The Effect of a Third-Party Facilitator on Supply Chain Collaboration: Evidence from a Dutch Supply Chain Network

(Authors' names blinded for peer review)

Collaboration among supply chain actors leads to improved market access, and reduced logistics costs. In practice, however, collaboration initiatives are challenging to implement, due to barriers such as the sharing of sensitive information, coordination complexity, and the lack of operational visibility. The impact of such barriers may be mitigated by a third-party facilitator – an organization that facilitates coordination among actors, and safeguards sensitive information. We assess the impact of such a facilitator on supply chain collaboration. We further investigate whether the facilitator may induce a positive, second-order effect on environmental impact and logistics costs through improving collaboration. We test our hypotheses using survey interviews on member organizations of Connekt, a logistics facilitator. Our results suggest that the facilitator increases the number of collaborations, which leads to reduction in supply chain costs and a positive environmental impact. Lastly, we demonstrate that larger firms further improve collaborations, in the presence of the facilitator.

Key words: Supply chain collaboration and costs, Third party facilitator, Environmental impact, Survey interviews, Multiple case studies

1. Introduction

In today's global economy, the focus on supply chain has shifted from individual firm operations to end-to-end, multi-firm supply chains (Horvath 2001). Such multi-firm supply chains bring together stakeholders from diverse organizations, whose objectives are often conflicting. The operational efficiency of such complex networks hinges on effective coordination and collaboration, through which firms can achieve reductions in transaction costs, mitigate supply risks, and improve their market oversight (Cousins 2002, Tella & Virolainen 2005). Despite these benefits, fostering effective supply chain collaborations in practice is challenging, as companies are often hesitant to share sensitive information. Furthermore, collaborations among multiple actors across complex supply

chains increases the administrative complexity of managing such joint operations, thereby hindering effective coordination. Some of these difficulties might be resolved by introducing a new actor, henceforth referred to as a 'third-party facilitator'. This actor is an independent party that safeguards information, and simplifies communication across parties, thereby stimulating collaborations. Our study focuses on the effect of introducing a third-party facilitator on three key metrics of operational performance: collaboration intensity, supply chain costs, and environmental footprint.

Existing literature on supply chain collaborations has demonstrated that lack of mutual trust (Barratt & Oliveira 2001, Ireland & Bruce 2000), competition (Park & Russo 1996), and inhibition towards resource sharing (Barratt 2004) act as detriments (or barriers) to supply chain collaboration. The barriers to collaboration may be overcome by the inclusion of a neutral, third party facilitator, who could collect and manage data from the involved parties independently, which eliminates the threat of sensitive information being disclosed to the other parties. Furthermore, a facilitator can coordinate the collaboration process, effectively reducing the coordination costs involved in setting up the collaboration. Past research demonstrates that a third-party facilitator not only helps in forming supply chain alliances (Perry & Sohal 2001), but also induces trust among the collaborating firms (Cannatelli & Antoldi 2010). Therefore, in this paper, we examine the extent to which a third-party facilitator improves collaborations among supply chain parties, as manifested by changes in the frequency and intensity of their pairwise interactions. Previous works that have investigated the role of third-party facilitators have predominantly focused on qualitative aspects (Cannatelli & Antoldi 2010, Perry & Sohal 2001). Furthermore, only a few studies have been conducted to identify the effects of supply chain collaboration on supply chain costs and environmental impact. Our study addresses both these issues by assessing quantitatively the impact of including a third-party facilitator on (i) the frequency and intensity of collaborations, (ii) supply chain costs, and (iii) environmental footprint. We further investigate whether the aforementioned effects differ depending on the size of the collaborating firms. An abundant literature has demonstrated the effect of firm size on collaboration (Dzeraviaha 2023, Rivera, Sheffi, & Knoppen 2016,

Torbett 2001), financial performance (Cao & Zhang 2011, Lin, Cheah, Azali, Ho, & Yip 2019, Solakivi, Töyli, & Ojala 2015, Younis & Sundarakani 2019), and environmental effect (Fianko, Amoah, Afrifa Jnr, & Dzogbewu 2021, Lee 2019). In this study, we examine the moderating effect of firm size on the outcomes discussed above. Our objective is to provide insights regarding the type of firms (smaller, or larger) for which the benefits from supply chain collaborations are more pronounced, in the presence of a third-party facilitator. Such information is valuable for policy makers, since they can focus their facilitating efforts on encouraging collaboration across firms of appropriate size, so that collective welfare is maximized. Specifically, we examine the following research questions: (i) Does a third-party facilitator increase and/or improve supply chain collaboration? (ii) Could an increase in collaboration lead to a reduction in: (a) supply chain costs, and (b) environmental impact? and, (iii) What is the moderating role of firm-size in the aforementioned relationships?

In order to analyze the stated relationships, we use a combination of survey data and case studies based on the member organizations of Connekt, a third-party facilitator in the Netherlands. We focus on Connekt's Lean & Green programme, which aims at zero emission through durable logistics and mobility (Connekt 2013a), and investigate whether it has led to increased collaboration among its partners (including collaboration induced by Lean & Green partners with non-Lean & Green partners), and whether this collaboration has led to supply chain cost reductions and reductions in environmental footprint. Our findings reveal that the presence of a third-party facilitator increases supply chain collaborations. We further find that this increase in supply chain collaborations leads to reduction in supply chain costs. However, no conclusive evidence was found regarding the effect of collaborations on the environmental impact. The findings further reveal that larger firms benefit more from supply chain collaborations, as they can reduce their supply chain costs significantly. However, we find no evidence of a positive effect of firm size on the number of collaborations, or the environmental impact (in the presence of a third-party facilitator). In the next section, we present past literature and our hypotheses. We then present our setting, dataset and variables, results, robustness checks and finally conclusions.

2. Literature Review and Hypothesis Development

The increased specialization of companies, and the resulting increase in outsourcing, have made collaborations paramount. However, the roots of supply chain collaborations stem from several economic theories and phenomena that have preceded the development of supply chain management: Transaction cost theory, economies of scale & scope, resource-based view, and the bullwhip effect.

Supply chain collaborations develop infrastructure for information sharing and as a result can reduce transaction costs, while oftentimes the number of required transactions itself is reduced (Arnold 1996). Cost reductions may also be achieved through economies of scale. As the quantity of production increases, average cost per unit decreases, due to the division of labor. In a supply chain collaboration context, companies increase demand volume at suppliers. A larger demand volume enhances the bargaining power of the supply chain parties involved, leading to cost reductions (Kraljic 1983). Collaboration can also lead to cost reductions by integrating new services or products to a firm's existing business, thereby leading to economies of scope. For example, collaboration between a distribution center operator and a logistics firm, reduces coordination and search costs for the end customer, as they purchase the end-to-end service from a 'one-stop shop' (Cruijssen, Dullaert, & Fleuren 2007). Supply chain collaborations might also help mitigate risks, and in-turn lead to reductions in costs and environmental impact. For example, Yavari and Ajalli (2021) investigate the design of a green resilient supply chain network under the risk of disruptions, and find that risk mitigation strategies such as supplier-supplier coalition can minimize total cost and carbon emissions, simultaneously.

Collaboration benefits also emerge from the resource-based view framework. In their research, Dyer and Singh (1998) argue that to ensure constant supply of critical resources, firms engage in supply chain collaboration and form alliances that enhance their bargaining power, as they are able to achieve economies of scale. However, not all supply chain collaborations seek critical resources. The resource-based view postulates that firms may also seek procurement of operand resources or lower-level resources (Barney, Ketchen Jr, & Wright 2021). Moreover, firms might actually seek

integration (not collaboration) to ensure a constant supply of critical resources (Davis & DeWitt 2021). Supply chain integration is defined as "the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra- and interorganizational processes" (Flynn, Huo, & Zhao 2010). Therefore, it becomes essential to distinguish between the supply chain collaboration and supply chain integration literature. Recent work on supply chain integration has covered a wide array of topics, such as, investigating the relationship between supply chain integration and organizational performance (Khan & Wisner 2019), the impact of supply chain integration on business performance through supply chain resilience, flexibility, and innovation (Danese, Molinaro, & Romano 2020, Siagian, Tarigan, & Jie 2021). Among research focused on green supply chain integration (GSCI), past studies have examined the mechanisms such as information sharing and collaboration used in GSCI to improve information processing capacity can reduce uncertain outcomes of green product and process innovation (Wong, Wong, & Boon-itt 2020), and the impact of GSCI on sustainable performance which includes environmental, social and economic performance (Han & Huo 2020). Our study differs from studies on supply chain integration in the sense that, within supply chain integration, separate companies or various internal functions of a company coordinate. On the other hand, supply chain collaboration is the business practice that encourages individual organizations to share information and resources with each other for the benefit of all participating entities (Mushaluk & Chen 2014). In summary, the benefits from cooperation outweigh the benefits that parties achieve when acting independently, thereby reinforcing the importance of enhancing collaborations across supply chain actors.

Lack of collaborations in supply chains has ramifications that go beyond what economic theories and phenomena postulate. Limited information sharing, for example, may cause the bullwhip effect, which leads to uncoordinated orders and inventories, high costs and reduced service levels. Even when actors are perfectly rational, small demand variations can propagate upstream in supply chains with increasing variability, leading to highly variable orders, stock-outs and excess inventories, higher costs, and lack of trust. Collaboration reduces the bullwhip effect in two ways:

First, vertical integration effectively eliminates an entire echelon of the supply chain: namely, the distributor, in a three-echelon system in which there are factory, distributor, and retailer activities (Towill & del Vecchio 1994), and second, an increase in information sharing, resulting from collaboration, reduces the uncertainty that exists between supply chain parties (Holweg, Disney, Holmström, & Småros 2005), essentially reducing variability moving upstream. The effect from horizontal supply chain collaboration is twofold: The direct effect comes from demand aggregation — that is, collaborating partners can reduce the required safety stock by observing aggregated demand (Chan, Chung, & Wadhwa 2004). Further, an indirect effect occurs because collaborating partners learn to anticipate the behavior of their peers towards their suppliers and customers over time, which enables them to proactively address information distortions. It is important to note that the development of such collaborative relationships brings benefits that go beyond cost reductions and improved operational efficiency. We elaborate on such benefits in the next section.

2.1. Supply chain collaboration: Drivers and benefits not directly attributable to cost reduction

Supply chain collaboration improves market and customer knowledge among the participating entities. This benefit is more obvious within vertical supply chain collaboration: Engaging with companies downstream brings a company closer to the final customer (Fawcett & Magnan 2004). On the other hand, market knowledge also increases with horizontal supply chain collaboration, which inherently implies obtaining more knowledge about customers of the partners. Supply chain collaboration may also enhance technological innovation. In vertical collaboration, where collaborating actors share different roles within the supply chain, companies obtain knowledge from both upstream and downstream partners, thereby stimulating the development of new products and services (Spekman, Kamauff Jr, & Myrh 1998). In horizontal collaboration, on the other hand, innovation is mainly achieved by complementing resources (Lamming 1993) across collaborating actors, who share the same role within the network.

Horizontal collaboration in supply chains might also ensure supply volume, since supply chain actors improve their access to critical resources. The aim of supply guarantee is perhaps the

strongest motive of supply chain collaboration, even between firms that are at arm's length (Lambert, Emmelhainz, & Gardner 1999). Scarce resources, for example, can be pooled between the collaborating firms, reducing the risk of running out of these resources (Hogarth-Scott 1999). Soosay, Hyland, and Ferrer (2008) find that firms are generally risk-averse and often invest jointly, to reduce the risk associated with new projects. In a recent work, Yavari and Ajalli (2021) find that coalition among suppliers is a useful risk mitigation strategy and leads to a reduction in the average total cost and total carbon emissions.

