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A Comprehensive Literature Review on Sustainable Horizontal Collaboration

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Abstract: Horizontal collaboration is one of the most effective strategies applied to address issues related to sustainability and the adverse effects of commodity distribution. Although it has received increased attention in recent years, no synthesis has been conducted to present the main practices and sustainability indicators used to assess the performance of horizontal collaboration. In addition, the factors that can further improve the performance of horizontal collaboration in terms of sustainability have not been presented in any literature review. Thus, we expose, in this paper, a review of the existing studies dealing with horizontal collaboration, and we define the key indicators used to measure its performance. The most commonly used practices of horizontal collaboration are also illustrated. In fact, the main objectives of the present study are to highlight the impact of certain factors on the success of collaboration and to identify several guidelines for researchers and companies wishing to implement horizontal collaboration.

Keywords: horizontal collaboration; pooling; optimization; sustainability; transportation; freight transportation; distribution network design problem; cost-sharing problem; logistics; distribution

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1. Introduction

During the last decades, collaboration has been considered a crucial factor that ensures the balance between the competing priorities of companies and their sustainability. It can be defined as a set of interactions between two or more actors in the supply chain. These interactions allow for achieving common goals. COVID-19 was the most significant challenge to global economic recovery since World War II [1], affecting both upstream and downstream flows in global supply chains [2]. The COVID-19 pandemic has strongly impacted various supply chains on several dimensions, namely: finances, lead times, demand, production performance, etc. In addition, the pandemic led some countries to close their borders for fear of foodborne transmission of the virus [3]. Some financially fragile companies suffered many economic problems because of these health restrictions. The crisis affected mainly the distribution of goods. In this context, collaboration has become the most effective solution for companies to be agile and resilient [4]. Indeed, collaboration can be vertical (VC) or horizontal (HC) [5–7]. The former occurs between partners operating at different levels of the logistics network. It allows reducing the procurement costs due to the synchronization effect through information sharing [8–10]. In contrast, horizontal collaboration takes place between partners at the same level (between suppliers, manufacturers, distributors, etc.) [11]. According to [10], it can be defined as the grouping of transport companies operating at the same level of the supply chain and having similar or complementary transport needs. It is also considered a collaboration between a group of actors belonging to different supply chains and operating at the same levels and under the same conditions [12]. Horizontal collaboration is one of the most innovative solutions adopted to effectively address the growing logistics challenges from environmental and economic point of views [13]. However, it has not been widely examined by the research community despite the promise of its substantial positive impact that could result from successful initiatives [14]. At a practical level, several projects applied horizontal collaboration, essentially to form a group of partners who share vehicles and distribution centers and, thus, minimize their logistics costs, increase vehicle fill rate, reduce inventory levels and GHG emissions, as well as to satisfy customers with high-quality and on-time delivery. Most of these projects, namely the HeCoRe project (Henkel, Colgate, and Reckitt) as well as the CHanGeS project (Colgate, Henkel, GlaxoSmithKline, Sara Lee), have been highly successful [15].

To the best of our knowledge, no synthesis outlining the main practices and sustainability indicators used to assess the performance of horizontal collaboration was conducted in previous research. Moreover, no literature review identified the factors that could enhance the sustainability performance of horizontal collaboration.

Given the importance and rapid development of HC in freight distribution, the current paper presents an exhaustive and in-depth literature review on this subject. Ten papers dealt with the state of the art in horizontal collaboration. On the other hand, some studies presented literature reviews on horizontal collaboration at the transport level [6,7,14], while others focused on the operational planning of road transport operators [16,17]. For instance, Cruijssen et al. [18] provided an overview of horizontal collaboration without considering transportation planning. However, some other research works examined the cost-sharing problem generated by collaboration [19,20]. Another study identified barriers to the implementation of collaboration [21]. Another literature review analyzed studies on horizontal and vertical collaboration in the supply chain from a sustainability perspective [22].

Overall, recent studies do not provide a comprehensive review of the literature in terms of sustainability indicators. Thus, this study was conducted to fill the gaps in the implementation of horizontal collaboration and to answer the following questions:

- What are the current directions of studies dealing with HC?
- Has HC been implemented in the industrial field?
- What is the role that HC plays to ensure sustainability?
- What are the challenges and success factors of implementing HC?
- How can the performance of HC be improved?

The objective of this paper is to answer these questions by carrying out a complete, exhaustive, and structured analysis of the existing academic studies dealing with HC. This paper also shows the main challenges and obstacles encountered during the implementation of collaboration.

The rest of this paper is organized as follows: Section 2 explains the procedure of selecting and classifying the reviewed articles and resources. Section 3 focuses on the results of the literature review, while Section 4 presents the challenges and obstacles that can prevent the successful implementation of HC. Section 5 provides some research perspectives. Finally, Section 6 gives some concluding remarks.

2. Selection Procedure and Classification of Articles

In order to address the perceived gaps, this paper follows a systematic approach based on five steps developed by [23]:

- Formulation of questions: This step consists in clearly identifying the research questions answered in the present study and defining the current directions taken in horizontal collaboration by citing these practices and their performance in terms of sustainability indicators. This paper also specifies the challenges and success factors of implementing horizontal collaboration. In addition, it shows the factors responsible for enhancing the performance of collaboration.

The used keywords can be classified into two categories. The first category contains: collaborative distribution, collaborative transport, horizontal collaboration, pooling, collaborative logistics, and cooperative transport. However, the second category includes: economic, environmental, social, green, and sustainability.

- Inclusion criteria: This step consists in using inclusion criteria to select the main papers to be analyzed. The used criteria are:
  - Papers published between 1998 and 2022,
  - Papers published in peer-reviewed academic journals focusing on logistics,
  - Papers written in English,
  - Papers dealing with problems related to logistics and transportation in horizontal collaboration.
- Data search: In this step, data sources were chosen. The following databases were utilized: ScienceDirect, Google Scholar, Wiley Online Library, Taylor and Francis, Emerald and Springer. Then, the research was conducted by combining keywords from the two categories defined in the first step.

In total, 160 papers were identified. However, by applying the inclusion criteria, approximately 125 papers published in 62 journals were selected according to their titles and the keywords employed in the papers. In fact, they focus on terms such as collaborative distribution, collaborative transport, horizontal collaboration, pooling, collaborative logistics, etc. The papers were classified into three categories according to the type of the conducted study (experimental, empirical, literature review) (see Figure 1).

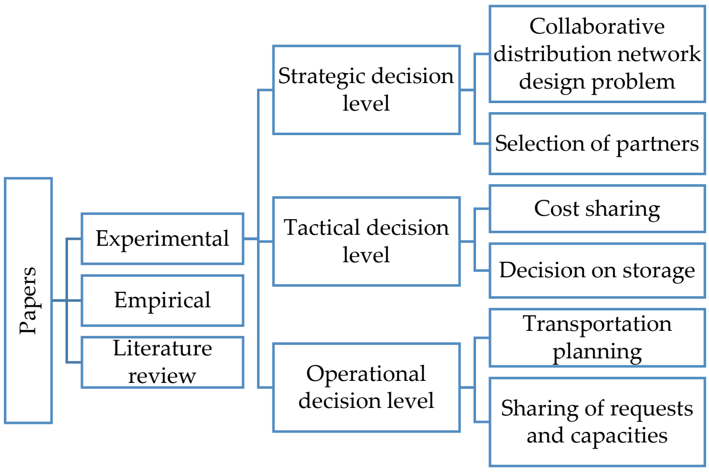


Figure 1. Classification of papers.

The other two steps, "Analysis and synthesis" and "Communication and use of results", will be detailed in the rest of the paper.

The analysis of the literature allowed classifying the studies into three categories: experimental studies, empirical studies, and literature reviews. The first class used scientific approaches based on mathematical models and simulation techniques. The second category contains exploratory studies relying on surveys, interviews, and discussions with academic and industry experts. Their objective is to cite the factors of success and failure of implementing horizontal collaboration. However, the third class includes literature reviews containing an analysis of the existing situation and a critical evaluation of the research developments.

The experimental studies are classified according to the three levels of decision, namely the strategic level, the tactical level, and the operational level. In fact, the strategic level concerns the general direction of the company and involves long-term decisions that affect its future (e.g., the problem of designing collaborative distribution networks and selecting partners). However, the second level revolves around medium-term decisions that play an important role in ensuring the success of decisions taken at the strategic or operational level. Typically, it includes two main issues: cost sharing and inventory decisions. On the other hand, the operational level concerns short-term decisions. It mainly addresses the collaborative transport planning problem and the request exchange mechanism.

The selected papers cover a wide range of journals in operational research, transportation, economics, and other research areas (see Table 1).

Table 1. Number of papers per journal.

Journal	No. of Articles
Transportation Research Part E: Logistics and Transportation Review	12
European Journal of Operational Research	10
Computers & Industrial Engineering	5
International Journal of Production Economics	6
Transportation Science	5
Computers & Operations Research	4
Journal of the Operational Research Society	4
Transportation Research Part B: Methodology	4
International Journal of Logistics Research and Applications	3
International Journal of Production Research	3
International Transactions in Operational Research	3
Supply Chain Management: An International Journal	3
Transportation Research Part D: Transportation and Environment	3
Transportation Research Record: Journal of the Transportation Research Board	3
Flexible Services and Manufacturing Journal	2
International Journal of Physical Distribution & Logistics Management	2
International Journal of Systems Science: Operations & Logistics	2
Mathematics	2
GOLD Spectrum	2
Production Planning & Control: The Management of Operations	2
supply chain management	2
The International Journal of Logistics Management	2
Annals of Operations Research	1
Applied Mathematics and Computation	1
CIRP Journal of Manufacturing Science and Technology	1
Decision Support Systems	1
Energy Economics	1
IFAC Proceedings Volumes	1
PapersOnLine	1
Industrial Engineering	1
INFORMS Journal on Applied Analytics	1
International Journal of Advanced Operations Management	1
International Journal of Industrial Engineering Computations	1
International Journal of Logistics Systems and Management	1
International Journal of Machine Learning and Cybernetics	1
International Journal of Shipping and Transport Logistics	1
Journal of Cleaner Production	1
Journal of industrial and management optimization	1
Journal of Management Control	1
Journal of Operations Research	1
Journal of Operations Management	1
Journal of Service Science and Management	1
Journal of Supply Chain Management	1
Journal of Transport Geography	1
Logistics Research	1
European Transport Research Review	1
Maritime Policy & Management	1
NETNOMICS: Economic Research and Electronic Networking	1
Networks and Spatial Economics	1
Omega	1
Operations Research	1
Operations Research letters	1
Research in Logistics and Production	1
Sustainability	1
Sustainable Cities and Society	1

Table 1. *Cont.*

Journal	No. of Articles
Transportation Reviews	1
Transportation Journal	1
Transportation Research Interdisciplinary Perspectives	1
Transportation Research Part A: Policy and Practice	1
Transportmetrica A: Transport Science	1
Some supply chain management	1
Working Papers	1

Figure 2 shows the distribution of studies by year of publication. It reveals that horizontal collaboration was given great attention in the literature.

