Supply Chain Coopetition:

A simulation model to explore competitive advantages in logistics

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SUBMITTED TO THE PROGRAM IN SUPPLY CHAIN MANAGEMENT
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF APPLIED SCIENCEIN SUPPLY CHAIN MANAGEMENT

AT THE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

May 2020

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ABSTRACT

Supply chains continuously face pressure to increase efficiency and differentiation to support business continuity. A not yet fully explored way to face this challenge is coopetition, where two competitor companies decide to partner on specific functions to get benefits and differentiate themselves from other companies. This project uses data from two world-renowned food manufacturing companies in Brazil as a case study to evaluate the quantitative benefits of the coopetition approach in terms of transportation cost, CO_2 emissions, and service level. Using a simulation model, this study demonstrates that the supply chain coopetition can drive importantbusiness advantages. This research also shows that if companies adhere to the coopetition approach without implementing collaborative policies, the overall costs, CO_2 emissions, and service level benefits are approximately around 5%, which may not be enough to motivate the companies to get onboard. Therefore, the study proposes policies that can leverage the reduction of outbound transportation costs up to 25%, the decreasesin average lead time up to 10%, and the drop in total CO_2 emissions up to 23%.

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ACKNOWLEDGMENTS

We would like to thank our advisor, Dr. Cansu Tayaksi, for providing guidance and support throughout this project. Also, we would like to thank Dr. Maria Jesus Saenz and Dr. Josué C. Velázquez Martínez, who generously provided feedback, suggestions, and guidance. Next, we want to thank Pamela Siska for reviewing our reports and providing detailed feedback on areas for improvement. Lastly, we both would like to thank our wives, for always being supportive throughout our master's program.

Tarso Melo & Henrique Pedreira

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1 INTRODUCTION

Supply chains have been facing pressure to continuously increase efficiency or differentiation in operations to support businesses. A broadly adopted initiative to overcome that pressureis supply chain collaboration.

Supply chain collaboration is an initiative of two or more companies sharing part of or their whole supply chain operations with one another, aiming to achieve substantial benefits and advantages in return.A large number of companies have implemented collaborative relationships with their suppliers targeting transaction costs reduction and competitive advantages, such as Hewlett–Packard, IBM, Dell, and Procter & Gamble. Furthermore, collaborative relationships can allow the partners to share risks, access strategic resources, reduce costs, enhance profit performance, and competitive advantage over time (Cao & Zhang, 2011).

1.1 Motivation

A more specific approach inside the supply chain collaboration initiative is the horizontal logistics collaboration, which is the collaboration among two or more independent companies operating at the same level of the supply chain, or echelon(Saenz, Ubaghs, & Cuevas, 2014).The horizontal logistics collaboration has the potential to help partners lower distribution costs, improve customer service, reduce environmental impact, and improve delivery flexibility.

Horizontal logistics collaboration is widespread in industry.Nestlé, Colgate Palmolive, and Mondelez have partnered using horizontal collaboration by sharing transportation networks, as have Mars, United Biscuits, Saupiquet, and Wrigley by sharing warehouse deliveries (Sheffi, Saenz, Rivera, & Gligor, 2019).Furthermore, a third example of partnership between Nestlé, PepsiCo, STEF (a logistics service provider),and TRI-VIZOR (a neutral trustee) uses horizontal logistics collaboration, resulting in savings of up to 15% in transport costs and reduction in CO_2 emissions.

Narrowing down the horizontal logistics collaboration, there is a more specific type of relationship known as logistics coopetition.Coopetition is defined as the simultaneous pursuit of cooperation and competition between firms (Brandenburger & Nalebuff, 1996). It is a new way of adding value to the chain, and this aspect has motivated its discussions and implementation in the last three decades. But why would enterprises partner with their competitors?

The returnsgotten from horizontal logistics collaboration varies depending on the type of operation and the synergy of the involved companies. Competitors are defined as any person or entity which is a rival of another;moreover, in business, it is any company in the same industry or a similar industry that offers a similar product or service. Intending to reach the same target customers, competitors build their downstream supply chain to deliversimilar productsat the same or very close places; therefore, the greater returns from a horizontal logistics collaboration come from the partnering between competitors; thus, logistics coopetition.