Supply chain collaboration also improves customer service. For example, in the Whirlpool-ERX collaboration, Whirlpool increased its customer service level by 14% (Lambert et al. 1999). Soonhong et al. (2005) find that information sharing in collaborations enhances the feedback flow from customers, which presents firms the opportunity to better serve their customers. Similarly, vertical supply chain collaboration, in the form of supply chain integration, has been found to have a direct positive impact on customer service (Vickery, Jayaram, Droge, & Calantone 2003). Among other work, Stanley and Wisner (2001) find that supplier collaborations lead to increased internal service quality, which in turn leads to increased customer service.

Accessing new markets, or improving market share in an incumbent market, can also be strong drivers for supply chain collaboration. For example, international companies often form horizontal collaborations with local companies to penetrate new markets, such as Hewlett-Packard, who entered the Japanese market through a joint venture with Yokogawa Electric (Lorange & Roos 1991). Both companies benefited from the collaboration, as HP enabled itself access to the Japanese market, and Yokogawa gained access to technology and expertise (Gomes-Casseres 1996). More recently, Warner Media and Bad Robot entered into a partnership, which allows Bad Robot to focus on making (producing) movies, rather than worrying about the marketing and distribution side of things (Beech 2023). Among other drivers, Yen (2018) finds that customer pressure and top management commitment are strong drivers of buyer–supplier collaboration. Furthermore, competitor pressure and regulatory pressure also indirectly affect buyer–supplier collaborations.

Despite the benefits of such collaborations, there are barriers that hinter their effective development. According to Webb (2017), 47% of supplier collaborations fail due to issues such as lack of trust. We next elaborate on the barriers to collaboration, and how a third-party facilitator can help overcome such barriers.

2.2. Supply chain collaboration: Boundaries and disadvantages

Supply chain collaboration exhibit important barriers that can have a negative, direct impact on supply chain performance (Richey Jr., Roath, Whipple, & & Fawcett 2010). Ireland and Bruce (2000) and Barratt (2002) find that firms, which start off actively engaging in the partnership, could later lose mutual trust. This lack of trust originates from the perspective that every firm tries to maximize its own interests, which goes at the cost of the collaborative interests (Park & Russo 1996). Bleeke and Ernst (1995) and Park and Russo (1996) find that collaborations between competitors are more likely to fail than collaborations between non-competitors, confirming the adversarial relationship as a barrier. However, with the advent of digital supply chains, and industry 4.0, the barriers to collaboration now considerably lower. We refer the readers to a recent study by Ming-Lang Tseng and Lim (2021), where the authors perform a bibliometric review of sustainable industrial and operation engineering as the field moves toward Industry 4.0. The study aims to analyze contemporary sustainable industrial and operations engineering in Industry 4.0 context. In particular, the role of collaboration is examined across eight study groups, including lean manufacturing in Industry 4.0, cyber-physical production system, big data-driven and smart communications, safety and security, artificial intelligence (AI) for sustainability, the circular economy in a digital environment, business intelligence and virtual reality, and environmental sustainability.

For any form of horizontal supply chain collaboration, some type of resource sharing will be inevitable. Indeed, the sharing of resources can be the goal of collaboration (such as the pooling of scarce resources or the bundling of transport capacity). However, sharing of resources also involves risks. These risks are especially pertinent in horizontal alliances, where cooperation occurs among competitors. Diffusion of company-specific technology and potential brand reputation damage are

two examples of these risks (Kogut 1988). Supply chain firms are often hesitant to share sensitive information with other parties (Barratt 2004), although continuous information flows are fundamental for supply chain integration (Lambert & Cooper 2000). On similar lines, Barratt and Oliveira (2001) investigate the barriers to implementation of collaborative planning, forecasting and replenishment (CPFR) and find that most barriers relate to a lack of visibility of the partner's supply chain. Y. Huang, Han, and Macbeth (2020) provide a different perspective while examining the influence of horizontal collaborations on vertical collaborations. The authors posit that collaborative activities are complex and should be aligned with the motive and type of business relations, which may change as the collaboration among actors develops.

In several cases, the benefits of improved coordination are not materialized as anticipated. Coordination costs arise due to higher interdependence of tasks and processes across actors, which lead to an ongoing need for communication and joint decision-making (Gulati & Singh 1998). Such interdependence is also associated with inflexibility and slow responses to environmental changes in vertical supply chain collaboration (Das, Narasimhan, & Talluri 2006), which can deplete innovation (Handfield, Ragatz, Petersen, & Monczka 1999).

The complexity of horizontal supply chain collaboration increases with the number of parties involved. It seems plausible that as the number of potential parties involved in an alliance increases, the willingness to join the alliance would decrease. Although there is evidence that the involvement of too many actors can be an important barrier (Moberg, Speh, & Freese 2003), the literature on this assertion is inconclusive. For example, Park and Russo (1996) argue that joint ventures are less likely to result in failure with an increasing number of firms involved. They mention that the correlation with previous experience in joint ventures might offset failures. Therefore, in the following section, we examine how to overcome the boundaries to efficient collaboration.

2.3. Overcoming boundaries of collaboration through the introduction of a third-party facilitator

The exchange of information and the process of coordination require significant trust and time from the parties that wish to collaborate. The inclusion of a facilitator might prove valuable in

this respect. A neutral, third party could collect and manage data from the involved parties independently, which reduces the threat of sensitive information being disclosed to the other parties. Furthermore, a facilitator can coordinate the collaboration process, effectively reducing the coordination costs involved in setting up the collaboration and sustaining the exchange of operational information.

The role of a third party as a facilitator in supply chain collaboration is underrepresented in the existing literature. Existing research on the role of third-party actors and supply chain collaborations has primarily focused on third-party logistics (3PL) providers and supply chain triads. However, there is limited research on the role of a third-party facilitator in supply chain collaborations. It is therefore essential to understand the key differences among 3PLs, supply chain triads, and third-party facilitators. To be precise, a 3PL provider offers outsourced logistics services, which involves the management of the various facets of procurement and fulfillment activities. 3PLs can improve efficiency of an organization's supply chain by optimizing transportation and distribution networks, providing flexibility in terms of logistics services, improving inventory management, and reducing lead times. Recent studies have focused on how 3PLs can improve supply chain performance (Kempa, Chandra Tanuwijaya, & Jiwa Husada Tarigan 2020, Mengistu, Dimitrov, & Qureshi 2023), and enhance information sharing (Valashiya & Luke 2022). Next, a separate branch of studies has examined supply chain collaborations from a triadic view (Choi & Wu 2009a, L. Huang, Lin, Zhou, & Ieromonachou 2016, Prataviera, Creazza, Dallari, & Melacini 2023, Świerczek & Szozda 2023). The studies examine *triads* in the supply network by considering the buyer-supplier relationship, the supplier-supplier relationship, and the buyer-supplier-supplier relationships (Choi & Wu 2009b, Kovalevskaya, Pedersen, Holmen, Kaloudis, & Ringen 2022). Precisely, within a supply chain triad, there exists a stable relationship between the focal supplier and the buyer; and some additional suppliers are involved in assisting certain projects which are jointly worked by the buyer and the focal supplier (L. Huang et al. 2016). Recent studies on supply chain triads investigate a plethora of topics, ranging from the need for a collaborative mechanism in supply chain triads

(L. Huang et al. 2016, Jraisat et al. 2021) to gaining competitive advantage through triadic supply chains (Świerczek 2019). A *third-party facilitator* differs from a 3PL or a supply chain triad in that, it is an independent organization, which is not directly involved in any of the supply chain processes of the companies involved. It simply provides oversight, safeguards information, and simplifies communication across parties, thereby initiating and improving collaborations.

Other research articles elaborate on strategic alliances or take in-house facilitators as their focal point. A case study on the textiles, clothing, and footwear (TCF) industry in Australia is one of the few papers that highlights the role of an independent facilitator in forming supply chain alliances (Perry & Sohal 2001). Several companies that formed an alliance within the TCF industry saw improvements through their quick response programme in areas such as lead time and inventory reduction. On similar lines, Cannatelli and Antoldi (2010) investigate Compagnia delle Opere (CdO), an association of firms in Italy. CdO acts as a network facilitator in forming an alliance between eight industrial furniture firms. All involved firms considered the presence of CdO crucial and felt that due to its long-standing relationships with each individual firm, and its non-competitor position within the alliance, CdO played a key role in inducing trust among the firms (Cannatelli & Antoldi 2010), p.11. A key point, however, is that in early stages of collaboration, firms are reticent and aware of probable opportunistic behavior by their partners. However, as the alliance matures, trust is developed between participating firms, effectively eliminating the necessity of a facilitator. McEvily and Zaheer (2004), who investigate the role of facilitators in geographical clusters, find the importance of a facilitator in developing trust among firms decreases over time.

Nuese, Cornell, and Park (1998) study alliances in the high-tech international business. In multiple alliances between the United States and South Korea, facilitators prove to be invaluable, especially when the facilitator representing one country is a native of the other country (e.g., when a South-Korean firm would hire an American facilitator).

Alliances might often fail in the light of power imbalance. Stuart (1997) argues that the longevity of an alliance (partly) rests on the parties' ability to not abuse their power. A facilitator removes

the threat of power imbalance within alliances. Giles (1991) pose the facilitator as a catalyst, who can make all involved parties aware of the other parties' views and help in forming a shared vision for the network. Similarly, Christopher and Jüttner (2000) argue that a facilitator should function as a 'relationship promoter' among companies.

It is important to reiterate that third-party facilitators have a crucial role when it comes to both developing and maintaining supply chain networks. Regarding network development, Marsden, Banks, and Bristow (2000) focus on the Llyn Beef Producer Co-operative, a food supply chain that relies on Livestock Marketing Limited, a facilitator that develops and expands the cooperative. When it comes to maintaining sustainable relationships, the study of Zhu and Cote (2004) show how the Chinese government acts as a facilitator for the Guitang Group, a sugar complex, and its sugar cane suppliers. In our setting, we measure the perceived importance of a third-party facilitator (using a likert scale-based measure) on improving supply chain collaborations. We argue that the perceived importance of a third-party facilitator (by participating supply chain actors) is associated with an increase in the total number of collaborations among the supply chain actors involved (Jung, Peeters, & Vredeveld 2018, Oyedijo, Francois Koukpaki, Kusi-Sarpong, Alfarsi, & Yang 2022, Prataviera et al. 2023, Soosay & Hyland 2015, Valashiya & Luke 2023). Hence, we hypothesize:

Hypothesis 1: *The higher the perceived importance of the third-party facilitator, the higher the number of supply chain collaborations between supply chain actors.*

2.4. Supply chain cost reduction through supply chain collaboration

The theory behind economies of scale suggests that firms that collaborate horizontally, achieve stronger bargaining power and are therefore able to outperform individual companies based on favorable procurement terms. Simatupang and Sridharan (2002) show that synchronization among supply chain companies leads to improved rates for both procurement and transportation contracts. They further argue that such collaborations help achieve better forecast transparency, thereby reducing inventory holding costs. Literature also suggests that by aggregating the demand of multiple firms, and purchasing larger quantities, firms can have a stronger influence on suppliers and

alter contracts to their benefit (Matopoulos, Vlachopoulou, Manthou, & Manos 2007). Contrary to the above point, it could also be that diversification of products and services (caused by collaboration among firms) usually leads to higher costs due to higher transaction costs. Sternberg, Linan, Prockl, and Norrman (2022) demonstrate that although horizontal logistics collaborations can improve environmental sustainability and reduce shipping (logistics) costs, systematic collaborations often fail due to a multitude of reasons. Higher (or intensive) collaboration often depends on how diversified are the suppliers (or actors) are, and therefore, collaboration might even lead to an increase in supply chain costs. It is therefore essential to examine whether collaboration brings forth the desired costs savings or not. For Small and Medium Sized Enterprises (SMEs), forming alliances to achieve economies of scale, is often the only possibility to compete with their larger counterparts (Cannatelli & Antoldi 2010). Such economies of scale are not limited to SMEs. For example, airlines have established significant cost efficiencies through joint maintenance, and use of facilities by forming alliances (Oum & Park 1997).