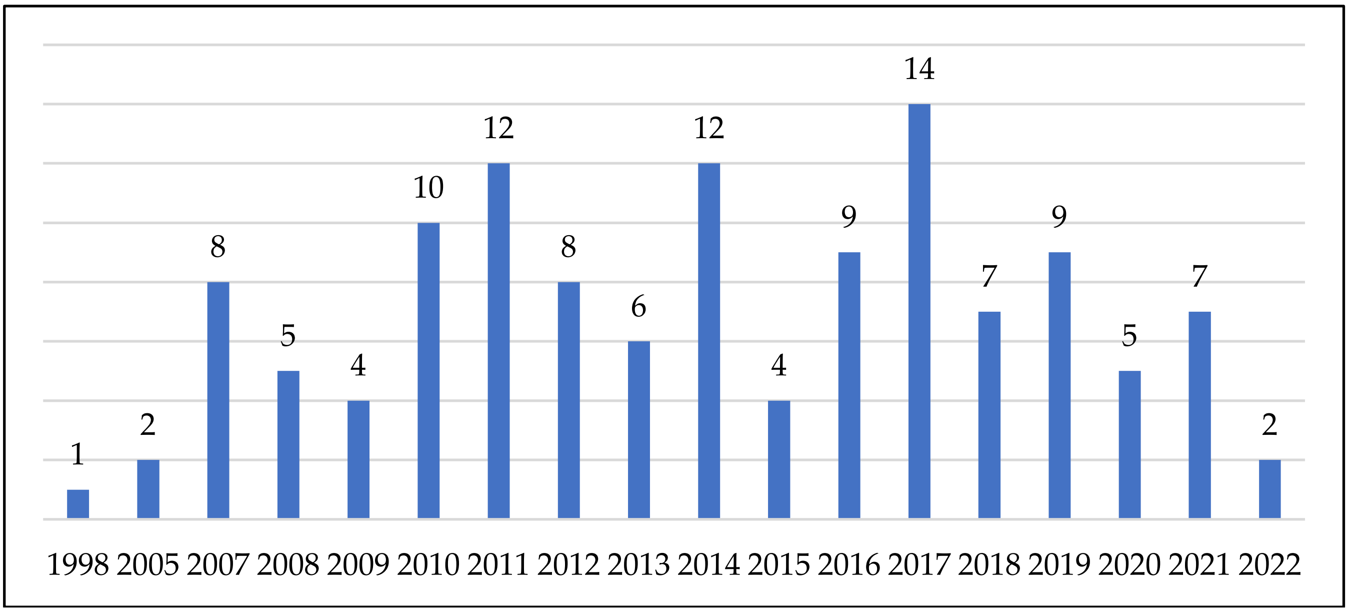


Figure 2. Number of papers published per year.

Table 2 presents the classification of the papers according to the type of the conducted study (note that some papers may belong to more than one category). It is clear that the majority of studies focus on cost sharing, transportation planning, and network design. This finding is consistent with that of Pan et al. [3] and Aloui et al. [4].

Table 2. Problem classification and references.

Types	Decision Level	References
Experimental studies	Strategic Level	
	○ Design of the distribution networks	[5,11,24–44]
	○ Selection of partners	[45–52]
	Tactical level	
	○ Cost sharing	[5,10,35,38,53–74]
	○ Storage decisions	[75–77]
	Operational level	
	○ Transportation planning	[62,78–98]
	○ Mechanism for the exchange of requests	[99–112]

Table 2. *Cont.*

Types	Decision Level	References
	Empirical studies	[13,18,113–130]
	Literature review	[6,7,14,16,17,19–22,131,132]

3. Results

Our contributions in this paper are multiple. First, we represent the main practices of horizontal collaboration. This can help researchers and industrialists to know the conditions of implementation of each practice. Second, we perform a detailed analysis of the literature by classifying the papers into three classes, namely: experimental studies, empirical studies, and literature reviews. In addition, the experimental studies are classified according to the three levels of decisions: strategic, tactical, and operational. This allows us to see the gaps in detail and to propose perspectives according to each decision level. The literature review is conducted by citing the sustainability indicators considered in each study. In the third step, we will cite the conditions for the successful implementation of horizontal collaboration. Thus, we will present the factors that can further improve the performance of HC in terms of sustainability, namely: the relaxation of delivery conditions, the use of a heterogeneous fleet of vehicles, the size and the degree of collaboration, etc. Finally, we will present several perspectives for future work based on the literature review.

3.1. Practices Used in the Collaboration

The objective of the horizontal collaboration is to pool dedicated logistics network schemes. It refers to how two or more companies can cooperate to achieve a common goal that consists essentially in minimizing the overall distribution costs [133]. Horizontal collaboration is based on: the establishment of Collaborative Consolidation Centers (CCC), Pooled Procurement Management (PPM), and Collaborative Transportation Management (CTM). The latter is applied in both vertical and horizontal collaboration as it refers to a collaboration in transportation.

- CCC: the establishment of collaborative consolidation centers is a key development factor because it promotes goods consolidation, which guarantees economies of scale in terms of transport. It also facilitates the shared distribution of goods by grouping many suppliers on the same site to consolidate their orders [24]. Indeed, consolidation centers reduce not only transportation costs but also GHG emissions [134].
- PPM: this strategy corresponds to the placing of orders jointly for part or all of a process by one of these entities or by a third party. Successful procurement depends on the technical capacity, the financial resources of the company, the type of information systems used, and the effectiveness of the management.
- CTM: it constitutes specific forms of logistics infrastructure such as shared distribution centers that are generally supported by the public authorities. Generally, these centers are installed in the city or on its outskirts to ensure freight distribution and improve transportation performance.

HC is generally adopted to pool resources and/or structures and, therefore, to increase flows, which involves companies (competitors or not) that can provide complementary goods or services. The massification of flows is one of the main objectives of pooling. It consists in grouping goods together in order to improve the fill rate of vehicles with the aim of reducing distribution costs and enhancing ecological performance. The main practices used in the HC are highlighted in the following sub-sections.

3.1.1. Transportation Collaboration

Transport collaboration is mainly based on vehicle routing. It makes it possible to obtain notable performance when the customers are geographically close, and the transported quantities are small. This strategy allows for improving the fill rate and minimizing the number of empty trips. However, it requires efficient information sharing to organize and plan transport in an optimal way [78]. Figure 3a represents the multi-pick strategy where goods are collected by vehicle round near suppliers and delivered to a single destination. In the opposite case, we talk about a multi-drop strategy where the products are delivered from one origin to several destinations. It is also possible that suppliers in the same region collaborate to collect and deliver their goods in a single truck on vehicle routes (see Figure 3b).

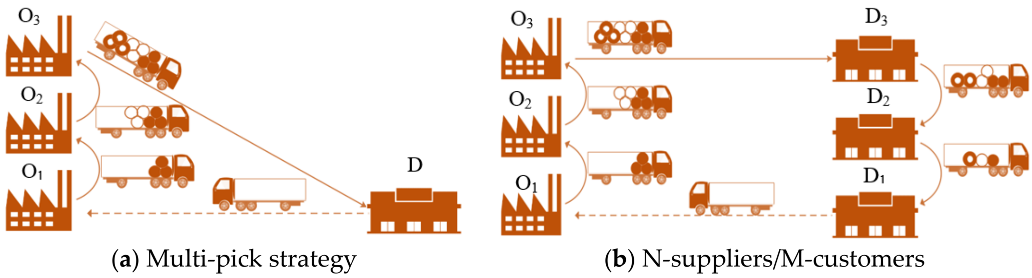


Figure 3. Examples of transport collaboration practices.

3.1.2. Collaboration in Transport and Storage

- Collaborative distribution network without vehicle rounds

Collaboration at the level of the logistic networks occurs between companies of the same type (e.g., small transport operators, networks of sales groups for retailers, or wholesale associations). It allows suppliers to meet the inventory reduction requirements of retailers, who require frequent deliveries in multiple small quantities, without putting more trucks on the road. By cooperating with other suppliers, it is possible to use full trucks and even reduce transport costs. This type of strategy can be applied to at least two echelons. The massification of flows is ensured by the shared warehouse, where goods from several suppliers will be gathered and stored. However, the main objective of the mathematical models developed is to locate a number of warehouses and assign the different nodes to them. The shared network in the case of three parts (upstream, midstream, and downstream) is illustrated in Figure 4. The first part is located between the collaborating suppliers and the upstream hub(s). However, the second part is placed between the upstream hub(s) and the downstream hub(s), while the third one is between the downstream hub(s) and customers or retailers.

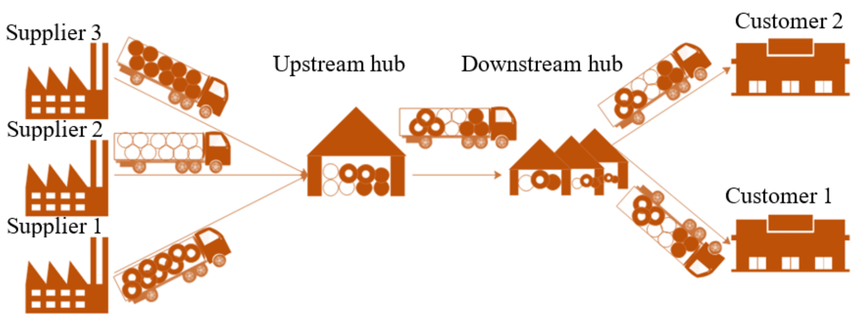


Figure 4. Three-echelon collaborative distribution network.

This pooling strategy was applied in several studies [9,16,25–29]. According to [27], it ensures economies of scale, especially between warehouses and distribution centers. According to [28], this strategy is mainly based on the appropriate selection and localization of an optimal number of hubs between suppliers and customers to minimize the overall storage and transportation costs as well as the operating costs of the hubs. According to the same authors, in the case of long-traveled distances, it is necessary to introduce hubs to improve the performance of the distribution network. In their case study of a distribution network in France, Ballot et al. [25] demonstrated that HC could significantly minimize CO_2 emissions due to freight transport and, therefore, consolidate the upstream and downstream flows. The interests and constraints of all stakeholders should be considered when designing a shared distribution network [6].

- Hub-and-spoke

The hub-and-spoke, represented in Figure 5, is a term derived from mechanics. Indeed, the hub is the point towards which the different lines converge to form rays. The hub-and-spoke network favors star-shaped traffic around a node and ensures economies of scale. This technique was first used by air transport. It was the express freight company FedEx that first tested it for packages in the United States using the Memphis hub. Later on, the system became widely used in the 1980s, and it was adopted in shipping in the 1990s. According to this strategy, freight traffic moves along spokes connected to a central hub. The centralized transport of goods allows for the continuous movement of loads, the reduction in the traveled distances, as well as the minimization of transportation costs and GHG emissions. In general, hub-and-spoke networks, studied in [30], are used to serve customers with high frequency [135].

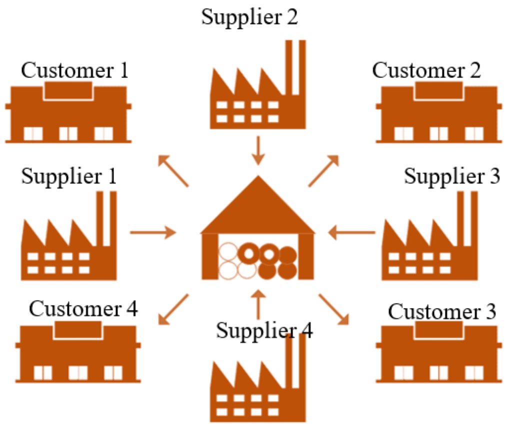


Figure 5. Hub-and-spoke collaborative network.

- The combination of multi-pick, multi-drop, and warehouse pooling

Typically, this type of network is based on the interdependence between decisions related to the location of hubs and those related to the routing of vehicles. It is called Location Routing Problem (LRP). It becomes a Location Inventory Routing Problem (LIRP) when dealing with storage decisions in hubs. LIRP can be designed in two echelons (see Figure 6) or more. This type of problem is studied in [5,11,30].

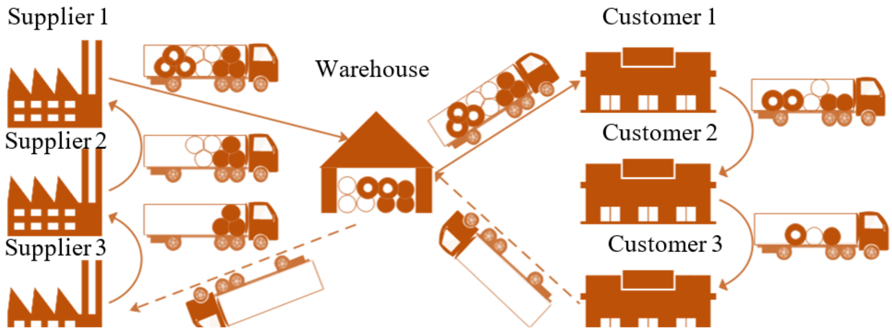


Figure 6. Multi-pick, multi-drop and warehouse pooling.

