistics companies will evolve from being service providers to becoming sustainability enablers and coordinators as well." (Company C)
Improvements and Future Role	Central enabling role	IM10	"Play a centered role by leveraging digitalization, improving operation efficiency and promoting sustainable and carbon neutral practices across supply chain." (Company C)