Companies can achieve reductions in their logistics costs through economies of scale and the transaction cost reduction. Economies of scale materialize through increased volume, while transaction cost reduction is achieved through the reduction in the number of contracts. Consolidation of logistics between firms within an alliance can also reduce inventory and increase responsiveness (Sabath & Fontanella 2002). According to Caputo and Mininno (1996), in addition to inventory reductions, vertical and horizontal supply chain collaboration can also lead to shorter order cycle time, and material handling reductions. Vanovermeire et al. Vanovermeire, Sörensen, Van Breedam, Vannieuwenhuyse, and Verstrepen (2014) further argue that horizontal logistics alliances can reduce costs of transportation and lead to sustainability improvements.

Capacity pooling is another benefit of supply chain collaboration that can lead to reduction in supply chain costs. Consolidation of resources, for example, leads to increased capacity utilization (Simatupang & Sridharan 2002). Menedeme (2011) conducted a study on the collaboration between Baxter and UCB and demonstrated that it led to a decrease in less-than-truckload shipments (due to consolidation) and an increase in full-truckload shipments (due to double stacking).

In summary, a large number of collaborations can lead to favorable procurement terms, reductions in logistics costs through economies of scale, operational transparency (such as shared forecasts), and increased flexibility (such as capacity pooling) (Benavides, De Eskinazis, & Swan 2012, Christopher 2021). Therefore, we postulate that:

Hypothesis 2: *A higher number of collaborations among supply chain actors leads to a reduction in supply chain costs.*

2.5. Environmental footprint reduction through supply chain collaboration

Past research has also investigated vertical collaborative approaches from an environmental viewpoint. For example, Vachon and Klassen (2008) find that the benefits of collaboration for manufacturers are most apparent upstream, with suppliers. Custom Print, a US-based printing company, reduced the number of chemicals used by 70%, by using the same chemicals for multiple tasks. They did so by collaborating with its suppliers, resulting in pollution and waste reductions (U.S.EPA 1996).

Ballot and Fontane (2010) investigate the effect of pooling networks between suppliers, retailers, and third-party logistics in the French supply chain. They find that the pooling of warehouses that are currently dedicated to specific suppliers, leads to a 23% reduction in CO_2-emissions. In another scenario, they find that a shift of high-volume transport from truck to train leads to CO_2-reductions in the range of 7.3% to 13.8%, although the delivery frequency for some customers decrease. Menedeme (2011) and Vanovermeire et al. (2014) advocate that significant CO_2-emission reductions can be achieved by horizontal logistics alliances, due to fewer utilized trucks and better use of truck capacity. Menedeme (2011) in particular, reports that the alliance between Baxter and UBC succeeded in decreasing joined CO_2-emissions by about 50%. In another study, Carballo-Penela, Mateo-Mantecón, Alvarez, and Castromán-Diz (2018) examine whether and to what extent collaborative strategies can be effective towards green supply chains, and find that collaboration among participants can help understand where to concentrate the reduction effort, as concentrating the effort in some stages of the supply chain is more effective than the others.

We believe that reduction in environmental impact is possible by leveraging the economies of scale and scope, which can be attained if a larger number of companies are collaborating and investigate the following hypothesis:

Hypothesis 3: *A higher number of collaborations among supply chain actors leads to a reduction in environmental footprint.*

2.6. The impact of firm size on supply chain collaborations, cost reduction, and environmental footprint reduction

In the previous sections, we discussed the impact of lean & green on supply chain collaborations, and then examined the impact of the collaborations on supply chain cost reduction and environmental impact (reduction in CO_2-emissions). In this section, we explore whether the size of the participating firms has a moderating effect on the aforementioned outcome variables. While large companies have an advantage of economies of scale as well as a higher financial, technical, and human potential, small companies are usually more flexible and innovative (Dzeraviaha 2023). Our objective, therefore, is to examine whether larger (or smaller) firms benefit more from supply chain collaborations in the presence of a third-party facilitator.

The literature on the moderating role of firm size on firm financial (or corporate) performance is vast. For the purpose of this paper, we focus on studies where firm size is used as a moderator to examine either the effect of lean and green practices on firm performance, or the effect of supply chain collaboration on firms' financial and/or environmental performance. We first analyze whether larger firms would increase collaborations in the presence of a third-party facilitator. Existing literature posits that there is a strong positive relationship between firm size and the propensity to collaborate (Torbett 2001). Rivera et al. (2016) further demonstrate that larger firms show higher levels of collaboration, especially if they are co-located or located in close proximity. On the other hand, small- and medium-sized businesses (SMBs) can improve growth through the use of third-party facilitators as such facilitators provide access to services that SMBs might not be able to build in house (Guevara, Tuttle, Cook, Gorin, & Fox 2023). However, the growth in collaborations for larger firms is likely to be higher because such firms not only benefit from improved coordination

and trust resulting from the presence of a third-party facilitator, but also benefit from the economies of scale and scope (Guevara et al. 2023, Panzar & Willig 1981). We therefore posit:

Hypothesis 4: *The perceived importance of a third-party facilitator on the number of supply chain collaborations becomes more prominent when the size of the participating firms is larger.*

Next, we examine the moderating effect of firm size on the relationship between number of collaborations and supply chain cost reduction. To begin with, we analyze a recent work on the moderating role of firm size while exploring the impact of green innovation strategy (GIS) on corporate financial performance (CFP). The results of the study reveal that firm size moderates the negative correlation among GIS and CFP. Specifically, smaller firms showed higher green innovation investments return than the larger firms, which indicated that smaller firms were more prone to seek variation and visibility, for accessing better resources, and could ultimately generate higher profits (Lin et al. 2019). Contrary to the previous study, another recent work on the impact of green supply chain practices on corporate performance demonstrates that there exists a positive relationship between firm size and economic performance, environmental performance, and social performance, but not with operational performance (Younis & Sundarakani 2019). Extrapolating the results to our setting, we might conjecture that collaboration among larger firms leads to higher economic performance through greater synergies, and economies of scale. Moreover, collaboration could also lead to reduction in logistics (inbound/outbound) cost and CO_2 emissions. In another study, Solakivi et al. (2015) discuss the role of firm size while examining how supply chain collaboration is connected with firm performance. The findings of the study suggest that lower logistics costs and better financial performance are associated with increased collaborations in the supply chain. Past studies have also investigated the moderating role of firm size while examining the impact of supply chain collaboration on firm performance (Cao & Zhang 2011). In particular, the authors find that supply chain collaboration improves collaborative advantage and has a bottom-line influence on firm performance. They further find that collaborative advantage completely mediates the relationship between supply chain collaboration and firm performance for

smaller firms, while partially mediating the relationship for medium and larger firms. We might therefore expect that collaboration among larger firms positively effects the (direct) relationship among number of collaborations and firm financial performance. Since reduction in costs is directly attributable to higher firm performance, we might further infer that collaboration among larger firms could lead to supply chain cost reductions. We therefore put forth the following hypotheses:
Hypothesis 5: *The supply chain cost reduction achieved through higher number of collaborations among supply chain actors is higher for larger firms.*

Next, we discuss the moderating effect of firm size on the relationship between supply chain collaboration and environmental effect. (Fianko et al. 2021) examine the impact of internal and external green supply chain practices on environmental performance. The findings of the study reveal that firm size moderates the relationship between green design (through external green supply chain practices) and environmental performance. Specifically, the larger the firm, the greater the environmental impact reduction. In another study, (Lee 2019) examine the effects of collaborative (and implementation) activities on environmental performance for sustainable supply chain management. The authors demonstrate that larger firm size partially moderates the relationships of collaborative activities with implementation activities and environmental performance. We therefore hypothesize:
Hypothesis 6: *The reduction in environmental footprint achieved through higher number of collaborations among supply chain actors is higher for larger firms.*

3. Setting, Data and Variables

Our setting is Connekt, an independent network that facilitates supply chain collaborations in the Netherlands and Europe. Connekt has partnerships with over 500 companies around the world. We focus on their Lean & Green programme, which aims at zero emission through durable logistics and mobility Connekt (2013b). Our aim is to assess whether the inclusion of Lean & Green has led to increased collaboration among its partners, reduction in supply chain costs, and a reduction in environmental footprint.

3.1. Lean & Green

The Lean & Green programme started in 2007 and entails focus on continuous improvement, efficiency, and cost reductions (Lean), and environmental impact reduction (Green). For this paper, three streams of the Lean & Green programme are used: (i) Lean & Green Logistics, (ii) Lean & Green Personal Mobility, and (iii) Lean & Green Synchromodal. The detailed descriptions can be found in the online appendix.

3.2. Data Collection

We test our hypotheses using a combination of archival and survey data analysis, and case studies from the Lean & Green logistics programme. The first hypothesis is tested using data collected via surveys. Surveys were sent out to all companies that are or have been participating in the Lean & Green Logistics programme. The nature of the companies participating (size, sector, and star rating) has been provided in the online appendix.

Since one of the primary objectives of a third-party facilitator (TPF) is to safeguard critical information (which includes firm financial data), we could not test the second hypothesis (which postulates the effect of a third-party facilitator on logistics cost reduction) using secondary (firm financial) data. Instead, we tested the second hypothesis using survey questions on whether cost reductions actually occurred due to the implementation of the Lean & Green programme. We caution the readers here that using survey data implies that we can only determine the *perceived* effect of a TPF on cost savings. Additionally, we describe four separate cases in the appendix section of the paper, which further demonstrate that the presence of a third-party facilitator lead to improvements in occupancy rates, and modal shifts, which in-turn lead to cost savings.

The third hypothesis is tested using archival data from the Lean & Green Logistics programme and data collected via surveys. Any company that intends to participate in the Lean & Green Logistics programme needs to provide a baseline assessment of their CO_2-emissions, which serves as an accurate proxy for a company's current environmental impact. Since the Lean & Green Logistics procedure required to obtain the first star spans five years, the impact of collaboration is tested

by considering the results of the final assessment at the end of the five-year period (or earlier, as some companies already achieved a minimum of 20% CO_2-emissions reduction within the five-year period). To further validate the findings, survey questions were posed on whether there was an actual environmental impact reduction due to implementation of the Lean & Green programme.

3.2.1. Survey Data The survey was distributed to participants of the Lean & Green logistics programme. A total of 682 email addresses were available for the 233 companies of the programme. Surveys were sent out to all addresses to maximize the response rate. If multiple surveys were returned from one company, the survey from the most senior employee was chosen. Out of the 682 invitations, 140 responses were received, belonging to 117 different companies.

The actual survey questions can be found in the online Appendix. The final five questions (Q.5 to Q.9) deliver quantitative input on the significance of a third-party facilitator, supply chain collaboration, and its impact on costs and the environment. For these questions, the different answers represent numbers on a Likert scale, where the answer options accrue from 1 to 7 ("sharply decreased" to "sharply increased"; or "not important at all" to "very important"). In this manner, the most 'negative' results are labelled with a 1, whereas the most 'positive' results are labelled with a 7.

3.2.2. Dataset for Environmental Impact The archival dataset that is used in our third hypothesis, on the effect of supply chain collaboration on environmental impact, contains all companies that are or have been participating in the Lean & Green programme in the Netherlands. In total, the dataset contains 610 entries. After removing entries with missing data, we are left with 175 companies.