Other configurations of HC can be proposed relying on the existing ones. The introduced distribution networks are based on the idea that collaborators share transport and/or storage areas as well as information.

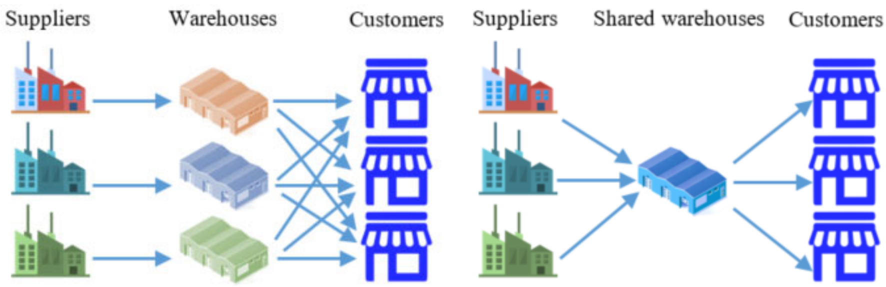
3.2. Experimental Studies

3.2.1. Strategic Decision Level

- Collaborative distribution network design problem

The collaborative distribution network design problem aims at reorganizing or designing a network by sharing means and resources between partners. Its main objective is to consolidate the logistic flows of different supply chains [6]. In terms of mathematical modeling, the collaborative distribution network design problem is similar to the classical problem of distribution networks [136], and it has rarely been studied in the literature. According to [27], it consists of: (1) finding the optimal locations for hub facilities (warehouses and distribution centers), (2) assigning nodes to hubs, (3) determining the links between hubs, and (4) specifying the route flows through the network.

Figure 7 shows the difference between a collaborative and a non-collaborative network. Before collaboration, each supplier is independent of the other in terms of transport and storage. Indeed, it uses its own warehouse to serve its customers. However, after collaboration, the partners share a pooled warehouse to consolidate flows and group the goods to be delivered in the same vehicles.



(**a**) Before collaboration (**b**) After collaboration

Figure 7. The distribution network before and after collaboration.

Groothedde et al. [27] used a heuristic approach to design a collaborative distribution network. Their objective was to determine the optimal number of hubs, their locations, and the best distribution frequency by minimizing the costs of intermodal transport, freight handling, order processing, and storage. The obtained results showed that collaboration enhances company outcomes. Despite the importance of the performed study, the authors did not consider the impact of the collaboration on other dimensions of sustainability, including the environmental dimension. Moreover, Cheong et al. [28] addressed the collaborative distribution network design problem by proposing a mathematical model in Integer Linear Programming (ILP) to minimize the logistic costs generated by storage, transport, and the operation of warehouses. Considering the long distance to be covered, the objective of this study is to find the best locations and the optimal number of shared hubs between suppliers and customers. The studied distribution network contains three components (suppliers, upstream hubs, downstream hubs, and customers). It aims at determining the right shipping frequency by planning multi-period transportation. In [28], small problems were solved by the Lingo Solver, while larger problems were solved through Lagrangian relaxation combined with heuristics. The major weakness of the research work is that the authors considered only economic indicators. In a similar vein, Tuzkaya and Önüt [31] addressed the same problem, including multiple suppliers delivering multiple products to manufacturers through a shared warehouse. The authors have proposed a linear programming (LP) model where the objective function makes it possible to reduce the logistic costs generated by the transportation, the loading and the unloading of goods, the storage, and the penalty due to the delay in delivery. Although the performed study provided good results, the authors only evaluated the logistics costs and neglected the environmental and social dimensions. Ballot and Fontane [25] examined the same problem by proposing a mathematical model in Mixed Integer Linear Programming (MILP) to minimize the CO_2 emissions generated by transport. The obtained results revealed that horizontal collaboration can improve the performance of vertical collaboration. Researchers concluded that horizontal collaboration may reduce CO_2 emissions by, at least, 25% compared to the non-collaborative scenario. The obtained results also showed that collaboration is always beneficial provided that the flows are sufficient to be shared and that the partners are close to each other. It was also deduced that, when low-volume and high-volume partners collaborate, the former could benefit more, in comparison to the latter since they already tend to operate fully-loaded vehicles. The main limitation of the study is that the authors took into consideration only the environmental dimension.

Leitner et al. [32] used simulation to examine two case studies of the automotive sector located in Romania and Spain. In the first case study, horizontal collaboration reduced costs and CO_2 emissions by 15% and 40%, respectively. On the other hand, in the second case study, it minimized the number of trips and CO_2 emissions by 14% and 17%, respectively. The main weakness of this study is that the authors did not evaluate the impact of collaboration on the social dimension. In addition, delivery was carried out by a homogeneous fleet of vehicles. Furthermore, Pan et al. [26] proposed a MILP to minimize CO_2 emissions from freight transportation in a three-echelon distribution network composed of suppliers collaborating to deliver their products to retailers through upstream and downstream hubs. The authors explored the effect of pooling by delivering goods based on two transport modes: road and rail. It was noticed that pooling is beneficial for the environment as it allows reducing CO_2 emissions by 14% and 52% by using road transport and the combination of the two modes, respectively. The study is based on the assumption that the delivery is carried out by a homogeneous fleet of fully-loaded vehicles. Pan et al. [9] extended the previous study [26] by minimizing transport costs and reducing CO_2 emissions in a two-echelon distribution network. The storage costs were evaluated after solving the mathematical model because of the non-linearity of its formulation. It was concluded that pooling allows reducing costs and CO_2 emissions generated by transport by approximately 14% to 52%, compared to the traditional distribution network. The authors proved that the costs and CO_2 emissions decrease with the increase in the number of shared hubs. This conclusion is not confirmed because the researchers did not take into account the costs and CO_2 emissions generated by the hubs. Moreover, the considered scenarios containing vehicle rounds upstream and downstream of the distribution network did not directly minimize CO_2 emissions. Indeed, in these scenarios, the objective function consists in solving the vehicle routing problem by minimizing only the traveled distances. Another limitation of the study is that it did not take into account the capacities of the hubs, and the delivery was carried out through a homogeneous fleet of vehicles.

Wang et al. [33] dealt with the centralized carrier collaboration problem. The latter was modeled in ILP, whose objective function is to minimize the costs generated by transport and the opening of hubs. Additionally, Verdonck et al. [29] investigated the two-echelon collaborative distribution network design problem modeled in MILP and consisting of opening a subset of the distribution centers and determining the optimal assignments between the different nodes. This objective was achieved by minimizing the costs caused by transportation and handling operations in the distribution centers. The results provided by a UK case study showed that the sharing of the distribution centers and the consolidation of flows allowed for reducing not only the logistic costs from 3.5% to almost 22% but also the total traveled distance. However, the authors did not assess the impact of collaboration on the other dimensions of sustainability, namely the environmental and social dimensions. On the other hand, the delivery was performed only by a homogeneous fleet of vehicles. Quintero-Araujo et al. [34] addressed the Integrated Routing and Facility Location Problem (IRFLP) in horizontal collaboration. They discussed three scenarios: a non-cooperative scenario in which all decisions are made individually; a semi-cooperative scenario in which route planning decisions are made jointly; and a fully cooperative scenario where route planning and facility location decisions are made jointly. The authors used the Biased Randomized Variable Neighborhood Search (BR-VNS) algorithm to optimize transport and warehouse opening costs as well as transport-related CO_2 emissions. They concluded that significant savings could be achieved by applying horizontal collaboration, especially in the case of full collaboration. Furthermore, Habibi et al. [35] proposed a MILP based on the formulation given by Ebery et al. [137] to reduce the costs generated by the transport and the installation of hubs. The authors considered uncertainty in the additional costs included in the cost of installing the shared hubs. In [35], Habibi et al. compared the performance of four scenarios: no collaboration, centralized collaboration, centralized collaboration with uncertain additional cost, and optimized collaboration with uncertain additional cost. The provided results demonstrated that the second and fourth scenarios are the best in terms of cost reduction. However, when taking into account the additional cost, the fourth scenario becomes the best. Indeed, the authors limited their study to the economic dimension while neglecting the other dimensions of sustainability. In their work [36], Tang et al. considered a multi-period horizon for transportation planning by designing a two-echelon shared distribution network. They proposed an MILP to minimize the costs induced by the transport of goods and the handling of regional distribution centers. Their objectives were to locate certain distribution centers, define distribution routes and establish optimized loading plans. The researchers showed that as the number of facilities increases, the cost decreases, as long as there is no fixed cost associated with facility selection. This finding is in agreement with that presented in [9]. In the latter, the capacities of the distribution centers were not examined, and the delivery was carried out with a homogeneous fleet of vehicles. On the other hand, the authors did not take into account the other types of costs (opening, penalty, etc.) and the two other dimensions of sustainability, in particular, the environmental one. Nataraj et al. [24] focused on the Location Routing Problem (LRP) in a collaborative context. They studied four scenarios: non-collaborative, weakly collaborative, semi-collaborative, and highly collaborative. Their resolution was based on the heuristic method. The evaluated indicators are the costs of routing vehicles and those of setting up urban distribution centers, as well as CO_2 emissions due to transport. The researchers concluded that the collaborative scenarios provided much better results compared to the non-collaborative scenario. However, goods were distributed through a homogeneous fleet of vehicles, and the authors did not take into consideration other constraints such as delivery times, storage, emissions generated by urban distribution centers and congestion, etc. Furthermore, Allaoui et al. [37] introduced an MILP to study an agri-food distribution network in order to verify the performance of horizontal collaboration within the framework of the Step Change Agri-food Logistics Ecosystems (SCALE) project. The authors also developed a decision support tool to help decision-makers choose the best solutions that offer a good compromise between economic, environmental, and social indicators. Despite the importance of the performed research work, it did not take into consideration the emissions generated by shared warehouses. Hacardiaux and Tancrez [38] applied a Mixed Integer Conic Quadratic Programming (MICQP) mathematical model to study the Location Inventory Problem (LIP) in a collaborative context. Their objectives were to determine the number and locations of the shared distribution centers, assign nodes and specify the shipment sizes and inventory levels. These goals were achieved by minimizing the costs generated by transportation, storage, ordering and installation of the distribution centers as well as by reducing CO_2 emissions resulting from transportation. The suggested model also made it possible to directly attribute costs and CO_2 emissions to specific partners. In order to find a good compromise between the economic dimension and environmental one, the authors used two approaches to solve the multi-objective model. The first approach, called coalition level articulation, consists in aggregating the objectives of the different partners. However, the second approach, named the weighted sum method, involves assigning a variable weight to each objective to favor it over another. It is worth to note that, the delivery was carried out by a homogeneous fleet of vehicles and emissions generated by the construction and operation of distribution centers were not taken into consideration. Fernández and Sgalambro [30] investigated collaborative LRP by proposing an MILP to minimize freight distribution costs. They compared the performances of the three collaborative strategies with those of the traditional non-collaborative strategies. Their comparative study revealed that collaboration ensures significant savings. The authors did not take into account the capacities of the hubs and vehicles and restricted their study to the evaluation of the distribution costs although it is important to consider other dimensions of sustainability to deal with such problem. In the same context, Ouhader and El kyal [5] studied the Two-Echelon Location Routing Problem (2E-LRP) by minimizing the costs and CO_2 emissions generated by freight transport. The authors used the ε-constraint method to solve the problem by combining the economic and environmental objectives. This method was utilized to minimize one of the two objectives by putting the other ones in the form of constraints to be respected. Mrabti et al. [39] proposed an MILP to address a collaborative two-echelon distribution network design problem. They considered the three dimensions of sustainability. They evaluated economically the costs generated by transport, the opening of warehouses, storage, and the penalty due to late delivery. At the environmental level, the authors assessed the CO_2 emissions due to transport and those generated by the depreciation of vehicles and by warehouses (their operation and construction). On the other hand, the social dimension was evaluated by the accident risk and the noise level resulting from freight transport. First, a mono-objective optimization (economic and environmental) was carried out to clearly define the optimal solutions. Then, multi-objective optimization was performed to obtain a good compromise between the objectives using the ε-constraint method. The researchers proved that flexible delivery times might improve the performance of collaboration. Aloui et al. [40] studied the Inventory Location Routing problem (ILRP) by developing an MILP to reduce the costs generated by transport, handling, storage, and the opening of warehouses, as well as the CO_2 emissions generated by transportation and warehousing operations. Subsequently, Aloui et al. [11] used a metaheuristic combining k-means clustering and the genetic algorithm to solve the same problem. The efficiency of horizontal collaboration and meta-heuristics was evaluated by conducting a case study of four agro-food SMEs in France. The obtained results showed that collaboration could reduce the costs, emissions and accident risk by 20%, 16% and 8%, respectively. In another study, Aloui et al. [41] introduced a two-step mixed-integer stochastic programming model to design a distribution network considering the epidemic disturbances and the uncertainty of the demand. Moreover, Gargouri et al. [42] dealt with the problem of designing a collaborative distribution network by taking into account the three dimensions of sustainability. The developed MILP was inspired from [39]. The economic and the environmental dimensions were investigated by minimizing logistics costs and CO_2 emissions, respectively. However, the social dimension was evaluated by accident risk and noise level. The problem was solved by single-objective algorithms, namely genetic algorithm (GA), simulated annealing (SA), particle swarm algorithm (PSO) and vibration damping optimization (VDO). The provided results demonstrated that the GA was the best in terms of GAP. However, regarding the computation time, the SA gave the best values in the shortest convergence time. Snoussi et al. [43] extended the same study [39] to a robust model by considering the uncertainty in demand, unit transport costs and the number of the available vehicles. They utilized uncertainty budget to control the level of conservatism in the solution networks. The experimental study proved that the robust model provided better results, compared to the deterministic model in terms of the analyzed uncertain parameter. Mrabti et al. [44] developed an MILP to address the collaborative distribution network design problem by minimizing CO_2 emissions from vehicles (depreciation and operation) and hubs (operation and construction). The authors compared the performance of three scenarios: non-collaborative, collaborative without vehicle routing and collaborative with vehicle routing. The obtained results proved that the third scenario was the most favorable as it reduced the overall traveled distances and improved the fill rates.