Although support for this new kind of relationship among companies has become typical, coopetition contracts are still rarely seen in the supply chain area, where working side by side with competitors still seems to be a strong paradigm.This project uses the data from two world-renowned food manufacturing companies in the marketin terms of their logistics operation in Brazil as a case to support the high potential returns of the coopetition approach. Although these companies are publicly known for their rivalry, they took the first step in order to understand whether a co-distribution between competitors would benefit both companies. Using the data delivered by both companies, the study sheds light on the coopetition practice in supply chain, not only proving that it is feasible and advantageous for all parts but also developing a list of potential initiatives that can leverage the benefits in terms of transportation cost, CO_2 emissions, and service level.

1.2 The Case Background

Both companies interested in understanding the benefits and risks of the logistics coopetition are important global food manufacturer players. As a pilot study, this research uses all the data from delivered customers' ordersin the companies' Brazil's operations, a very promising market.

Brazil plays a significant role in the global food and beverage industry by representing 1,78% of all food produced and commercialized in the world (Anderson, 2020). By the end of 2018, Brazil was the world's greatest orange juice producer and supplier, as well as the largest exporter and the second-largest global producer of chicken and beef (EMIS Insights Industry Report, 2019).On the one hand, Brazil is a BRICS member, a fast-growing country trading a large part of the world's commodities; on the other hand, the high operational costs in a very price-sensitive market prevent Brazil from taking advantage of this opportunity.

Supply chain challenges affect the costs in the local market negatively. A few examples are the lack of logistics infrastructure and modal options, local current inflation, high labor rates, complex tax rules for different states and counties, new regulations, fuel and energy rising costs. While other continent-sized countries, such as the US, spent around 1.8% of their GDP on transport services costs in 2016(MarketLine, Transportation Services Industry Profile: United States, 2017), Brazil spent 3.4% of its gross domestic product on it at the same year(MarketLine, Transportation Services Industry Profile: Brazil, 2017).In addition, Brazil's market is highly sensitive to pricing, as 90% of Brazilians earn less than US$ 1,136 per month as Professor Fernando Nogueira da Costa of Unicamp University stated in his 2017 article(Costa, 2017). This poorly distributed income flattens consumption, causing the large market of 210 million people to shrink for major high-quality consumer goods.As a consequence, these challenges produce high transportation cost, high business risks and reduce the supply chain response speed of the local companies.

This challenging scenario demands that companies plan and implement bold strategies to bring efficiency so that theycan better compete in the global market.Supporting companies increating efficiency, the objective of this research is to examine the “size of the prize” for implementing a logistics coopetition approach as an innovative way to acquire competitive advantages.

1.3 Objective

Although the coopetition has being discussed for decades, the “peace or war” paradigm still prevents companies to step into the bold strategic move of implementing it; thus, the coopetition in the supply chain seem to beeven a rarer activity, with only a very few observed cases.

The purpose of the research is to define the benefits of the coopetition in the supply chain by presenting aframework for companies to evaluate the benefits of using this approach; thus,inspiring them to move towardsthe implementation of this strategy.

Althoughthe logistics cooperation with the competitor may return great benefits and provide advantages to the involved companies, it can also expose those companies to managerial implications and operational risks.In an attempt to avoid these risks,many companies stay away from the competition’s partnerships. However, the only strategy guaranteed to fail in the volatile, uncertain, complex, and ambiguous(VUCA) world is not taking risks; thus, not taking risks is the biggest risk.Due to this thought, this research includes a discussion of the risks involved, as well as strategiesto mitigate these risks.

1.4 Research Question

What are the potential advantages of adopting a coopetition approach in the supply chain? This research answers that questionto helpcompanies to overcome the challenges of breaking the coopetition paradigm to create a responsive, sustainable, and cost-effective supply chain.

2 LITERATURE REVIEW

The global market has evolved into a competition system "where the advantage goes to those organizations which can better structure, coordinate and manage the relationships with their partners in a network committed to better, closer and more agile relationships with their final customers"(Martin & Towill, 2000). Focusing on either vertical or horizontal supply chain dimensions can help to achieve this goal. On the one hand, the vertical dimension drives partners within each supply tier to share information and goals, synchronizing the chain more efficiently. On the other hand, the horizontal dimension partnership allows different companies with similar supply chains, similar products hence similar suppliers and similar point of deliveries, to join their chain and reach a high level of synergy. The horizontal dimension of a supply chain, which has attracted less study than the traditional vertical focus. Thus, this research evaluates the benefit of competitor industries sharing their logistics network in a horizontal collaborative approach, or a coopetition approach, once they are competitors.