3.3. Variables

3.3.1. Dependent Variables In this section, we describe the outcome (dependent) variables.

Number of Collaborations. We use this variable to capture whether there was an increase in the total number of collaborations among the participating companies, due to the Lean & Green programme. The data has been captured using the survey question: *"How did the number of*

companies that an organization was currently collaborating with change, through participation in the Lean & Green programme?" The responses ranged from sharply decreased to sharply increased (on a scale of 1-7).

Supply Chain Costs. To capture this data, we use responses of the survey that indicate any potential reduction in the supply chain cost. The survey response on *"how have the supply chain costs of the company changed through participation in the Lean & Green programme?"* is used as the dependent variable. The responses ranged from sharply decreased to sharply increased (on a scale of 1-7).

Average CO_2 reduction. Environmental impact reduction is captured by measuring the CO_2-emissions against the number of FTE employed by the companies in the dataset. However, the absolute reduction numbers might present an inaccurate figure. If a company experiences rapid growth, its CO_2-emissions might have increased, despite introduced reduction measures. Therefore, a key performance indicator (KPI) is introduced, which measures the average CO_2-emissions over a pre-specified unit of measurement. The unit of measurement differs per company due to the diversity of industries present in the dataset. The value of the KPI at the start of the programme is compared with the value of the KPI at the end of the programme. The environmental impact reduction is therefore measured as the percent change between the KPI values. The higher the % change, the higher the environmental impact reduction.

3.3.2. Independent Variables In this section, we describe the independent variables.

Importance of third-party facilitator (Importance of L&G). We use this variable to examine its impact on the number of collaborations. We use the survey to obtain information on the perceived importance of the Lean & Green programme in increasing supply chain collaboration, to capture this information. The responses ranged from not important at all to very important (on a scale of 1-7).

Number of collaborations. We use this variable in order to examine its effect on supply chain costs and environmental footprint, respectively. We capture this variable by the survey question on *"how did the number of companies that an organization was currently collaborating with, change through participation in the Lean & Green programme"*.

4. Method and Results

Descriptive statistics and correlations for all our variables are presented at table 1 and table 2 below:

Insert Table 1 and Table 2 approximately here

4.1. Impact of third-party facilitator presence on supply chain collaboration

Out of the 117 respondents, there are only two respondents who have indicated that a decrease in collaboration occurred. About 60% of the respondents did not see a notable increase or decrease in collaboration.

For our first hypothesis, the following OLS model with robust standard errors was created:

$$CN_i = \alpha_x size_{ix} + \beta_y status_{iy} + \gamma_z sector_{iz} + \delta LG_i + \epsilon - (1)$$

Where:

CN_i: Number of collaborations for company i in the Lean & Green programme

$size_{ix}$: Dummy variable for size x of company i

$status_{iy}$: Dummy variable for status y of company i

$sector_{iz}$: Dummy variable for sector z of company i

LG_i: Importance of third-party facilitator of Lean & Green for company i

ϵ: Error term

Insert Table 3 Approximately Here

The results of our analysis are presented in model 1 of Table 3. The coefficient of the variable Importance of L&G is positive and significant at 5%, which indicates that the (perceived) importance of a third-party facilitator increases the number of collaborations, thereby providing full support for our first hypothesis.

4.2. Impact of supply chain collaboration on cost reduction

The delicate nature of these collaborations prohibits the use of actual cost savings. We therefore tested our second hypothesis using our surveys' data as answers to both collaboration and supply chain costs reduction questions were obtained for 111 companies. The results of the regression

model are shown in model 2 of Table 3. The coefficient of "Number of collaborations" is positive and significant at a 5%, which indicates that an increase in the number of collaborations would lead to a reduction in supply chain costs. Therefore, we have full support for our second hypothesis.

Additionally, we use four case studies (presented in the online appendix) to assess our second hypothesis. As mentioned in the research methodology, proxies (occupancy rates, and modal shifts) are used for cost savings. For some case studies, the names of the participating companies have been anonymized, for the sake of confidentiality. No numbers are presented in Case Study 3, since these results have not been published.

4.3. Impact of supply chain collaboration on environmental footprint reduction

We introduce a KPI, "Mean relative CO_2-decrease," which measures the CO_2-emissions over a prespecified unit of measurement. After removing the companies with missing data, the final dataset comprised of 167 observations. The average relative CO_2-decrease percentage is equal to 24.17%. Only one company has seen its CO_2-emissions increasing, providing convincing evidence for the proposition that participation in the Lean & Green programme leads to a reduction in CO_2-emissions.

Providing direct evidence for the effect of collaboration on environmental footprint reductions is challenging, since it requires more nuanced information on established relationships within the programme. However, some important supporting evidence exist: The initial participating companies and Connekt's Managing Director determined that a 3% annual reduction in environmental footprint was achievable individually (Anten 2017). Since the average footprint reduction overall is well above the 15% that should be achievable individually in five years, collaboration appears to exert a positive effect. Out of the 167 entries in the dataset, 140 companies have achieved a reduction beyond 15%. Excluding the "Award status" leaves companies that are still in the five-year assessment process, which leads to an even higher average percentage reduction of 29.25%.

A second method of evaluating the impact of supply chain collaboration on environmental footprint reduction is by linking the verification numbers and monitoring tool data with the responses

to the surveys. Within the survey, two questions revolve around collaboration. Since the respondents are known, the answers to these questions can be entered one-on-one with the company data from the verification documents or monitoring tool data. This link was possible for 115 companies. We link the relative KPI reduction numbers to the survey responses and create our regression model. The equation is of the form:

$$Y_i = \alpha_x size_{ix} + \beta_y status_{iy} + \gamma_z sector_{iz} + \delta CN_i + \epsilon - (2)$$

Where:

Y_i: Average CO_2 reduction for company i in the Lean & Green programme

$size_{ix}$: Dummy variable for size x of company i

$status_{iy}$: Dummy variable for size y of company i

$sector_{iz}$: Dummy variable for size z of company i

CN_i: Number of collaborations for company i in the Lean & Green programme

ϵ: Error term

The results for this analysis are presented in model 3 of Table 2, according to which we do not get support for our third hypothesis, as the variable *NoofCollaboration* is insignificant. A potential explanation is the small number of observations in our final sample, so this relationship is further investigated in the robustness checks section. We investigate further all our hypotheses in the robustness checks section of the online Appendix.

4.4. The moderating effect of firm size on number of collaborations, supply chain cost reduction, and environmental footprint reduction

We next examine the moderating effect of firm size on the outcome variables. Table 4 below, presents the results of the interactions.

Insert Table 4 Approximately Here

The results of the interaction coefficients for *Large*ImportanceofLG* reveals that larger firms are likely to significantly increase the number of supply chain collaborations (Model 1 of Table 4). However, collaboration among larger firms is unlikely to significantly reduce supply chain costs or carbon emissions (Models 2 and 3 respectively, of Table 4).

5. Discussion and Conclusion

Although horizontal and vertical supply chain collaboration have several benefits which make it an attractive proposition for various organizations, these benefits come at the cost of compromising intangible assets such as customer flows, demand forecasts and operational performance. In this study, we study how a third-party facilitator can help supply chain actors reap the benefits of collaboration through enhanced transparency and visibility, while securing proprietary knowledge of the individual organizations. The present study focuses on these aspects and improves our understanding of what the cost and environmental benefits of such a collaborative effort are.

The impact of a third-party facilitator on supply chain collaboration demonstrated that it increases the number of collaborations. According to our main model, an increase of one standard deviation of *ImportanceofLG* increases the number of collaborations by 0.123. This positive effect was also confirmed using the *IntensityofCollaboration* as an additional measure.

The impact of supply chain collaboration on supply chain cost reduction was tested with the help of regression analysis on survey results. Our findings indicate that the number of collaborations can decrease supply chain costs. To corroborate our results, we further tested the potential supply chain costs reduction using case studies. Overall, in each of the case studies, the involved companies were able to reduce their supply chain costs through either modal shifts or occupancy rate increases, the two proxies used to estimate financial performance.

The impact of supply chain collaboration on CO_2 emissions was tested with the dataset available with the Lean & Green programme on environmental footprint using a regression analysis. The companies in the eligible dataset achieved an approximate 24% reduction on CO_2-emissions, and an absolute reduction of almost 350,000-ton CO_2. The t-test conducted to determine whether there were differences between relative CO_2-reduction numbers before and after the programme was statistically significant. However, these numbers could not attribute environmental impact reduction directly to collaboration, since there was no measure of contribution in either the verification documents or the monitoring tool. To further verify the impact of collaboration on environmental

footprint, the collaboration questions in the survey conducted were linked to the relative reduction numbers one-on-one. However, the number of collaborations was found to be an insignificant predictor of environmental impact reduction. This unexpected result might be because many of the companies that could not be linked, have the 1st and 2nd Star status. Therefore, no conclusive evidence was found on the impact of collaboration on environmental impact. Nonetheless, in all the case studies, the reductions in supply chain costs through either modal shifts or occupancy rate increases, were accompanied by reductions in environmental footprint.

Finally, the moderating effect of firm size on supply chain collaboration demonstrated that large firms facilitate an increase in the number of collaborations. However, the impact of supply chain collaboration among large firms on supply chain cost reduction and CO_2 emissions was found to be non-significant.

6. Limitations and Future Scope

Like all empirical studies, ours has its limitations. First, all data within this research have been acquired from a single programme. Our findings therefore should be generalized with caution. To validate the findings, further research into other third-party facilitators will be necessary. The paper also uses data from multiple sources. Although the data are all linked to the Lean & Green programmes, the responses from the surveys cannot be linked one-on-one to the numbers from the monitoring tool and verification documents for all companies. Furthermore, information from both the Lean & Green Logistics and the Lean & Green Synchromodal programme have been used to substantiate the hypotheses. Although the two are intricately connected, they are not the same. Synthesizing data by using information from both qualitative and quantitative sources increases the generalizability and external validity of the findings (Scandura & Williams 2000). Furthermore, since the environmental footprint reductions are often accompanied by supply chain costs reductions, there is no incentive for a company to reverse the actions taken to achieve the environmental footprint reductions in the first place. The only variable that is used in quantifying environmental footprint, is the amount of CO_2 that a participating company emits. Other factors

that make up the environmental footprint of a company, such as N2-emissions and energy usage, are not considered here.

The current study has also highlighted several potential future research directions. Although the size of a company has not been a defining factor in this research, differences between the company sizes have been featured. Earlier research Cannatelli and Antoldi (2010) suggested that smaller companies benefit more from collaboration, as they are not able to achieve economies of scale on their own. In this paper, the larger companies outperformed the small companies in terms of number of collaborations. Future research should confirm whether these findings are consistent across different industry sectors and geographies. Finally, partial evidence was found for the link between supply chain collaboration and environmental footprint reduction. Future research could therefore focus more on this relationship and the factors that are related to this link.

Despite its limitations, our study constitutes the first quantitative attempt to highlight and quantify the effect of the presence of a third-party collaborator in different measures of performance such as number of collaborations, and by assessing the impact of these collaborations on supply chain costs and environmental footprint.