Table 3 summarizes the studies addressing the collaborative distribution network design problem according to the evaluated indicators.

Table 3. Studies dealing with the collaborative distribution network design problem according to the evaluated indicators.

Reference	Approach	Economic Costs of:	Environmental CO_2 Emissions Due to the:	Social
[27]	Heuristic	Transport Storage Order picking Handling		
[28]	ILP	Transport Storage Warehouse operations		
[31]	LP	Transport Handling Storage Delayed delivery		
[25]	MILP		Transport	
[32]	Simulation	Transport	Transport	
[26]	MILP		Transport	
[9]	MILP	Transport Storage (post-evaluation)	Transport	
[33]	ILP	Transport Opening of the hubs		
[29]	MILP	Transport Warehouse operations		
[34]	Heuristic	Transport Opening of the hubs	Transport	
[35]	MILP	Transport Opening of the hubs		
[36]	MILP	Transport Handling		
[24]	Heuristic	Transport Opening of the hubs	Transport	
[37]	MILP and meta-heuristics	Logistics cost	Transport Water and energy consumption	Created job opportunities Accident risk
[38]	MICQP	Transport Storage Opening of the hubs Placement of orders	Transport	
[30]	MILP	Transport		
[5]	MILP	Transport	Transport	
[39,42]	MILP and meta-heuristic	Transport Opening of hubs Storage Delayed delivery	Transport	

Table 3. *Cont.*

Reference	Approach	Economic Costs of:	Environmental CO_2 Emissions Due to the:	Social
[11,40,41]	MILP	Transport Storage Handling Opening of hubs	Transport Warehouse operations	
[43]		Transport Storage Handling Opening of hubs Delayed delivery	Transport Depreciation of vehicles Operations of hubs Construction of hubs	

- Selection of partners

The partner selection problem and the management of the negotiation phase [13] the main factors that determine the success or failure of horizontal collaboration [18]. Indeed, the latter occurs when two or more competing companies cooperate to share their means and resources. Therefore, collaboration consists in identifying and exploiting win-win situations that present an equal opportunity for each partner [127]. Consequently, two or more companies willing to work together should check if they are strategically suited for such a collaboration. The main objective of this problem is to choose suitable partners to collaborate with based on several criteria. According to [52], there are few studies focusing on partner assessment and selection.

Generally, the latter is based on quantitative and qualitative evaluation criteria. Therefore, it can be described as a Multi-Criteria Decision Making (MCDM) problem involving decision criteria, decision maker, and decision method.

As part of the collaborative distribution network, Ding and Liang [45] used the Fuzzy Multiple Criteria Decision-Making (FMCDM) approach to determine the most suitable partner. The authors considered several attributes, such as complementary capabilities and facilities. Additionally, Büyüközkan et al. [46] combined the two approaches Fuzzy Analytic Hierarchy Process (FAHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), to assess collaboration between partners by integrating uncertain and imprecise data into the evaluation process. The authors employed two types of criteria. The first focuses on the strategic partner aspects such as goals, size, financial stability, culture, tracking the record of success, and the ability to develop a lasting relationship. However, the second uses evaluation criteria to measure the important aspects of the partner's activity in four main sub-groups, namely its technical expertise, its performance, its quality, and its previous experience in management.

Additionally, Bahinipati et al. [47] provided a quantitative model to assess the degree of horizontal collaboration and test compatibility between partners. The Analytic Hierarchy Process–Fuzzy Logic Model (AHP–FLM) approach was employed to verify the strategic compatibility of the partners, including the characteristics of the sector, the competitive advantages as well as the internal and external parameters of each partner. According to [48], the success of collaboration depends strongly on the selection of partners. They applied the Fuzzy Multiple Attribute Decision Making (FMADM) approach to select appropriate partners based on two types of criteria provided by experts: individual criteria and collaborative ones. The first type includes technological capacity, financial health, management knowledge, and previous experience, as well as the ability to access new markets. Collaborative criteria correspond to the complementarity of resources, overlapping knowledge bases, as well as the correspondence of objectives and cultural compatibility. The approach was applied to select two companies out of seven firms to collaborate with Baosight Enterprise, which is ranked among the top five software companies in China.

Chen et al. [49] developed a partner selection mechanism relying on AHP and considering the criteria of organizational compatibility, technological capacity, R&D resources, and financial conditions. Furthermore, Creemers et al. [50] proposed a tool to identify potential partners to collaborate in the field of maritime transport. The selection was performed using the Bundling, Back-hauling, and Round-trip Tool (BBaRT) algorithm and based on the geographical compatibility of the partners. In the same context, Ben Jouida et al. [51] evaluated the expected profitability of each partner in order to select those who should participate in the collaboration. The problem was solved by the theory of cooperative games relying on the Cooperative Replenishment Algorithm (CRA).

According to [52], ignoring the cooperative factor can increase the probability of failure even if the partners have a good performance history. To this end, the authors approached the problem of partner selection using the double-factor theory, including individual and collaborative factors. The former was taken into account to determine the potential for creating competitive advantage through collaboration, whereas the latter refers to the possibility and stability of successful cooperation. The authors used two multi-criteria approaches, namely the Triangular Fuzzy Soft Set (TFSS) and the TODIM (the acronym in Portuguese for "Interactive Multi-Criteria Decision Making").

From the above-presented analysis, we may deduce that the selection of the appropriate partners is very important when implementing horizontal collaboration. It is also obvious that the used criteria and sub-criteria are mainly individual (technological capability, financial health, managerial experience, ability to access a new market, product characteristic, etc.) and collaborative (correspondence of objectives, cultural compatibility, technical resources, etc.). Despite the good results provided by the cited studies, the latter neglected the criteria concerning the participation of partners in sustainability, in particular their impact on the environment and their brand images with customers.

Table 4 summarizes the papers addressing the partner selection problem according to the used criteria.

Table 4. Studies addressing the problem of partner selection.

Reference	Approach	Type of Criteria	Criteria
[45]	FMCDM	Individual criteria	Additional capabilities Similarities in correspondence Financial health Physical facilities Availability of the adequate equipment Intangible assets Access to the market knowledge
[46]	FAHP	Criteria on the strategic aspect	Objectives of each partner Partner size Financial stability Culture of each partner Successful track record Ability to develop a lasting relationship
		Evaluation criteria	Technical expertise Performance Quality of partners Management experience

Table 4. *Cont.*

Reference	Approach	Type of Criteria	Criteria
[47]	AHP–FLM	Characteristic of the industry	Industry Structure Financial stability Global Reputation
		Competitive advantages	Product orientation Overall competitive advantage
		Internal parameters	Operational parameters Tactical parameters Strategic parameters
		External parameters	Product characteristics Industry focus
[48]	FMADM	Individual criteria	Technological capability Financial strength Management knowledge and experience Ability to access new markets
		Collaborative criteria	Complementarity of resources Overlapping knowledge bases Matching objectives Cultural compatibility
[49]	AHP	Organizational compatibility	Compatibility of the business strategies Symmetry of scale and scope Management and organizational culture Mutual trust and commitment
		Technological capacity	Manufacturing the technological capability Product development and improvement Capacity for innovation and invention Potential breadth of the application of skills
		Resources for R&D	Intensity of R&D investment Extent of the additional resources Number of R&D personnel Quality of R&D personnel
		Financial conditions	Return on investment over the last five years Future profitability Growth potential
[50]	BBaRT	Individual criteria	Geographical compatibility and volume of the delivered goods
[51]	CRA	Financial conditions	Expected profitability of each partner
[52]	TFSS TODIM	Individual criteria	Operations and financial health Management knowledge and previous experience Geographic distance Technological capacity
		Collaborative criteria	Cultural compatibility Trust and commitment Willingness to share information Additional benefits

3.2.2. Tactical Decision Level

The tactical level concerns medium-term decisions that ensure the success of decisions taken at the strategic or operational level. Typically, it includes two main issues: sharing the benefits of horizontal collaboration and inventory decisions.

- Sharing the costs of collaboration

More than 70% of collaborations fail [138] due to several factors and obstacles that generally fall under four areas: inappropriate partners, false determination and bad distribution of gains, inefficient negotiation, coordination, and information technology, as well as insufficient collected information and ineffective communication strategy [18].

In this section, we are particularly interested in the cost-sharing problem. Indeed, there are several points to be negotiated between the partners before implementing collaboration. For instance, we may cite the methods used to distribute the total costs or savings among the participants. In this section, we present an exhaustive analysis of the literature dealing with the problem of sharing the savings obtained through horizontal collaboration.

The existing approaches can be classified into two categories, namely classical approaches and those based on cooperative game theory. The former consist of using a proportional allocation relying on the overall volume or the weight of the transported products [10]. In such approaches, the cost allocated to a partner is obtained by multiplying the total cost of the collaboration by the weighting rate. The latter is related to the weight of the goods, the number of pallets, the traveled distances, etc. However, cooperative game theory approaches model an allocation problem as a transferable cooperative utility game and develop cost allocation schemes [61].

As part of collaborative transportation planning, Frisk et al. [60] used several allocation methods, namely the Volume method, Shapley value, Nucleolus, Cost Gap Method (CGM), and Avoided Cost Allocation Method (ACAM). Their aim was to distribute the transport costs generated by the collaboration of eight forestry companies located in southern Sweden. The authors suggested that it is beneficial to implement an initial allocation where relative earnings are as similar as possible for all partners. For this reason, they proposed a new approach called Equal Profit Method (EPM). Then, they demonstrated that the Equal Cost Method (ECM) and the ACAM satisfy the two properties (Pareto-efficiency and symmetry), whereas the CGM technique verifies the individual rationality and the fictitious property.