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Tables

Table 1 Summary Statistics

	Mean	SD	Min	Max	N
Number of collaborations	4.49	0.82	1	7	116
Average CO_2 Reduction	5.16	1.48	1	7	116
Supply chain costs	4.47	0.96	2	7	112
Importance of L&G	4.50	1.30	1	7	117
Small	0.12	0.33	0	1	117
Medium	0.42	0.50	0	1	117
1st Star	0.38	0.49	0	1	117
2nd Star	0.17	0.38	0	1	117
Construction	0.07	0.25	0	1	117
Energy	0.03	0.18	0	1	117
LSP	0.59	0.49	0	1	117
Wholesale	0.07	0.25	0	1	117
Industry	0.04	0.20	0	1	117
Government	0.03	0.16	0	1	117
Retail	0.05	0.22	0	1	117

Table 2 Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) Number of collaboration	1.00														
(2) Average CO_2 Reduction	0.07	1.00													
	(0.48)														
(3) Supply chain costs	0.29*	0.01	1.00												
	(0.00)	(0.92)													
(4) Importance of L&G	0.42*	-0.03	0.05	1.00											
	(0.00)	(0.79)	(0.62)												
(5) Small	-0.32*	0.01	-0.27*	-0.10	1.00										
	(0.00)	(0.87)	(0.00)	(0.28)											
(6) Medium	0.04	-0.09	0.05	-0.06	-0.31*	1.00									
	(0.66)	(0.34)	(0.58)	(0.54)	(0.00)										
(7) 1st Star	0.02	0.00	0.16	0.03	-0.18	-0.05	1.00								
	(0.84)	(0.98)	(0.10)	(0.75)	(0.06)	(0.58)									
(8) 2nd Star	0.26*	-0.06	0.04	0.23*	0.04	-0.16	-0.35*	1.00							
	(0.01)	(0.50)	(0.69)	(0.01)	(0.65)	(0.09)	(0.00)								
(9) Construction	-0.04	0.04	0.12	-0.21*	-0.10	0.11	0.07	-0.03	1.00						
	(0.68)	(0.66)	(0.22)	(0.02)	(0.28)	(0.22)	(0.46)	(0.72)							
(10) Energy	-0.06	0.11	0.06	-0.07	-0.07	0.22*	0.15	-0.09	-0.05	1.00					
	(0.55)	(0.25)	(0.56)	(0.44)	(0.46)	(0.02)	(0.12)	(0.36)	(0.59)						
(11) LSP	-0.15	-0.09	-0.12	0.01	0.20*	0.11	0.07	-0.08	-0.32*	-0.23*	1.00				
	(0.11)	(0.33)	(0.21)	(0.91)	(0.03)	(0.24)	(0.43)	(0.37)	(0.00)	(0.01)					
(12) Wholesale	0.07	0.11	0.04	0.08	-0.10	-0.02	-0.14	0.06	-0.07	-0.05	-0.32	1.00			
	(0.46)	(0.24)	(0.64)	(0.39)	(0.28)	(0.80)	(0.13)	(0.54)	(0.43)	(0.59)	(0.00)				
(13) Industry	0.03	-0.05	0.07	0.08	-0.08	-0.01	0.10	-0.10	-0.06	-0.04	-0.25	-0.06	1.00		
	(0.76)	(0.59)	(0.44)	(0.38)	(0.40)	(0.93)	(0.29)	(0.30)	(0.54)	(0.67)	(0.01)	(0.54)			
(14) Government	-0.03	0.02	-0.08	-0.02	0.11	-0.03	-0.13	0.07	-0.04	-0.03	-0.19*	-0.04	-0.03	1.00	
	(0.74)	(0.83)	(0.39)	(0.83)	(0.25)	(0.76)	(0.18)	(0.45)	(0.64)	(0.74)	(0.04)	(0.64)	(0.71)		
(15) Retail	0.10	0.08	0.09	-0.03	-0.09	-0.12	-0.02	0.10	-0.06	-0.04	-0.28*	-0.06	-0.05	-0.04	1.00
	(0.30)	(0.39)	(0.35)	(0.75)	(0.36)	(0.20)	(0.83)	(0.28)	(0.50)	(0.64)	(0.00)	(0.50)	(0.60)	(0.69)	

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3 Main Results

	(1) NoofCollaboration	(2) Supplychaincosts	(3) CO2Reduction
ImportanceofLG	0.077*	-0.030	-0.065
	(0.033)	(0.068)	(0.138)
IntensityofCollaboration	0.581***	-0.072	0.430+
	(0.102)	(0.199)	(0.244)
NoofCollaboration		0.397*	0.007
		(0.193)	(0.234)
Large	0.499**	0.456	-0.018
	(0.155)	(0.319)	(0.429)
Medium	0.539**	0.410	-0.547
	(0.168)	(0.334)	(0.483)
2.status	0.329*	-0.171	-0.193
	(0.158)	(0.264)	(0.435)
3.status	0.063	-0.282	0.359
	(0.130)	(0.219)	(0.357)
2.sector	-0.493	-0.055	0.609
	(0.411)	(0.398)	(0.535)
3.sector	0.033	-0.626	-0.989+
	(0.258)	(0.559)	(0.568)
4.sector	0.064	-0.125	0.028
	(0.315)	(0.467)	(0.857)
5.sector	0.114	-0.139	-0.663
	(0.314)	(0.429)	(0.836)
6.sector	-0.159	-0.370	-0.510
	(0.229)	(0.339)	(0.430)
7.sector	0.058	-0.586	-0.158
	(0.335)	(0.694)	(0.842)
8.sector	0.032	-0.157	-0.077
	(0.430)	(0.436)	(0.656)
constant	1.121*	3.236***	4.039***
	(0.457)	(0.814)	(1.097)
R-sq	0.542	0.182	0.101
Observations	116	111	115

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4 Interaction Results-1

	(1) NoofCollaboration	(2) Supplychaincosts	(3) CO2Reduction
ImportanceofLG	0.029	-0.023	-0.077
	(0.046)	(0.069)	(0.138)
IntensityofCollaboration	0.580***	-0.119	0.497*
	(0.102)	(0.194)	(0.248)
NoofCollaboration		0.246	0.255
		(0.215)	(0.294)
Large*ImportanceofLG	0.113+		
	(0.064)		
Large*NoofCollaboration		0.311	-0.600
		(0.266)	(0.405)
Large	-0.009	-0.900	2.551
	(0.316)	(1.197)	(1.752)
Medium	0.550**	0.484	-0.736
	(0.166)	(0.336)	(0.498)
2.status	0.310+	-0.224	-0.076
	(0.156)	(0.263)	(0.454)
3.status	0.049	-0.321	0.424
	(0.130)	(0.219)	(0.363)
2.sector	-0.526	-0.129	0.761
	(0.397)	(0.393)	(0.584)
3.sector	0.019	-0.691	-0.851
	(0.253)	(0.569)	(0.576)
4.sector	0.049	-0.151	0.097
	(0.313)	(0.457)	(0.842)
5.sector	0.104	-0.262	-0.414
	(0.307)	(0.442)	(0.853)
6.sector	-0.164	-0.397	-0.446
	(0.223)	(0.328)	(0.446)
7.sector	0.041	-0.668	-0.021
	(0.333)	(0.718)	(0.830)
8.sector	0.060	-0.129	-0.103
	(0.436)	(0.417)	(0.664)
constant	1.343**	4.087***	2.733+
	(0.511)	(0.851)	(1.434)
R-sq	0.549	0.193	0.124
Observations	116	111	115

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix - The Effect of a Third-Party Facilitator on Supply Chain Collaboration: Evidence from a Dutch Supply Chain Network

(Authors' names blinded for peer review)

Appendix A: Conceptual Model

After a careful review of the existing literature, a research model has been formulated, that attempts to underpin the effect of a neutral quantitatively and qualitatively third party in supply chain collaboration:

Insert figure 1 approximately here

Appendix B: Setting

Lean & Green Logistics consists of a stepwise programme, where each step entails certain requirements to adhere to. When these requirements are met, the participant receives a star. The last step in the programme is zero emission. Companies that wish to participate, must draw up an action plan that specifies how they will reduce their CO_2-impact by at least 20% at the end of a 5-year period. After approval, the companies are awarded the Lean & Green Award. During the conception of the Lean & Green programme, Connekt and the participating companies established that a company should individually be able to reduce its CO_2-impact by 3% per year (Anten, 2017). Over a five-year period, this leads to a 15% reduction in CO_2-impact. The additional 5% can only be achieved by collaborating with other supply chain actors. A participating company, that succeeds in reducing its CO_2-emissions by at least 20%, is awarded the first Star. During our study, about 450 companies are or have been involved in the Lean & Green Logistics programme.

So far, 23 companies have been awarded the second Star and 87 companies have been awarded the first Star.

Lean & Green Personal Mobility (PM): The Lean & Green Logistics programme has attracted many companies, most of which operate in/as logistics service providers (LSP), fast moving consumer goods (FMCG), and the retail sector. However, logistic activities are not applicable to all companies, especially, consultancy firms, banks, and legal offices. To promote sustainability in these sectors too, Lean & Green has developed the Personal Mobility (PM) programme. Lean & Green PM measures the environmental impact of a company over its full-time equivalents (FTEs). These companies can reduce their impact by enhancing the sustainability of, for example, commuter traffic. During this study, the PM programme was currently comprised of 165 companies. Out of these 165 members, 13 have been awarded the first Star.

Lean & Green Synchromodal: This is a separate programme under the Lean & Green umbrella. Synchromodality refers to a network of synchronized and interconnected transport modes, which can adapt to the needs of the network users individually and instantaneously (Tavasszy et al. 2014). The programme aims to identify the volume and stream of goods of shippers and LSPs and thereafter investigate the potential for synchromodality among these parties. The goal is to shift away from expensive road transportation to less costly and more environmentally friendly transportation modes, such as sea and barge carriers, and railroads. Often, the volume necessary to use these modes of transportation is a barrier to adoption. Lean & Green Synchromodal aims to intensify collaboration so that sizeable volume streams are realized, leading to increased adoption.

Appendix C: Survey Data

While it might seem that the response percentage was 20.5% (140/682) of all invitations sent, the percentage of responses received, when we look at a company level, was actually much higher at 50.2% (117/233), which is generally accepted as a high response rate.

The first three questions of the survey (on size of the company, status within the Lean & Green programme, and industry sector) are used for segmentation. This way, the differences between

participating companies can be evaluated. One would expect, for example, that companies that have reached a higher status within the programme will be able to further reduce their environmental and cost impact, in comparison to their peers with a lower status. The fourth question defines the roles that the participating companies believe Lean & Green to fulfil. For example, Q.5 asks, "How did the number of companies you are collaborating with, change through participation in the Lean & Green programme". Here 7, which is the highest score, represents a "sharp increase" in number of collaborations through participation in the programme. The increased-decreased order has been reversed in the last two questions, i.e., from "sharply increased" to "sharply decreased". The reason to do so was the format of the question. For example, Q.9 asks, "How have the supply chain costs of your company changed through participation in the Lean & Green programme". Here, 7, which is the highest score, represents a "sharp decrease" in supply chain costs through participation in the programme.

As expected, most of the respondents are employees of a logistics service provider (LSP). The small companies constitute a minority: Only 14 respondents work for a small organization. Furthermore, the 2nd Star is the smallest status group, consisting of 20 respondents. About 76% of the respondents (89 out of 117) indicate that Lean & Green is an 'institute for certification'. The roles of 'source of information and knowledge' and 'organizer of meetings and gatherings' are also endorsed by many respondents. The other roles are less apparent. Surprisingly, this is also the case for the 'facilitator for contact with other companies' role, one of the essential roles in the existing literature (Christopher and Jüttner 2000, Nuese et al. 1998, Raimond and Eden 1990). Perhaps this role is partially captured in the 'organizer of meetings and gatherings' role that closely resembles the orchestrator role (Bitran et al. 2007, Perry and Sohal 2001).

We observe that the higher the status within the programme, the more likely it is that a company has seen its number of collaborations increase through the Lean & Green programme. For the 2nd Star status, 65% experienced an increase in the number of collaborations, as compared to approximately 35% for the 1st Star status and 29% for the Award status. This is precisely what

was expected, although the difference between the 1st and 2nd Star is very large. This could be the result of new collaborative efforts undertaken to further become sustainable beyond the 20% requirement. With respect to the intensity of collaborations, the same reasoning holds true, although the numbers are slightly different: 55% of the 2nd Star companies experienced an increase in intensity, as compared to approximately 41% of the 1st Star and 25% of the Award companies.

The larger companies have profited most from the programme. Approximately 45% of the large- and 39% of the medium-sized companies experienced an increase in the number of collaborations, as opposed to none of the respondents of the small companies. The numbers are comparable for the intensity dimension. The smaller companies seem to struggle to fully capitalize on the network of the Lean & Green programme. The spread in answers is higher than in the previous questions. The largest percentage of the companies (37%) view Lean & Green's importance as neutral. The important answers, however, make up about 50% of the respondents, whereas the unimportant answers only make up 13% of the respondents.

The differences between the companies based on size were very small, although the small companies achieved the highest average reduction, which could be an indication of potential access to economies of scale. The differences based on status, however, were very large: average reductions of 16% for the Award, 29% for the 1st Star and 32% for the 2nd Star companies. The average reductions based on sector were quite comparable, although the absolute numbers were highest for the LSPs, FMCG and retail companies. These numbers may have been due to a relatively higher number of large companies in these sectors.

Appendix D: Control and Robustness Check Variables

Occupancy Rates. For the case studies, since a direct measure of cost reduction was not available, proxies are used to capture this measure. The first proxy used is occupancy rates. Higher occupancy rates (achieved by consolidation) are a clear indication of cost reduction (Caputo and Mininno 1996, Menedeme 2011, Sabath and Fontanella 2002, Simatupang and Sridharan 2002, Vanovermeire et al. 2014). To capture this, we conduct four case studies of companies participating in the Lean & Green programme.

Modal shifts. Modal shifts is the second proxy used to measure reduction in supply chain costs in our case studies. Past research indicates that modal shifts can lower costs. (Delucchi and McCubbin 2010) compare the external costs that various modes of transportation impose on society. The Online Appendix presents a table with an overview of the minimum and maximum estimates of external costs for selected variables, by transportation mode. The numbers indicate that the external costs of road transportation exceed the external costs of other transportation modes in virtually all cases. On similar lines, Bloemhof et al. (2011) compare the three modes of rail, road, and inland navigation, and conclude that road transportation is the least costly alternative in infrastructure costs, such as construction and maintenance, but this is more than compensated for by external costs, such as emissions. Combining these two cost categories makes road transportation the most, and inland navigation the least expensive mode. Our online Appendix presents a table of costs of freight transport per hundred ton-km, adapted from Bloemhof et al. (2011). Protopapas et al. (2013) also reach the conclusion that a shift from waterborne transportation to either rail or road would endanger the well-being of the public and could jeopardize the national economy of the US. Conversely, a modal shift to waterborne transportation from either of the other two modes could lead to 'sizeable economic, environmental, and social benefits for the private and public sectors'.

Intensity of collaborations: For our second hypothesis, we use this variable as a control, as we believe that both the number of collaborations and the intensity of such collaborations can have an impact in reducing overall supply chain costs. We capture this variable by using the survey question on "how did the intensity of collaboration with companies change, through participation in the Lean & Green programme." However, we do not use this variable to study the reduction in environmental impact as we believe that reduction in environmental impact is something that is possible by leveraging the economies of scale and scope, which can be attained if a larger number of companies are collaborating, as opposed to a smaller number of companies collaborating more intensively.

Size: Dummy variables are used to represent the size of the company (small, medium, or large) The benefits of collaboration might be higher for large organizations as opposed to smaller ones. Considering 'large' as the reference category, the 'small' variable is equal to one if the company has less than 50 employees and zero otherwise and medium variables is equal to one if the company has between 50 and 249 employees and zero otherwise.

Status: Dummy variables are used to represent the status of the company within the Lean & Green programme (Award, 1st star, or 2nd star) as benefits of collaboration might change owing to higher status within the programme. Considering 'award' as our reference category, we include two indicators, one for first star companies and one for second star companies.

Sector: Eight industry sector dummies are created for different industry sectors, as some industries might benefit more from collaborative efforts. Specifically, the categories are the following: Logistics Service Provider (LSP), FMCG, Retail, Construction, Wholesale, Governmental, Production Industry, and Energy. Considering FMCG as our reference category, we include seven indicators that are equal to one if the company belongs to the respective category and zero otherwise.

Appendix E: Case Studies

Case study 1: 'The Candybarge'

In 2012, a contest was written out by the IDVV, a programme by the Rijkswaterstaat (a department of the Dutch Ministry for Infrastructure) and Connekt. The contest was meant for projects that would promote the use of inland shipping and synchromodal transportation (Rijkswaterstaat 2012). One of the contestants was a modal shift project between two shippers, a logistics service provider and two terminals. This modal shift project was named 'The Candybarge' (InlandTerminalVeghel 2013). Both shippers operated in the FMCG sector. Since the FMCG sector generally requires short lead times, trucks were the default transportation mode. The goal of this project was to create a modal shift from road to barge – a shift that required collaboration, both vertically and horizontally. Vertical collaboration with both the port and inland terminal, and the logistics service provider was necessary to ensure a smooth transportation flow. Horizontal collaboration

between the two shippers was necessary to ensure the volume was large enough to justify the use of container ships. 'The Candybarge' entailed a point-to-point connection between the inland terminal in Veghel and the port terminal of Rotterdam. Within the first nine months of the project, a modal shift of 7,500 TEU was achieved. The annual target for year 1 was 9000, a volume that was exceeded. At an occupancy rate of 100%, 'The Candybarge' reduced the CO_2-emissions by 19% per container. At a 100% occupancy rate, the shipping costs of the freight were below those of the alternative transportation mode by road (PrijsvraagIDVV 2012). This project proved that a modal shift to barge transportation is possible and saves both on costs and environmental impact, even with products that require a short lead time.

Case study 2: 'Synple'

Synple is a young Dutch start-up, founded in 2015. The name is a contraction of the words synergy and simple. The two founders used to work at a company that was split over several smaller companies (Starterslift 2016). When these smaller companies merged into a single company, multiple cost saving opportunities emerged, especially in the logistics area. Synple focuses on reducing the empty kilometers on the Dutch roads. Nationwide, at least 25% of the trucks drive around empty, and that number increases even further when the less-than-truckload shipments are taken into consideration (Starterslift 2016). These empty kilometers exist in two ways. First, many shippers do not have enough volume to reach a 100% occupancy rate of their trucks. Second, return transport often entails empty containers. Synple provides a solution for these empty kilometers. Synple operates as a neutral third party, providing an IT platform that is solely for companies that perform transportation activities. Customers of shippers and LSPs do not obtain intelligence about the collaborations that are set up via the platform. This has often been a barrier in the past, since customers wished to profit from these collaborations as well. The Synple platform is called the 'Synple Match-Maker.' This platform operates as an online 'dating' application for shippers. The 'matchmaker' enables shippers to view open routes, offer their own open routes and bundle freight with other shippers. It is a smart method to ensure higher occupancy rates through

horizontal collaboration, during both the outbound and return journeys, while keeping sensitive information invisible to the companies with which collaboration is being undertaken. An extra benefit is that it reduces congestion on the roads. Synple has started to collaborate with Lean & Green in developing an analytical tool that provides insights into the CO_2-footprint of participating companies. Through this method, companies can apply for the Lean & Green Award and Stars via Synple. Lean & Green has introduced their members to the Synple platform, creating a two-way exchange. Synple specializes in the consumer goods and heavy and exceptional transportation. Through the 'matchmaker', companies have been able to save up to 15% on their driven miles (Starterslift 2016).

Case study 3: "Why still empty kilometers?"

The third case study is also centered on a project for the IDVV contest. The project was established in 2011 by two companies, with support from Connekt. One of the companies is Kloosterboer, a logistics service provider, the other is Lamb Weston, a FMCG company. Kloosterboer is in Vlissingen and receives reefer import containers. Once emptied, Kloosterboer sends the containers to Rotterdam and Antwerp. Lamb Weston retrieves these empty containers from Rotterdam and Antwerp to use them in their export operations from their terminal in Bergen op Zoom. 35% of these streams are transported by road, 65% by inland navigation (Kloosterboer 2012). In the first quarter of the collaboration, the companies were able to exchange 1,000 reefers, a significant amount that saved empty kilometers in both road and water transportation. Kloosterboer uses its existing collaboration with Lamb Weston as a successful example, with the intention to get as many companies as possible on board. Large volumes are necessary to create a profitable business case: in this manner, using barge for the entire roundtrip can be justified, since both exporter and importer pay part of the trip. Furthermore, an IT system is set up to monitor and balance streams. Out of the 70,000 TEU, 16,250 are already transported by barge (65% of the 25,000 TEU that are received in Vlissingen). If all containers were taken off the road, this would imply an additional 53,750 containers to be shipped by barge. The target of the two companies is to ship about 10,000

extra containers by barge at the end of the first year of the project. In 2016, Kloosterboer had shipped an amount of 11,000 export reefers by barge (Compeer 2017). The participation of the onion exporters has resulted in tremendous savings: 1,500-ton CO_2-emissions have been saved and 1.5 million kilometers have been taken off the road (Logistiek 2016).

We also conduct the pilot phase of another case study, the results of which could not be finalized during our study (see online appendix). All the above-mentioned case studies have shown that both horizontal and vertical supply chain collaboration are necessary for modal shifts, and truck occupancy rate increases. Modal shifts and truck occupancy rate increases directly lead to cost savings (although modal shifts are only profitable when volume thresholds are reached). In the case studies, the supply chain cost reductions were accompanied by environmental impact reductions too. We use the results from the case studies to check the robustness of our third hypothesis as well. We use case studies as the primary means of assessing our second hypothesis, as we do not have actual empirical data for supply chain cost savings, and therefore rely on proxies of cost savings.

Case study 4: "The next level in logistic collaboration"

The third case study is a collaborative pilot between three shippers and three LSPs. The pilot is codeveloped by Connekt and Synple. The actual collaboration occurs between LSPs (horizontal supply chain collaboration), while keeping intact the existing collaboration between shipper and LSP (vertical supply chain collaboration). No relationships are formed between the shippers, and they can operate independently, while using the synergy of the supply chain networks (Rodenburg 2017). Three LSPs have been selected on existing relationships: two are large transporters for one of the shippers, the third has a good relationship with one of the other transporters. The LSPs are accompanied by Connekt and Synple during the creation of mutual agreements and trust. Synple has data from the shippers and LSPs and has analyzed the potential for synergy of the individual networks. An analysis of the combined networks has not been performed: this would lead to full transparency, which could entail sensitive information becoming visible. The sharing of data is limited to individual transactions. The involved parties were able to reduce their empty kilometers.

However, the environmental impact reductions (in the form of decreases in CO_2-emissions) were not one-on-one translatable to supply chain costs reductions. Actual savings only occurred after investments were made in forming new relationships, and the cost reductions on short distances were relatively small. An essential factor in the collaboration is the allocation of gains, which are based on the existing relationships between shipper and LSP. This implies that the LSPs will benefit from cost reductions first. The allocation of the cost reductions from LSP to shipper will be determined reciprocally. At the end of the pilot, the evaluation displayed that the deployment of an independent third party was crucial to the success of the collaboration.