Frisk et al. [60] and Vanovermeire and Sörensen [10] showed the non-stability of the Volume method since a partner can reduce his cost by changing sub-coalition. The allocation by the EPM method is not always unique. Thus, Dahlberg et al. [55] introduced another technique, called the Lexicographic Equal Profit Method (LEPM), that guarantees a unique solution. Additionally, Defryn et al. [58] used several approaches, such as the Volume method, the Shapley value, the Nucleolus, the ACAM, and the EPM, to allocate transport costs.

Moreover, Massol and Tchung-Ming [66] studied the transportation cost allocation problem using the Shapley value and the Nucleolus. Since green thinking also has become a critical success factor, Wick et al. [71] employed the Shapley value to allocate CO_2 emissions. Computer simulation and operations research have been used to address the complexity of this approach.

Algaba et al. [53] developed two theoretical approaches based on a cooperative game theory called Egalitarian Solution (ES) and Colored Cost Proportional Solution (CCPS) to share costs. The authors demonstrated that both approaches are stable. Furthermore, Leenders et al. [63] applied two types of approaches to allocating CO_2 emissions generated by transport. The first is a classic method that combines volume and the traveled distance. The second technique, named the τ-Value method, relies on the theory of cooperative games. As it is easy to introduce several criteria in it, the authors introduced the quantity ordered by each customer, the origin–destination distance, the relative distance from warehouses, and the relative distance from other customers.

To design a shared distribution network, Habibi et al. [35] utilized three approaches to allocating costs. These approaches are the Shapley value, Volume, and Egalitarian Allocation (EA), where the costs are divided in an equitable way between two distribution networks. They were applied to distribute the costs generated by the installation of hubs and freight transport. In the same context, Ouhader and El Kyal [5] used the Shapley value to allocate the costs and CO_2 emissions generated by transportation when designing a collaborative distribution network. Additionally, Xu et al. [73] employed the Shapley value to share costs and taxes on CO_2 emissions generated by freight transport. Recently, Hacardiaux et al. [38] have introduced individual firm rationality into a non-linear mathematical model to account for firm preferences to allow each partner to specify its preference concerning cost reduction versus CO_2 emissions reduction. The authors have also used the Volume approach and the Separate Deliveries weighted Approach (SDA) to share location and transport costs, respectively.

Regarding collaborative freight distribution, Lozano et al. [65] addressed the cost-sharing problem based on the theory of cooperative games to develop a fair system that ensures cost-sharing among partners. The authors utilized four approaches to allocate the costs of shipping goods, namely Shapley value, τ-Value, Core-center, and Minmax core. The authors showed that the two approaches (τ-Value and Shapley value) provided too close solutions. Additionally, Audy et al. [54] addressed the cost-sharing problem using EPM and ACAM. The obtained results demonstrated that horizontal collaboration meets the requirements of real estate companies, and it can be adopted by all partners. Meanwhile, the authors suggested an extension of the EPM approach in order to guarantee that the cost allocated to a partner is always lower than its individual cost before pooling and, thus, to introduce a minimum percentage of savings greater than zero. They highlighted that the determination of this percentage is complex and requires negotiation between partners.

In [56], Dai and Chen used the Payload Allocation (PA) approach to distributing the costs generated by collection and delivery within the framework of a centralized collaboration between carriers. Similarly, Ramaekers et al. [68] applied the same approach in the context of collaboration in multi-modal distribution networks. The allocated costs were generated by transport and storage in the logistics platforms. Moreover, Özener and Ergun [67] used the Shapley value and the Nucleolus to distribute the costs of pooling between shippers. Vanovermeire and Sörensen [10] utilized several approaches, namely the Volume approach, the Shapley value, the ECM, the Nucleolus, and the Activity Based Costing (ABC) approach, to allocate the transport costs between partners. In fact, the ABC approach consists in distributing the costs according to the type of activity. The main objective of this study is to reward the most flexible partners in terms of delivery times. Subsequently, Vanovermeire and Sörensen [70] proposed a mathematical model integrating Shapley value method to optimize collaborative transport by balancing changes in the delivery date of each partner. The authors applied a heuristic method to solve the problem.

In the context of collaborative vehicle routing problems, Krajewska et al. [62] utilized the Shapley value to share costs between freight carriers.

Liu et al. [64] employed some approaches to profit sharing, such as the classical PA approach and two other approaches based on cooperative game theory, namely Shapley value and Nucleolus. They also developed a new approach called Weighted Relative Savings Allocation (WRSA), based on the concept of cooperative game theory, to minimize the maximum difference between the weighted relative savings of the partners. Moreover, Kellner and Otto [61] employed several approaches: the EA, the PA, the Allocation based on tours Stops and Payload (SPA), the Direct Distance weighted Allocation (DDA), the Centrality weighted Allocation (CenA), the Tons-Km weighted Allocation (ToKmA), the SDA and the allocation relying on Tons-km approach (KTA), to allocate CO_2 emissions.

In addition, Sanchez et al. [69] used the Shapley value to allocate CO_2 emissions from freight transport. Furthermore, Engevall et al. [59] utilized the Shapley value, the Nucleolus, and the τ-Value to allocate costs to solve the collaborative traveling salesman problem. The authors introduced a new concept, called "Demand Nucleolus", to assign high-demand customers a high cost. They noticed that the first three approaches yielded almost the same cost distributions.

Some authors have dealt with the problem of cost-sharing problem in relation to the pooling of warehouses. For instance, Wong et al. [72] used the Shapley value to process cost allocation in the context of pooling spare parts inventories. These costs were generated by holding inventory, downtime, and transportation. Moreover, De Vos and Raa [57] employed the Shapley value and the Nucleolus to allocate costs between retailers. They concluded that Nucleolus ensures high stability, and proportional allocation approaches are easy to implement, but they are not stable. Moreover, Defryn et al. [58] utilized the Volume approach to share costs between partners in the collaborative vehicle routing problem. They also introduced the property of individual rationality into the mathematical model to solve the non-stability of the used approach. In addition, Mrabti et al. [44] applied the three allocation approaches, namely EA, Volume, and Shapley value, to share the CO_2 emissions generated by vehicles and hubs when designing a collaborative distribution network. The same authors highlighted, in [74], the importance of flexibility in terms of delivery dates and sustainability when sharing the costs of collaboration. They presented a new metric to reward partners for their flexibility and the role they play to ensure sustainability. They also introduced an overall rate of sustainability and flexibility in the τ-Value approach. The latter was applied to allocate costs and CO_2 emissions to the partners participating in collaboration. The performed analyses and the obtained results showed the good performance of the proposed approach and its efficiency in preventing partners from taking advantage of each other.

Table 5 summarizes the papers addressing the cost-sharing problem.

Table 5. Studies addressing the cost-sharing problem.

Type of Approach	Approach	Reference
Classical approaches	ABC	[10]
	EA	[35,61]
	PA	[56,61,64,68]
	Volume	[10,35,38,58,139]
	CenA;ToKmA	[61]
	KTA;DDA	[61]
	SDA	[38,61]
Approaches based on cooperative game theory	ACAM	[54,60,61,139]
	CCPS	[53]
	Core-centre	[65]
	Demand Nucleolus	[59]
	ECM	[10,60]
	EPM	[54,60]
	ES	[53]
	LEPM	[55]
	Minmax core	[65]
	Nucleolus	[10,57,59,61,64,66,67]
	Shapley value	[5,10,35,57,59–62,64–67,69,72]
	WRSA	[61,64]
	τ-Value	[59–61,63,65]

- Storage decisions

Researchers in [140] demonstrated that companies start the planning phase by forecasting demands. In order to reduce the forecast errors about uncertain demands, Özen et al. [75] used cooperative game theory when addressing storage-level collaboration. They focused on the cooperation between retailers, who coordinated and re-allocated their orders by taking into account the updated forecasts. Additionally, Stellingwerf et al. [76] studied the Inventory Routing Problem (IRP) with product temperature control. The authors employed linear programming to show that collaborative inventory decisions could bring economic and environmental benefits through reduced costs and CO_2 emissions. The same problem was addressed by Soysal et al. [77] in the context of perishable products. Linear programming formulation was also applied to reduce CO_2 emissions due to transport and the costs generated by storage, vehicle routing, and the penalty of waste products.

Table 6 summarizes the papers addressing storage decisions.

Table 6. Studies addressing storage decisions.

Reference	Approach	Economic Cost of:	Environmental CO_2 Emissions Due to:
[75]	Cooperative game theory	Transport Storage	
[76]	LP	Transport Storage	Transport
[77]	LP	Vehicle routing Penalty for wasted products Storage	Transport

3.2.3. Operational Decision Level

The operational level concerns short-term decisions and, mainly, the collaborative transport planning problem and the request exchange mechanism.

- Collaborative transportation planning

In a given transport network, the optimization of collaborative transport is ensured by establishing optimal transport plans. The two main objectives of this problem are: the improvement of the vehicle fill rate (in particular for transport in Less-than-TruckLoad) and the reduction of empty trips. As shown in [6], two modeling approaches are often used for collaborative transportation planning, namely the Collaborative Vehicle Routing Problem (CVRP) and the Collaborative Lane Cover Problem (CLCP).

As far as the first approach is concerned, Krajewska et al. [62] studied the Pickup and Delivery Problem with Time Windows (PDPTW) in a horizontal collaboration by proposing a heuristic approach based on local search. The obtained results revealed that collaboration between two carriers reduced the number of vehicles and the routing cost by 10% and 12.46%, respectively.

Moreover, Agarwal and Ergun [79] studied a large-scale maritime distribution network by investigating the problem of ship scheduling and routing. They proposed an MILP to determine all the routes to be followed and the quantities of goods to be delivered by maximizing the profit resulting from the collaboration. Furthermore, Hernández et al. [80] addressed the collaborative transportation planning problem between LTL carriers. The provided findings proved that collaboration is an efficient strategy that allows for reducing the effects of delays and transportation costs.

In addition, Wang et al. [82] extended conventional routing to integrated operational transportation planning by introducing external resources, including vehicles from contractors and horizontal collaboration partners. The studied problem was modeled in ILP to minimize the total costs of fixed vehicle routing and subcontracting. The authors showed that the proper management of the external relations between partners could further improve the efficiency of collaboration.

Furthermore, Montoya-Torres et al. [83] designed a conceptual framework for the pre-evaluation of implementing collaborative strategies in urban areas. This framework uses quantitative operations and management methods. It was demonstrated that the collaborative vehicle routing problem improves the delivery time, reduces the traveled distance, and, therefore, minimizes the costs and CO_2 emissions. In addition, the authors proved that pooling enhances the level of services.

Chabot et al. [84] studied the CVRP by proposing an ILP. They analyzed four collaborative scenarios having different objectives: (1) minimization of transport costs for shippers, (2) reduction of carrier costs, (3) reduction of environmental costs, and (4) the combination of the three scenarios. It was concluded that collaboration significantly reduces costs. According to [85], empty returns can be avoided if a company takes advantage of working with a partner to meet its complementary transportation needs. To this end, the authors proposed a Quadratic Integer Programming (QIP) to deal with the problem of planning and coordination of collaborative transport and, thus, reduce the costs of collaboration within the framework of a transit system by applying a meta-heuristic called Greedy Randomized Adaptive Search Procedure (GRASP).

Pérez-Bernabeu et al. [86] examined the Multi-Depot Vehicles Routing Problem (MD-VRP) in a collaborative setting. They introduced a heuristic algorithm to test the performance of collaboration compared to non-collaboration by evaluating the costs and CO_2 emissions generated by the transport of goods. The experimental results proved that horizontal collaboration allows for reducing costs, the traveled distance, and greenhouse gas emissions.

Additionally, Fernández et al. [87] investigated the CVRP to optimize the collaboration scheme between carriers. Two MILPs were proposed to maximize the total profit while respecting a lower limit of the individual profit in order to ensure that all partners benefit from the collaboration. The authors highlighted that this solution could increase profit remarkably. Moreover, Hernández and Peeta [88] addressed the problem of centralized collaboration between multiple LTL carriers that seek to determine a routing strategy of a time-dependent collaborative network for a central entity such as a 3PL. The problem was modeled as an ILP whose objective is to minimize the costs induced by the transport and the handling and service of the 3PL. In the same context, Fernández et al. [89] suggested an MILP to examine the vehicle routing problem where several carriers collaborate to serve their customers. The objective of the performed study is to reduce the overall operational cost generated by the collaboration. The considerable savings obtained through collaboration can be enhanced depending on the partners' number.