Appendix F: Robustness Checks

We tested our first hypothesis using a different dependent variable. Specifically, the presence of a third-party facilitator might not only increase the total number of companies involved in the collaboration, but it may also increase the intensity of collaborative efforts among companies. Therefore, another measure of collaboration for our first hypothesis that can be used is the intensity of collaborations, which indicates whether there was an increase in the intensity of collaborations among the participating companies, due to the Lean & Green programme. The data has been captured using the survey question on how did the intensity of collaborations change, through participation in the Lean & Green programme. The responses were recorded in a 7-point Likert scale ranging from sharply decreased to sharply increased. The results are presented at model 1 of table 1 and provide full support for our first hypothesis as our independent variable Importance of L&G has a positive and significant at 1% coefficient, indicating that it increased the intensity of collaborations.

Furthermore, as a robustness check for hypothesis 3, we expect that reduction in CO_2 emissions could not only be due to the increased number of collaborations, but also due to the increased intensity of collaboration. Results in model 2 of table 1 provide additional evidence that intensity of collaborations could lead to environmental impact reduction.

Insert Table A1 approximately here

In addition, for our first hypothesis, we conducted further analysis in order to alleviate any overfitting concerns. Overfitting occurs when the fit of the model with the data is due to the idiosyncrasy of a specific data set, and therefore one may be concerned that statistical relationships observed may be a result of this. It can occur when a model is excessively complex with too many parameters relative to the number of observations (Freedman 2009). Our model however is not that complex as we include only theoretically relevant variables in it. In addition, we also repeat our analysis using a simpler version of our original model. Specifically, similar to Aggarwal et al. (2015) we repeat our analysis after excluding the control variables that are insignificant in our model. Our results (using both the number of collaborations and the intensity of collaborations as dependent variables) in table A2 indicate again full support for our first hypothesis.

Insert Table A2 approximately here

The survey responses depict support towards our second and third hypotheses. 50 of the 112 respondents (five respondents did not answer this question) accomplished a decrease in supply chain costs, which is approximately 45% of the respondents. The respondents that experienced an increase in supply chain costs only make up 11% of all respondents. In addition, out of the 116 respondents (one respondent did not answer this question), 88 accomplished a decrease in environmental impact, which is 76% of all respondents. 14% experienced an increase in environmental impact.

Despite the evidence that an increased number of collaborations can reduce environment impact we got from our cases studies of hypothesis 2, and the preliminary analysis of our data, we could not get full support for our third hypothesis, based on our regression model. A potential explanation could be the low number of observations in that model, as the combination of the dependent variable with the survey responses was possible for only 116 companies. We also compare the CO_2 emissions of the companies in our sample at the beginning and at the current state of the programme. The survey data indicated that about 40% of the participating companies experienced an increase in their collaborative efforts through the Lean & Green programme. As such, achieved reductions within the programme provide some evidence for a collaboration effect, which can be

compared using a paired sample t-test to determine whether the emissions before are significantly different from that after, and validate the results. Since the numbers over time are from the same companies, a paired sample t-test is appropriate (Statistics Solutions, 2017). The paired samples t-test suggested that the mean CO_2 emissions of the 167 participants decreased by about 17% during the programme and also that the difference between the two means is significant at 5%. Since the programme spans a vast period, the impact of other variables cannot be ruled out, although the CO_2 emissions do compensate for growth and decline by adjusting the pre-specified unit of measurement over which the CO_2 emissions are measured in time. These findings also seem to be in line with the survey responses for hypothesis 1, where only 16 out of 116 respondents experienced increases in their CO_2 emissions. We therefore believe that an increased number of collaboration can actually lead to a reduction in the environment impact of a company.

Appendix G: Survey Questions

Insert Figure 2 & 3 approximately here

Appendix H: External Costs of Transportation Nodes

Insert Figure 4 approximately here

Appendix I: Costs of Freight Transport per hundred ton-km

Insert Figure 5 approximately here

Appendix J: Interviews

Nine semi-structured interviews in different companies have been conducted. All companies have been involved in the programme for at least five years. Many of the interviewees are appointed as Ambassadors: industry promotors of the Lean & Green programme.

Question 1: In order to reach the 1st/2nd Star of the Lean & Green programme, you had to collaborate with other supply chain actors. Can you elaborate on the intensity and form of these collaborations?

All interviewed parties indicated that collaborative efforts with other parties had increased since they commenced with the Lean & Green programme, providing strong evidence for the need for collaboration to be successful in achieving the goals specified by the 1st and 2nd Star. The way in

which this observed increase in collaborative efforts emerges, however, differs per company. Five out of nine interviewees indicated that certain collaborations would not have been formed without any involvement of the Lean & Green programme. One of the case studies that has been discussed in hypothesis 2, for example, is the fruit of the Lean & Green programme. Most interviewees see the programme as an entrance to collaboration: starting a conversation, with the intention to become more durable through collaboration, is an excellent opening.

Question 2: Which role(s) exercised Lean & Green during the process of going from award to star, apart from establishing the programme?

Several roles have been identified throughout the interviews. These roles have been outlined in the table below. The circles indicate the number of endorsements by interviewees.

Insert Figure 6 approximately here

Out of the interviews, seven clear roles have come up. The three roles that are backed by most interviewees, are the ones of the Connector, Knowledge center and Certification institute. Some roles are very comparable to certain roles in the survey: The Facilitator, for example, is the Organizer of meetings and gatherings in the survey, whereas the Connektor is the Facilitator for contact with other companies. There are many similarities between the interview roles and the survey roles. The two roles that were mentioned most in the survey (Source of information and knowledge and Institute for certification), are also ranked high in the interviews (Knowledge center and Certification institute). Five of the above-mentioned roles were also specified in the survey.

The interviewees indicated that the Lean & Green programme had strong expertise in environmental impact calculations, possessed ample examples of best practices and provided practical advice and support. Furthermore, they enabled them to provide documentation for their environmental efforts and thus a sustainable image. Next to that, Lean & Green was instrumental in bringing companies together to induce collaborative efforts. This role was crucial to collaboration both within and outside the own branch of the interviewees. Especially bringing companies together within their own branch is important since these are usually competitors that would otherwise not cooperate.

Question 3: Has the role of Lean & Green changed over time? If so, in which manner?

Previous literature has indicated that the role of an independent neutral party in collaboration tends to be heavier at the start of the process but diminishes when the collaboration ages (Cannatelli and Antoldi 2010). The findings from the interviews fall into two categories: on the one hand, some roles of the third-party facilitator tend to increase in importance as companies progress within the programme; on the other hand, some roles decrease in importance from national to regional projects in the Netherlands.

The interviewees indicated that three roles are becoming more important over time. First, Lean & Green increasingly becomes a database of success stories. Secondly and thirdly, it broadens the opportunity for collaboration by extending the range of the programme, both geographically and programme wide. On the other end, the interviewees expect Lean and Green's leading role to decline. The growing influence of and co-development by the Ambassadors is a good example of this decline. Furthermore, Lean & Green has less influence in deepening established relationships. These findings are in line with Cannatelli and Antoldi (2010).

Question 4: Through the Lean & Green programme, your company has been able to reduce its environmental footprint. How many of these reductions are attributable to supply chain collaboration? How many of these reductions are attributable to Lean & Green?

All interviewees indicated that at least part of their environmental impact reduction could be attributed to collaboration. This contrasts with the regression analysis in hypothesis 3, where both collaboration dimensions (number and intensity) were no significant predictors of environmental impact reduction. The impact is largest for companies that either have transportation as their main activity (LSPs) or are heavily reliant on transportation (FMCG). The two largest contributors to reducing environmental impact are reductions in the number of empty kilometers, either by picking up freight on the return trip or by combining cargo to increase the occupancy rate, and multi-modality, where companies shift from road transportation to rail and barge. These two contributors have also been pointed out by the case studies in hypothesis 2. Both reducing the number of empty kilometers and multi-modality are unattainable without collaboration.

The role of Lean & Green is less obvious: some companies mentioned that their environmental impact reduction was not attributable to the Lean & Green programme at all, while others indicated that their environmental impact would also have been reduced without the programme, but on a smaller scale. Herein lies the difficult bifurcation that results from the indirect role of Lean & Green: although all companies seem to value the programme and endorse its importance, the real measures to reduce environmental impact are taken by the companies itself. As such, it is hard to directly attribute any reductions to the Lean & Green programme.

Question 5: Were you able to reduce the supply chain costs of your company as well? If so, how many of these reductions are attributable to supply chain collaboration? How many of these reductions are attributable to Lean & Green?

In correspondence with the answers to question 4, all interviewees indicated that their supply chain costs had decreased. The influence of collaboration is even more important: six interviewees indicated that the reduction in supply chain costs were only achievable through cooperation, especially on a horizontal level, and quite often with competitors. The reduction of empty kilometers and shift to barge and train (moving 'off the road') were also positioned as the two main contributors to supply chain costs reduction. These two contributors were also elementary in reducing supply chain costs in the case studies of hypothesis 2. The role of Lean & Green is even less apparent: only one interviewee mentioned its importance. This is in line with the survey responses for hypothesis 1: the question about environmental impact depicted more 'decreased' answers than the one about supply chain costs.

An interesting note is that all but one interviewee stated that environmental impact reductions go hand in hand with supply chain costs reductions. Switching from road to barge, for example, does not only reduce the CO_2-emissions, but is also more cost-efficient (at high occupancy rates). These findings confirm that the programme touches both the lean and green. The potential causal connection between these two reductions could be an interesting future research topic. The relationship between these two concepts has also been identified within the case studies.

Question 6: Have you encountered other programmes aimed at reducing environmental impact/supply chain costs? If so, why did you choose Lean & Green?

Throughout the interviews, only two different parties were mentioned: Green Freight Europe and CO_2-prestatieladder. Green Freight Europe used to be a competitor of Lean & Green, and mainly focuses on road transportation. Its strongest points were its international network and environmental calculation methods. The companies that were affiliated with Green Freight Europe, have denounced their membership. Lean & Green had the larger network, outperformed Green Freight Europe in marketing and visibility, and was especially strong in retail and FMCG, the sectors in which most interviewees either operate or in which their most important customers are. Furthermore, Lean & Green had the first-mover advantage: most interviewees indicate that they prefer to be involved intensively in one network platform.

Question 7: Are there any shortcomings and/or risks in the Lean & Green programme? If so, which?

The shortcomings and risks of the Lean & Green programme can be substantiated into three categories. Although the network is seen as one of the strongest points of the Lean & Green programme, improvement is necessary. The interviewees deem the number of participants still too low and also emphasize the importance of embedding the Lean & Green values within participating companies. If only a few people truly believe in the ideas of the Lean & Green programme, the risk of dropping out when these employees leave, is high. Furthermore, a strong call for further expansion in Europe is apparent. Only a few countries have Lean & Green programmes in place, and they are not as developed as the Dutch programme yet. This is partly due to cultural differences: the Germans, for example, are far more reticent and biding in joining such programmes. Furthermore, Lean & Green focuses too much on measures with a small impact, such as driving behavior. Next to that, there is a lack of success stories to back up the efficacy of the Lean & Green programme. This might be connected to the lack of attribution of the results of the programme to Lean & Green itself. Also, a clear success factor of the programme was its practicality and tangibility. With

the development of the 3rd, 4th and 5th Star, Lean & Green risks becoming too scientific. This is especially true for small- (and medium-) sized enterprises that are already struggling to keep up and achieve the same success as their larger counterparts, which was also apparent in the surveys for hypothesis 1. Finally, the success of the last years should not lead to casualness: Lean & Green needs to innovate itself continually.

Tables

Table 1 Regressions with "Intensity of collaboration"

	(1) Intensity of Collaborations	(2) Average CO_2 Reduction
Importance of L&G	0.225***	
	(0.057)	
Intensity of Collaborations		0.410*
		(0.184)
Small	-0.184	0.039
	(0.240)	(0.485)
Medium	0.117	-0.532
	(0.165)	(0.333)
FirstStar	0.357*	-0.350
	(0.164)	(0.338)
SecondStar	0.265	-0.597
	(0.204)	(0.408)
Construction	-0.421	1.072
	(0.349)	(0.706)
Energy	-0.008	1.654+
	(0.455)	(0.917)
LSP	-0.259	0.500
	(0.233)	(0.483)
Wholesale	-0.226	1.104
	(0.327)	(0.670)
Industry	-0.660+	0.307
	(0.391)	(0.803)
Government	-0.515	0.863
	(0.474)	(0.966)
Retail	-0.009	0.964
	(0.360)	(0.730)
constant	3.472***	3.195**
	(0.334)	(0.950)
R-sq	0.258	0.110
Adj R-sq	0.172	0.006
N	117	116

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2 Regression on (1) number of collaborations, and (2) intensity of collaborations

	(1) Number of Collaborations	(2) Intensity of Collaborations
Importance of L&G	0.218^{***}	0.252^{***}
	(0.052)	(0.052)
Small	-0.733^{***}	
	(0.201)	
Second Star	0.409^{*}	
	(0.177)	
First Star		0.274^{+}
		(0.139)
constant	3.528^{***}	3.219^{***}
	(0.241)	(0.248)
R-sq	0.289	0.196
Adj R-sq	0.270	0.182
N	116	117

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figures

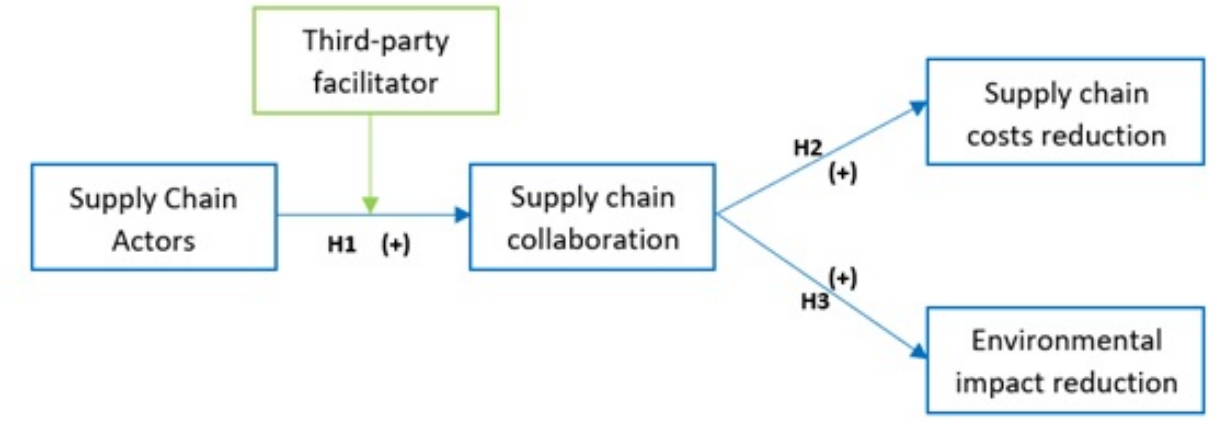

Figure 1 Conceptual Model

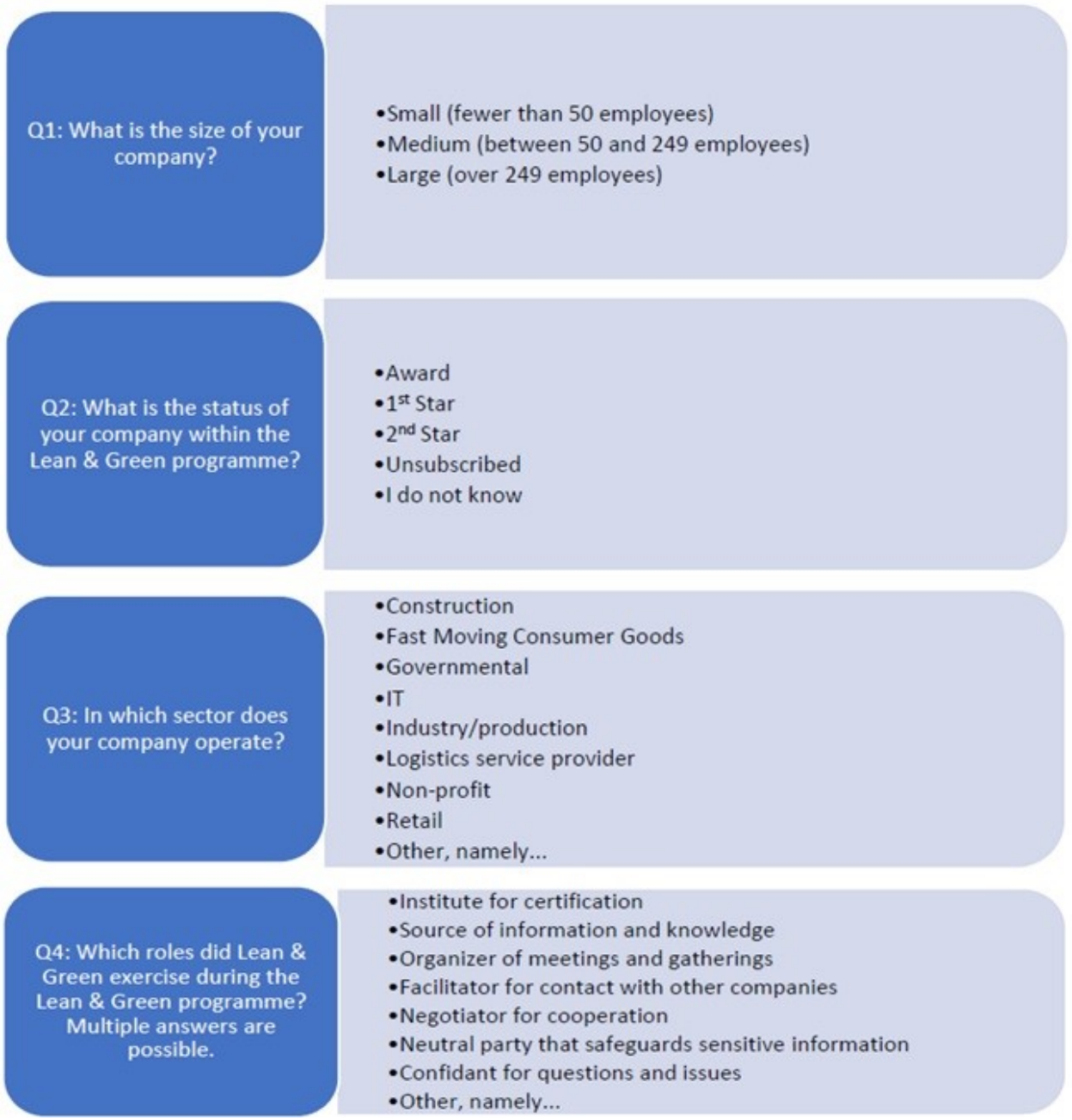

Figure 2 Survey Questions 1-4

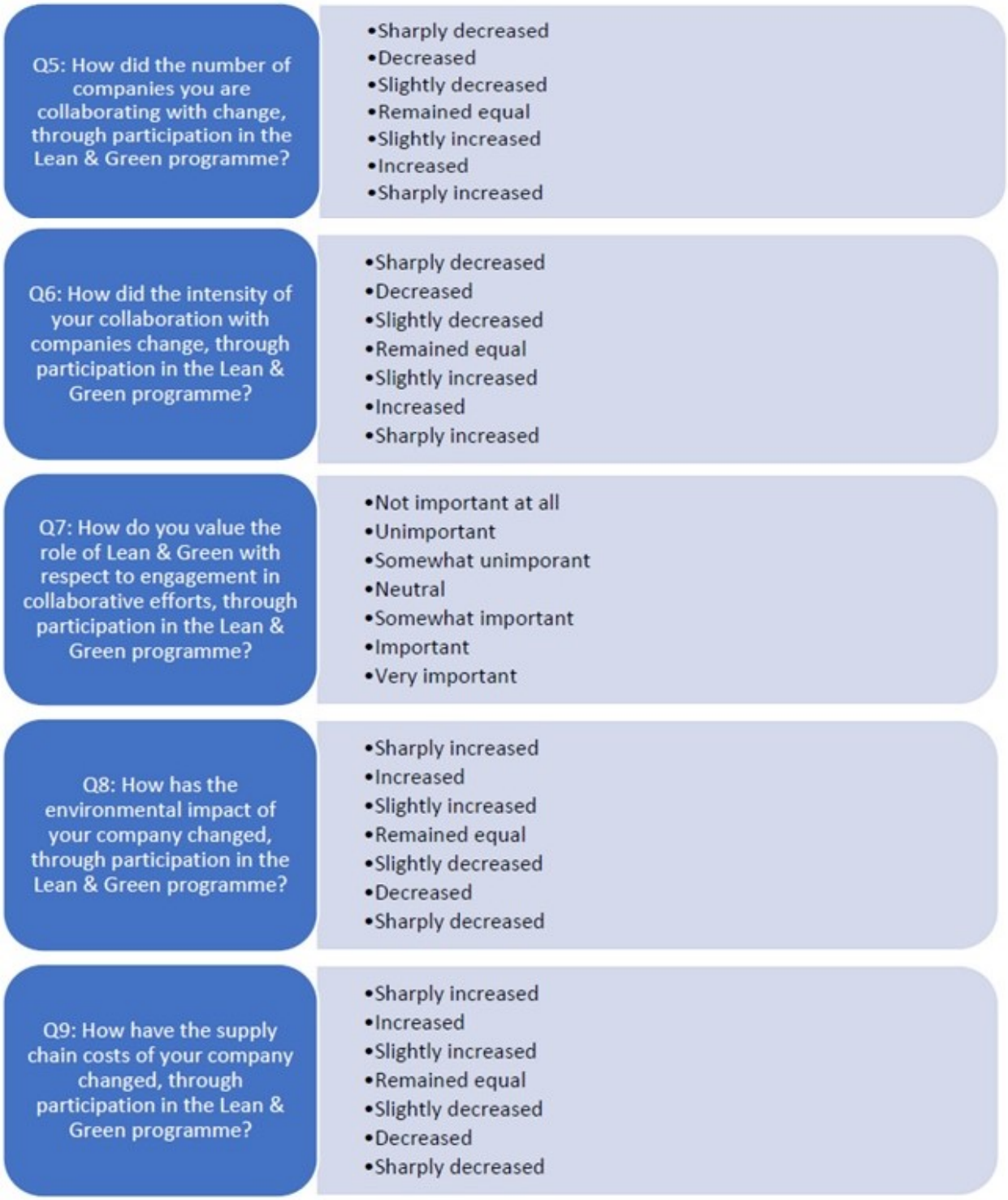

Figure 3 Survey Questions 5-9

	Road	*Rail*	*Air*	*Water*
Congestion delay	0.54	0.03	-	-
Accident	0.11-2.00	0.22	-	-
Air pollution, health	0.10-18.7	0.01-0.35	0.0-1.9	0.08-1.7
Climate change	0.02-5.9	0.01-0.47	0.45	0.00-0.23
Noise	0.0-5.3	0.05	-	-

Figure 4 External costs by transportation mode (US$ cents)

	Infrastructural costs	**External costs**	**Total costs**
Road	0.51	1.94	2.45
Rail	1.86	0.43	2.29
Inland navigation	0.82	0.10	0.92

Figure 5 Costs of freight transport per hundred ton-km

Figure 6 Roles played by Lean & Green with endorsement score by interviewees

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