Other authors considered time windows and journey delays when planning collaborative transport. For instance, Caballini et al. [90] investigated the same problem when road carriers collaborate to meet their demand for containers to and from a seaport. They proposed a mathematical model in Binary Linear Program (BLP) to reduce empty runs by maximizing the total profit from collaboration.

Molenbruch et al. [91] studied the operational effects of horizontal collaboration between remote access providers by assuming that joint route planning implies that customer requests could be exchanged between providers to minimize the overall cost of routing. The problem was modeled in Mixed Binary Linear Programming (MBLP) to reduce the cost of transport, the traveled distance, and the drivers' salaries.

According to [6], some other researchers considered the level of information availability for transport planning (static, dynamic, or real-time information). For example, Dai and Chen [81] proposed a model in MILP to study the collaborative transport planning problem with collection and delivery tasks. The two main objectives of this study are to reduce empty journeys and to improve the filling rate of vehicles. The authors compared the performance of two scenarios: the collaborative scenario and the non-collaborative one, where each carrier is independent of the other. Moreover, Wang and Kopfer [92] showed that collaborative transport offers potential cost savings, even in the presence of capacity limitations and restrictions on information exposure. The treated problem was modeled by linear programming to minimize the fixed planning and transport cost.

Hernandez and Peeta [93] addressed the collaboration between carriers, more specifically, when an LTL carrier seeks to collaborate with other carriers. The authors also studied the impact of the degree of collaboration on costs. The problem was formulated in binary form (0–1), and the obtained findings demonstrated that transport costs could be reduced by increasing the degree of collaboration.

Moreover, Wang and Kopfer [94] revealed that transport collaboration could help small and medium-sized freight forwarders benefit from economies of scale and reduce costs incurred in meeting customer demands. In order to solve this dynamic routing problem, they introduced two planning approaches using linear programming. The main conclusion drawn from their study is that carriers can further enhance their transport plans if they obtain demand information in advance.

In the same context, Zhang et al. [95] dealt with the problem of collaborative transport planning by using a stochastic plant-pollinator algorithm to maximize the total profit without reducing the individual profit of the partners. They noticed that the higher the degree of collaboration is, the greater the benefits made by the transporters will be. The authors concluded that it is essential for small and medium carriers to collaborate to be more competitive and sustainable, especially with rising fuel prices.

Other studies evaluated CO_2 emissions during the planning of collaborative transport. For instance, Muñoz-Villamizar et al. [96] assessed the implementation of a fleet of electric vehicles in collaborative urban freight distribution. Their objective was to reduce environmental impacts, in particular, CO_2 emissions while providing high-quality service. The problem was formulated in MILP and solved by a heuristic method to find a good compromise between costs and CO_2 emissions.

Regarding the CLCP, it aims at designing a set of transport plans covering all lanes to minimize the total cost. Authors, in [97], stated that the main difference between CVRP and CLCP is that the objective of the former is route optimization, while that of the latter consists in optimizing lane exchange without considering lane routes vehicles. Moreover, Kuyzu [97] investigated the collaborative lane coverage problem to cover a set of arcs. The problem was formulated in MILP to minimize transport costs. The same problem was addressed in [78,98], where the authors proposed an ILP to prove that collaboration allows for reducing the cost of transport.

Table 7 summarizes the papers addressing collaborative transportation planning.

Table 7. Studies addressing the collaborative transportation planning.

	Reference	**Approach**	**Economic Costs of:**	**Environmental CO_2 Emissions Due to:**
VRP	[62]	Local Research	Transport	
	[79]	MILP	Transport	
	[80]	ILP	Transport	
	[81]	MILP	Transport	
	[88]	ILP	Transport Handling 3PL Service	
	[92]	ILP	Use of vehicles Transport Subcontracting	
	[85]	QIP	Transport	
	[92]	LP	Transport Planning	
	[88]	Binary (0–1)	Transport	
	[94]	LP	Transport	
	[83]	Mathematical modeling	Transport	Transport
	[87]	MILP	Transport	
	[90]	BLP	Transport	
	[91]	MBLP	Transport Driver's salary	
	[95]	Algorithm Stochastic	Transport	
	[96]	MILP	Transport	Transport
	[84]	ILP	Transport	Transport

Table 7. *Cont.*

	Reference	Approach	Economic Costs of:	Environmental CO_2 Emissions Due to:
	[89]	MILP	Transport	
	[86]	Heuristic	Transport	Transport
CLCP	[97]	MILP	Transport	
	[98]	ILP	Transport	
	[78]	ILP	Transport	

- Mechanism used to exchange requests

When companies fully collaborate, they operate in a coordinated manner and work as one company. Thus, collaborating carriers can share or exchange demands, so that freight will be consolidated and shipped in common vehicles. As revealed in [6], it is very important to study this issue because it could be introduced in collaborative transport solutions. Two main mechanisms were presented in the literature: lateral payment and auctions.

The lateral payment mechanism refers to the monetary transfer between two carriers when requests (or capacities) are exchanged. It is also called collaboration pricing [102] or capacity exchange pricing [99]. According to [6], the latter can be defined as the price set by a carrier for the additional capacity it wishes to sell. The main issue here is to specify the right price with a double objective: encouraging carriers to exchange their requests and achieving an optimal exchange solution [99]. To attain these goals, the authors studied the problem of request exchange between carriers by developing a linear programming mechanism to manage the interactions and, thus, achieve optimal collaboration behavior. The provided results showed that the proposed mechanism is robust with respect to the variability of collaboration and the demand for freight, which makes it possible to find solutions that ensure optimal profits and guarantee a stable distribution of income between partners.

Additionally, Özener et al. [100] studied the problem of exchanging requests between carriers to determine the maximum benefit that can be derived from the collaboration by proposing an ILP. The authors also developed various exchange mechanisms that differ in terms of information sharing requirements and payment options. The same problem was addressed by [101] using inverse optimization.

It was also solved by Zhou et al. [102] to improve the fill rates. The authors used simulation to find the optimal collaborative expedition plan. They took into consideration the time constraint that each shipment must be delivered to its destination at a specific deadline.

Van Lier et al. [103] employed discrete event simulation techniques to evaluate a scenario in which product outflows were consolidated. Their objective was to increase truck fill rates by sharing demands between three cooperating firms producing three different product categories. It may turn out that certain demands cannot be integrated effectively during transport planning. For this reason, horizontal collaboration ensures demand reallocation to improve the overall network efficiency and the individual carrier profit.

The second type, called the auction mechanism, is also applied to exchange requests. According to [6], this mechanism selects a winner in each application based on the submitted prices. The objective of the studies that addressed this issue is to allocate many demands in an optimal way using linear mathematical models such as [104–112]. The main disadvantage of the auction mechanism is that it does not always guarantee global optimality for all carriers if it is not based on centralized planning [105].

Table 8 summarizes the papers addressing the mechanism for exchanging requests.

Table 8. Studies addressing the mechanism for exchanging requests.

Problem	Reference	Approach
Exchange of requests with lateral payment	[101]	Inverse optimization
	[99]	LP
	[100]	ILP
	[102]	Simulation
	[103]	Simulation
Exchange of requests with an auction mechanism	[105]	LP
	[107]	LP
	[109]	LP
	[104]	LP
	[106]	LP
	[102]	LP
	[105]	LP
	[108]	LP
	[110]	LP

3.3. Empirical Studies

In the literature, empirical studies based on experimentation and observation have been conducted to verify a hypothesis. This research methodology includes forming a hypothesis to be investigated as well as collecting, analyzing data and interpreting the results. Typically, researchers used large-scale surveys and questionnaires to make their observations.

For instance, Cruijssen et al. [18] concluded that the selection of partners decides the success or failure of collaboration. The authors also deduced that finding a reliable party to lead collaboration and build a mechanism for equitable benefits sharing are the main factors that guarantee the success and continuity of collaboration. These conclusions were drawn from a large-scale survey carried out in Belgium in the sector of logistics service providers. Moreover, Sandberg [113] highlighted the role of management in the success of a collaboration. To perform his study, he sent questionnaires to logistics managers in Swedish manufacturing companies. He noticed that there is a clear relationship between the intensity of collaboration and the resulting benefits. It was also observed that the selection of the best top management ensures the success of such horizontal collaboration.

Furthermore, Mason et al. [114] carried out an empirical study based on discussions with logistics industry experts from the three sectors (steel, grocery, construction) and experienced academics in the field of logistics and supply chain management in the UK. The obtained results revealed that the combination of vertical collaboration (between actors in the same supply chain) and horizontal collaboration (between logistics providers) might optimize transport efficiency. Additionally, Verstrepen et al. [115] identified the motives and factors that lead Logistics Service Providers (LSPs) to initiate horizontal collaboration. They concluded that horizontal collaboration could help to cope with difficult market conditions such as high fluctuation in demand, intensive competition, etc. It was also noticed that such collaboration makes it possible to serve new geographic regions, improve the level of customer service and make efficient use of the existing infrastructure and assets. The authors presented the main steps followed to implement and manage horizontal collaboration: (1) the strategic positioning by defining the objectives of the collaboration, (2) the design by identifying the best partners, the strategies for sharing the gains and sights, etc., (3) implementation by setting up a cooperation charter, information and communication systems, etc.; and moderation by good management and better control, etc. (4).

Furthermore, Klaas-Wissing and Albers [116] identified the issues of strategic management of transport networks and developed a framework that allows the systematic exploration of LTL networks from an institutional point of view. The provided findings showed the contingent effects of governance on the strategic decision-making fields of LTL networks. The authors stated that collaboration suffers from potential partner incompatibilities, inefficient strategic decision-making, and bad network configuration. Wallenburg and Raue [117] conducted an empirical study to determine the factors of success and failure of collaboration between German logistics service providers. They analyzed the impact of conflicts on the results obtained by applying collaboration and the role of governance mechanisms in the success of a collaborative strategy. Additionally, Hingley et al. [118] identified the benefits and limitations of using Fourth Party Logistics (4PL) as a horizontal collaboration manager. In the study, three suppliers, three logistics service providers, and a food retailer were interviewed. The authors concluded that large LSPs could agree to implement 4PL management, but the required investment costs are daunting.

Schmoltzi and Wallenburg [119] carried out an empirical study to specify the set of motivations, structure, and performance characteristics of horizontal collaboration between LSPs. Univariate and multivariate statistical methods, including Analysis of Variance (ANOVA) and cluster analysis, were applied to the dataset of 226 cooperations in Germany. The authors deduced that the success rates of collaborations could vary enormously from one sector to another and from one industry to another. Additionally, Albers and Klaas-Wissing [120] analyzed the ways in which horizontal collaboration between German logistics service providers is organized. From the performed analysis, the main factors that ensure the continuity of the collaboration (i.e., the selection of partners, the attribution of the benefits of the collaboration, and the coordination between the partners) were identified. According to [121], empirical studies focused mainly on the two levels of strategic and tactical decisions, namely partner selection and profit sharing. To this end, the authors empirically studied the operational decision level in order to show how to conceptualize the operational planning and control of carriers and to define the challenges faced by carriers. Another critical point comes down to the sharing of information between the partners. Indeed, its absence can hamper the success of horizontal collaboration [118]. Therefore, the study conducted by [121] also focused on information technology applied to facilitate operational planning and communication between carriers.

Additionally, Wang et al. [122] investigated how Information and Communication Technologies (ICT) can reduce CO_2 emissions in road freight transport and identify opportunities for further improvements. This study was carried out based on interviews with food retailers located in the UK, demonstrations, and observations. The obtained results showed that ICT solutions minimize remarkably CO_2 emissions that may be further reduced by sharing information with competitors. By interviewing senior executives from retailers, suppliers, and logistics service providers, Rodrigues et al. [123] carried out an empirical study about the horizontal collaboration of supply chains located in the United Kingdom. The authors identified several factors determining the success of collaboration, namely synergies and enablers (e.g., legislation, trust between partners, suppliers, 3PL, and equitable benefit sharing. Furthermore, Allen et al. [124] studied the challenges faced in optimizing multi-drop collection and delivery schedules in horizontal collaboration between carriers. It was deduced that sharing the gains of collaboration represents one of the main challenges that require the use of advanced approaches such as those based on cooperative game theory. The authors highlighted the role of a trusted third party, called the Freight Traffic Controller (FTC), to supervise, manage collaboration and distribute activity among carriers. Agrell et al. [125] analyzed how governance structures in the trucking industry affect coordination between a freight forwarder and carriers. They showed that coordination between carriers plays an important role in the success of collaboration. The authors also revealed that cooperative freight forwarders survive because they offer lower optimal prices. Other researchers identified another very important factor for successful collaboration, which is trust between partners. This factor is extremely relevant when partners are competitors, as is the case in horizontal collaboration (Wilhelm [126]). In fact, the lack of trust between the partners can compromise the objectives of the collaboration and block its success [13].

Naesens et al. [127] emphasized the importance of strategic alignment between partners before applying a collaborative strategy. Moreover, Schulz and Blecken [128] verified that the main obstacles to a cooperative approach are mutual distrust and a lack of transparency. Dahl and Derigs [129] empirically studied the effectiveness of a decision support system in an express transportation network. The authors found that to make a collaborative transport system successful, it is necessary to ensure economic success and the stability of collaboration through equal distribution of the benefits. Recently, Badraoui et al. [130] examined the factors that influence the performance of horizontal collaboration, particularly in the agro-food sector in Morocco. The empirical results proved that strict food safety regulations and product-specific requirements limit the choice of partners whose products require similar handling conditions and present low risks of interaction. The seasonality of food demand and production also restricts the choice of potential partners to those offering products with inverse seasonality, which increases the use of the asset. Indeed, expensive technical equipment is seen as a factor responsible for increasing the willingness of companies to collaborate by mutually investing in a specific domain or sharing technical resources. On the relational level, the provided findings demonstrated that trust is the main element that affects the success and continuity of collaboration.

Table 9 summarizes the empirical studies and the main findings of each study.

Table 9. Summary of empirical studies in the context of horizontal collaboration.

References	Tools	Sector	Country	Conclusion
[18]	Investigations	LSP	Belgium	- Importance of partner selection - Importance of equitable distribution of benefits - Importance of finding a reliable party to drive collaboration
[113]	Investigations	Manufacturing companies	Sweden	- Top management is an important factor for the success of collaboration
[114]	Interviews with experienced experts and scholars	LSP	UK	- The combination of vertical and horizontal collaboration can further optimize transport efficiency
[115]	Data gathering	LSP	Belgium and The Netherlands	- Collaboration faces competition and fluctuating demands - Collaboration makes it possible to serve new geographic regions - Collaboration improves the level of service - Collaboration makes efficient use of resources - Collaboration saves costs - Importance of partner selection and gain sharing - Importance of ICT systems for better coordination - Importance of finding a reliable party to ensure the success of collaboration
[127]	Synthetic approaches	General	General	- Importance of strategic alignment between partners - Importance of equitable distribution of benefits - Importance of information sharing
[128]	Synthetic approaches	General	General	- Importance of trust between partners
[116]	Interviews	LSP	Germany	- Importance of partner selection - Importance of profit distribution
[126]	Interviews	Japanese and German automotive industries	Japan and Germany	- Importance of trust between partners
[117]	Investigations	LSP	Germany	- Relational governance reduces the scope of conflict - Formal governance increases the scope of conflict - Conflicts decrease the efficiency of collaboration
[118]	Interviews	LSP	UK	- Large LSPs agree to implement 4PL management - Setting up a 4PL generates a high investment cost - Retailers promote 4PL implementation
[129]	Analysis of simulation results	Carriers	General	- Importance of equitable distribution of benefits
[120]	Interviews	Small and medium-sized LSPs	Germany	- Importance of partner selection - Importance of strategic decisions such as network design

Table 9. *Cont.*

References	Tools	Sector	Country	Conclusion
[119]	Interviews with logistics practitioners and researchers	LSP	Germany	- Collaboration between LSPs is more stable than that between manufacturing industries
[13]	Synthetic approaches	General	General	- Importance of trust between partners
[121]	Interviews	Carriers	UK and Netherlands	- Importance of partner selection - Importance of profit distribution - Importance of information sharing
[122]	Interviews	Retailers	UK	- Importance of ICT in reducing CO_2 emissions
[123]	Interviews	LSP	UK	- Importance of synergies and enablers (legislation, trust, 3PL and equitable benefit sharing)
[124]	Interviews	Carriers	UK	- Importance of a trusted third party
[125]	Exploratory	Carriers	Sweden	- Importance of coordination - Importance of trust between partners
[130]	Exploratory	Food companies	Morocco	- Product compatibility - Selection of partners Technical equipment Trust between partners

3.4. Literature Reviews

Some studies presented literature reviews on horizontal collaboration. For example, Cruijssen et al. [131] provided an overview of the different types of horizontal collaboration, i.e., the levels of integration between collaborators. Moreover, Nagarajan and Sosic [19] exposed a review of the literature on cost sharing using cooperative game theory. Verdonck et al. [16] focused on the operational planning of motor carriers. Additionally, Pomponi et al. [132] identified the theoretical and practical challenges of horizontal collaboration. They proved that trust between partners is the main factor that can prevent the success and continuity of collaboration. Guajardo and Rönnqvist [20] dealt with the cost-sharing that represents a key factor for efficient collaboration. They also illustrated the sharing mechanisms introduced in the literature and classified them into classical approaches and approaches based on cooperative game theory. Moreover, Chen et al. [22] conducted a literature review on horizontal and vertical collaboration within the supply chain. The authors were able to show that the two economic and environmental dimensions still dominate scientific research, while the social dimension is not sufficiently considered. Gansterer and Hartl [17] presented the state of the art on centralized and decentralized transport planning, in particular on the CVRP. The first type of planning is generally used when partners agree to share their complete information to a central planner, whereas the second is employed when they are unwilling to give complete information to a central planner. The same authors also cited some research works dealing with partner selection and cost-sharing in the context of collaborative planning. Pan et al. [6] showed the state of the art on horizontal collaboration. They demonstrated that carrier alliance and service provider collaboration are the most frequently investigated in previous studies. With respect to implementation issues, the literature focused on the development of decision-making models, including transport planning, route swapping, and gain sharing. Furthermore, Ferrell et al. [14] exposed a literature review on horizontal collaboration. They highlighted mainly studies describing the areas of on-demand logistics, freight bundling, facility sharing, case studies and quantitative analyses. In the same context, Aloui et al. [7] showed a literature review on studies examining the three levels of decision-making, namely strategic, tactical and operational. They concluded that the majority of studies concentrated essentially on the operational level, in particular the problem of collaborative transport planning. Finally, Karam et al. [21] presented a literature review to identify barriers to the implementation of collaborative transportation networks. The authors proposed a conceptual framework by grouping the 31 barriers into five categories, namely: business model, information sharing, human factors, collaborative decision support systems, and market.

3.5. Sustainability Indicators

Sustainable development is now one of the most important challenges in freight distribution. Soubbotina [141] proved that sustainable development is ensured by the successful balance between economic, environmental, and social dimensions, also called the TBL (Triple Bottom Line) (People, Profit, Planet).

Several research studies, such as [142], classified the sustainability impacts of freight transport according to this Triple-P.

In most cases, sustainability has traditionally been identified with the three following dimensions: environmental, economic, and social. These three dimensions must be given the same importance to achieve sustainability.

The two most common methodologies applied in the literature to perform thematic and sub-thematic categorization of indicators are: the Triple-P and the different dimensions of sustainability.

- Classification according to the Triple-P

The Triple-P is widely utilized in sustainability practice. Quak [143] examined the impact of freight transportation on sustainability according to the Triple-P classification:

- Profit impacts: inefficiency and waste of resources, low route reliability, and on-time delivery, potentially resulting in deteriorating the quality of service, reduced economic development, and congestion, as well as low accessibility to the city.
- Impacts on the planet: polluting emissions, use of non-renewable natural resources, waste, and loss of wildlife habitat.
- Impacts on people: physical consequences of pollutant emissions on public health, injuries, and deaths resulting from traffic accidents, increased nuisance, reduced air quality, and damaged buildings and infrastructure.

- Classification according to dimensions

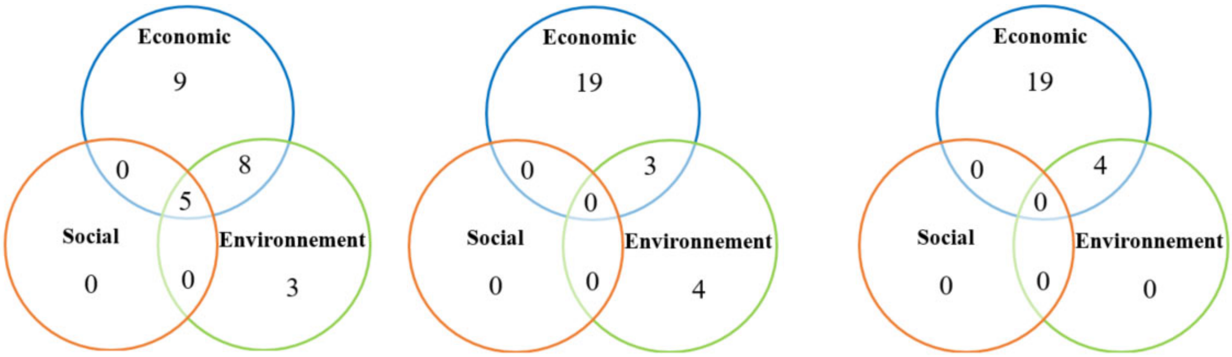
- Economic impacts: logistical costs, increased traffic congestion, lost time and inefficiencies for person or company doing the transport, unreliable delivery, inadequate use of resources.
- Environmental impacts: emissions of pollutants that contribute to global climate change (e.g., carbon dioxide (CO_2)), use of non-renewable resources (fossil fuels, aggregates, soil, etc.), waste materials such as tires, oil, and other materials, loss of wildlife habitat, and threats to wildlife.
- Social impacts: health impacts (local air pollution, traffic accidents, and noise pollution), traffic congestion, damaging the buildings and infrastructure (vibration, traffic accidents, degradation of pavement due to the weight of commercial vehicles), deteriorating quality-of-life issues (loss of sites, visual intrusion, physical barrier, stench, vibration).

In general, most studies reported more or less the same negative impacts of freight transport. They sometimes differ in the category to which they attribute these impacts.

In the context of collaboration, the economic dimension was generally evaluated by the logistical costs generated by transport, storage, the penalty for late delivery, and the installation of hubs. On the other hand, the environmental dimension was assessed by the CO_2 emissions due to vehicles and hubs. As far as the social dimension is concerned, it was estimated by the created job opportunities, the noise level, and the risk of accidents caused by freight transport.

Figure 8 represents the number of studies classified according to the type of the addressed problem and the considered dimensions of sustainability. It reveals that the economic dimension is the most widely examined in the literature on the collaborative DNDP (see Figure 8a). To a lesser extent, the literature paid attention to the environmental dimension by minimizing CO_2 emissions separately or in conjunction with logistics cost reduction. With regard to the cost-sharing problem, it is quite clear that most studies have shared costs and, to a lesser extent, CO_2 emissions and both together (see Figure 8b).

However, studies dealing with the planning of collaborative transport focused on the evaluation of logistics costs, in particular, those generated by transport (see Figure 8c).



(**a**) DNDP (**b**) Cost-sharing problem (**c**) Transportation planning problem

Figure 8. Distribution of studies according to the dimensions of sustainability.

4. Success and Failure Factors

4.1. Success Conditions

Horizontal collaboration is based on the sharing of means and resources, and information. It aims at improving the performance of all partners in terms of sustainability. It represents three main challenges for the different actors in the supply chain: (i) the improvement of the provided services [83], and (ii) the minimization of costs by the massification of flows and logistics purchases [6]; and the reduction of the CO_2 emissions [5].

The analysis of the literature and the feedback from the identified industrial projects identified proves that the implementation of horizontal collaboration is often perceived by the actors involved in the approach as a real challenge. Indeed, before implementing it, several conditions must be met, such as:

- Partner selection: the first step that should be made is to choose the appropriate partners [18] based on several criteria (size of the partner, financial status, number of joint customers, reputation, visions, etc.).
- Product compatibility: this condition is essential in order to group products in the same trucks and in the same warehouses under the same storage conditions (temperature, humidity, etc.) [130].
- Common objectives: the partners participating in pooling must have the same objectives and the same visions [5].
- Common customers: collaboration with partners who have common customers ensure the massification of flows by grouping goods from several origins and transporting them to the same destination [131].
- Information sharing: pooling refers to collaboration with partners who may be in competition, which makes information sharing a critical factor for all partners [52]. This problem can be overcome by entrusting the coordination and management of pooling to a neutral organizer such as the logistics providers. In addition, a minimum of trust is necessary to improve the performance of pooling [123].
- A fair system of gain sharing: this factor can prevent the success and continuity of pooling. Therefore, before collaboration, it is essential to find an approach that ensures the equitable sharing of gains [124].

4.2. Collaboration Performance Enhancers

The analysis of the literature shows that horizontal collaboration can be further improved thanks to several factors cited below.

- The relaxation of delivery conditions

Generally, the more restrictions companies place on their planning, the higher the total cost will be [10]. Previous studies proved that the benefits of collaboration are highly dependent on the flexibility of the delivery time allowed by each partner. This flexibility can be achieved by relaxing the delivery times or by splitting orders [74]. Some researchers stated that it is possible to reduce transport costs by delaying the delivery of a certain quantity of goods [10,144]. Mrabti et al. [39] have recently highlighted the importance of flexibility to improve the three dimensions of sustainability by reducing logistics costs, CO_2 emissions, noise level, and accident risk. Thus, we may conclude that flexibility becomes beneficial by exploiting more alternatives and maximizing the possibilities presented to optimize the transportation plan. Indeed, the relaxation of the delivery conditions makes it possible to delay a quantity of freight to create less expensive and more sustainable distribution plans. Reducing the number of trips can also reduce the total traveled distance, minimizing not only logistics costs but also CO_2 emissions, accident risk, noise level, congestion, and damage to roads and highways.

- The use of a heterogeneous fleet of vehicles

The use of a heterogeneous fleet of vehicles allows for optimizing transport plans and improving the fill rate [145]. This approach was not widely applied in studies dealing with horizontal collaboration. However, several studies have shown that the use of a heterogeneous fleet of vehicles can effectively model the economy of scale by determining the optimal number of vehicles to be used [145–147]. This approach uses a unit cost of transport that depends on the type of vehicle and is integrated into the mathematical model. According to [147], a heterogeneous fleet of vehicles is essentially employed to achieve economies of scale and reduce transport costs by employing larger-capacity vehicles. The collaborative DNDP is similar to the traditional problem in terms of mathematical modeling [136], which confirms that the performance of collaboration can be enhanced by a heterogeneous fleet of vehicles.

- The size of the collaboration

The literature review reveals that it is more beneficial to use collaboration when there are a large number of partners to satisfy a large number of customers. By studying carrier collaboration in distribution center location problems, Fernández and Sgalambro [30] proved that the overall cost savings associated with implementing collaboration improve as the number of carriers increases. In another study, Ballot and Fontane [25] pointed out that CO_2 emissions can be further reduced by increasing the number of companies or product families due to higher volume. Ouhader and El kyal [5] also showed that the rise in the number of customers positively influences the gains obtained, especially if the partners have a greater number of common customers.

- The degree of collaboration

Some studies in the literature demonstrated that the performance of the collaboration strongly depends on the partners' degree of participation. By comparing several scenarios, Nataraj et al. [24] concluded that the higher the degree of collaboration is, the greater the benefits will be. In another study [34], Quintero-Araujo et al. showed that important savings could be achieved by applying total horizontal collaboration in transport and storage.

- The multi-modal transport

In some studies, it was confirmed that multi-modal transport could further enhance the performance of horizontal collaboration. For instance, Pan et al. [26] demonstrated that joint transport by road and rail represents an efficient solution to reduce CO_2 emissions, provided that the emissions generated by power generation are low. According to [27], it is advisable to use short sea shipping and rail or a combination of air and sea transport.

- The increase in the number of warehouses

Several studies showed that transport costs and CO_2 emissions could be reduced by increasing the number of open hubs. This observation can be explained by the fact that the increase in the number of open hubs may augment the possibilities of grouping flows, which makes it possible to consolidate flows more [9,38]. However, this conclusion could be different when taking into account the costs and the CO_2 emissions generated by the opening of hubs, as each installation generates additional costs and increases CO_2 emissions [9].

- The resilience and uncertainty

Taking into account the uncertainty in the parameters of the models makes it possible to contribute to a better approximation of the real practice and take into account fluctuations in flow and costs. Although uncertainty in the literature of horizontal collaboration was not intensively studied, the few existing research studies that address this issue have highlighted its importance. Habibi et al. [35] revealed that the collaborative scenario with uncertain additional costs provides better results compared to the other scenarios. Moreover, Aloui et al. [41] demonstrated the importance of considering demand uncertainty to overcome the disruption caused by COVID-19. Snoussi et al. [43] also proved that it is very beneficial to take uncertainty into consideration when designing sustainable distribution networks. Uncertainty, in this study, is taken into account in terms of unit transport costs, demands, and the number of available vehicles.

5. Research Insights

This section discusses various research perspectives obtained. Firstly, sustainability indicators, especially social indicators that deserve to be better involved in all three levels of decision making (strategic, tactical, and operational), should be further investigated. Indeed, sustainable development is any development that serves to save nature without harming social cohesion or, in another sense, a development that respects human beings without sacrificing their environment.

Secondly, many traffic-related problems in the delivery of goods, such as traffic congestion and road safety problems, must be dealt with. The consideration of these conditions provides traffic relief and further reduces the emissions generated by freight transport [148]. It is therefore important to study the implementation of horizontal collaboration, taking into account these traffic conditions. This allows for an optimal and more realistic implementation.

Thirdly, some studies have shown the importance of introducing multimodal transport (rail, road, and sea) to further improve the performance of horizontal collaboration. According to [26], joint transport by road and rail is an effective way to reduce CO_2 emissions. It is, therefore, necessary to deepen these studies by analyzing other sustainability indicators than costs and emissions generated by transport.

Fourthly, the introduction of uncertainty is not sufficiently studied. This issue can be examined in the three decision levels. Indeed, the majority of the studies analyzed present models based on deterministic parameters (demand, unit costs, etc.). This helps provide useful information but can be relaxed to focus on more realistic situations. Indeed, long-term strategic decisions, such as the location of hub facilities, must be taken under conditions of high uncertainty about the future conditions of the relevant parameters (i.e., costs, demands, and distances) that affect the performance of the distribution networks. In addition, model parameter uncertainty can be achieved by integrating artificial intelligence, such as artificial neural networks, to predict the values of uncertain parameters based on their evolution.

Fifthly, the cost-sharing problem is one of the main factors that can block the success and continuity of the collaboration. Therefore, even before participating in such a practice, it is essential to find an equitable approach to cost sharing. In this sense, the approaches based on cooperative game theory are the best approaches applied for this kind of problem. However, they are not very effective when dealing with larger problems [20]. Therefore, it is interesting to propose meta-heuristics to share the benefits of collaboration. Moreover, none of the existing approaches verify all properties: Pareto efficiency, Individual Rationality, Stability, Additivity, etc. For this reason, we suggest that researchers jointly have to solve the cost-sharing problem with the other problems that require identifying the savings allocated to each partner better.

Sixthly, it is very important to examine the cost-sharing problem deeply by integrating the participation of each partner in sustainability. This was the objective of the study conducted by Mrabti et al. [74], who proposed a new metric to reward the most flexible and sustainable partners. Indeed, this rewards partners for their participation in sustainability and encourages them to improve their performance and relax their delivery terms. In this sense, it is important to further analyze the impact of flexibility on the performance of horizontal collaboration by evaluating the sustainability indicators.

Seventh, it is recommended to deal with the collaborative DNDP by taking into account the risks of installation at such a location and/or the preferences of each partner (probability of disaster, unsecured location, proximity, transportation and connectivity, telecommunications around warehouse location, land cost, taxes, etc.). This allows for getting closer to reality, managing incidents well, and avoiding conflicts between partners since each one will put their preferences.

Eighth, it is worth noting that trust between partners is a key factor that determines the success of a horizontal collaboration. Thus, some researchers highlighted the role of a trusted third party to supervise and manage collaboration. It is also interesting to conduct an empirical study on the possibility of introducing block-chain technology to ensure excellent coordination between partners, which eliminates third parties, provides real-time traceability and ensures a secure exchange of monetary values and information. The impact of this technology will be remarkable in terms of sustainability. Economically, transparency allows for excellent resource management by reducing waste and, therefore, distribution costs. Environmentally, it reduces CO_2 emissions due to unsustainable practices. This is possible by identifying the vehicles that emit the highest quantities of CO_2 emissions. On a social level, thanks to traceability, block-chain allows fighting against companies that violate working time limits, underage labor, and inhumane working conditions [149].

6. Conclusions

In the last decades, horizontal collaboration has gained great importance in maintaining business competitiveness. It has become a necessity rather than an option for some companies after the COVID-19 crisis and its bad effects on the economic sector. From the analysis presented in this paper, we may deduce that, in the future, the collaboration will play a key role in meeting logistics needs. The contributions in this paper are multiple. Firstly, we presented the main practices used in horizontal collaboration and identified questions that should be answered in order to provide researchers and companies with useful information on this issue. Secondly, we reviewed recent papers on horizontal collaboration. The experimental, empirical, and literature studies were analyzed in depth to draw several conclusions and propose suggestions for researchers and companies. The comprehensive analysis of the experimental studies according to the three levels of decision allowed us to identify the sustainability indicators evaluated according to each level: strategic, tactical, and operational. It also allowed us to identify gaps in the literature in detail. Thirdly, factors that may prevent the success and continuity of such a collaborative project were identified. Fourthly, solutions that can further improve the performance of collaboration in terms of sustainability (e.g., the relaxation of delivery conditions, the use of a heterogeneous fleet of vehicles, the size of the collaboration, etc.) were also presented. As a result, we have shown that the majority of researchers are interested in the operational decision level and, more specifically, in the transportation planning problem. Researchers have also started to give more attention to the strategic decision level, especially to the collaborative distribution network design problem. The most discussed problem in the literature is that of cost sharing. From a sustainability point of view, the economic dimension is the one most evaluated by logistics costs. To a lesser extent, researchers have started to give more attention to the other two dimensions, in particular, the environmental dimension, through the evaluation of CO_2 emissions. Nevertheless, researchers need to pay more attention to the social dimension that directly affects citizens. This study provides a good basis for researchers, not only for what has been performed but also for what has been suggested. Industrially, this study is a guide for logistics actors who wish to engage in collaboration, helping them to choose the practice to implement and anticipate the factors that may block its success. The main limitation of our study is that it was possible to use other criteria for analysis, namely: the number of citations, the network of citations and co-citations, and keywords. On the industrial side, a detailed analysis of industrial projects where horizontal collaboration has been implemented is missing. It has been reported in this paper that collaborative projects have been very successful, especially in terms of logistics costs, CO_2 emissions and service rates, etc. However, a thorough analysis of the feedback is needed from the industries. This will encourage those who have not yet been convinced of the importance of collaboration. We, therefore, encourage researchers to address these limitations.

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