2.1 Logistics Horizontal Collaboration

Collaboration is the action of working with someone to produce or create something;a collaborative supply chain "simply means that two or more independent companies work jointly to plan and execute supply chain operations with greater success than when acting in isolation" (Simatupang & Sridharan, 2002). In an attempt to overcome the pressure toincrease efficiency in operations continuously and to build more responsive supply chains, companies have looked to collaborative opportunities outside the organization, such as logistics collaboration, which can provide advantages to the involved partners(Cao & Zhang, 2011). Such collaboration can be divided into two types: horizontal and vertical (Gonzalez-Feliu, Morana, Grau, & Ma, 2013).Represented the yellow blocks in Figure 1, the vertical collaboration can involve the company, its suppliers, and its customers. Also, the horizontal collaboration in this Figure is represented in blue, and it can include the company, and other companies in the same echelon of the supply chain, competitors, or not.

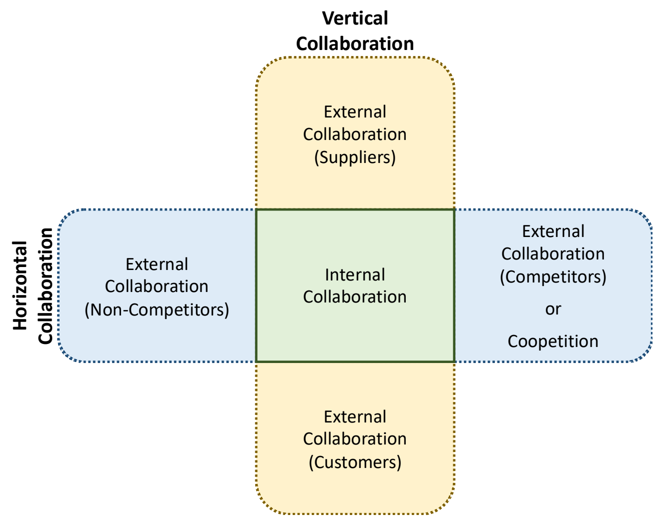

Figure 1. Forms of collaboration (adapted from Saenz, Ubaghs, & Cuevas, 2014)

Classified as horizontal is the collaboration between two or more companies with distinct supply chains but similar needs, acting on the same levels of the chain(Gonzalez-Feliu et al., 2013).Narrowing the definition to logistics, horizontal collaboration is identified asa partnership of two or more transport carriers, distribution companies (for example wholesalers), or retailers(Gonzalez-Feliu et al., 2013).

On the one hand, there is an antagonism in the collaboration between companies due to relationship conflicts(Simatupang & Sridharan, 2002); on the other hand, there are benefits for all stakeholders. The autonomous behavior of companies sometimes leads to self-oriented decisions, which can impede members from improving the overall supply chain performance(Simatupang et al., 2002). It is important to highlight that the existence of conflicts in the relationship in a supply chain collaboration does not necessarily means dysfunctional outcomes; Therefore,as conflicts are part of the relationship, theyneed to be managed in a constructive way, by identifying the source and deploying interventions(Simatupang et al., 2002). The overall goal and its benefits must be well set, and it can support overcome the managerial implications. The horizontal logistics collaboration can benefit all parties: in terms of efficiency by intelligent freight combinations; in terms of effectiveness by incremental delivery frequencies and service level; in terms of sustainability by CO_2 emissions reduction; and in terms of risks by sharing among the partners (Saenz et al., 2014).

A survey among five senior executives from three different industries revealed the most important motivation for companies to apply logistics horizontal collaboration: Cost reduction; Allowing easier response to demand fluctuations; Improving the service level; Improving the vehicle fill utilization; Lowering carbon emissions; And accessing new markets (Saenz et al., 2014).The main barriers found by these companies when initiating horizontal collaboration are the following, ordered from the highest impact to the lowest: Organizational culture; Lack of trust; Difficulty finding collaborators; Lack of common processes; Competitors acquiring information; Difficulty agreeing to horizontal collaboration terms; Difficulty distributing the benefits in a balanced manner (Saenz et al., 2014). Addressing these barriers is the recommended way to make horizontal collaboration between companies feasible and sustainable.

2.2 Logistics Coopetition

Coopetition is the agglutination of co-operation and competition. It is a business method that combines seemingly opposite approaches. Since business is neither pure war nor peace, the best approach for a company is to defeat competitors in some cases; in others, it is best to adopt a plan that benefits several stakeholders(Brandenburger & Nalebuff, 1996). However, what circumstances led to the practice of coopetition?

Coopetition should be established when companies seek to secure access to resources or capabilities they do not have, without having to invest in its development due to it is potentially expensive or time-consuming(Wood, 2012). However, coopetition imposes some challenges due to its dual nature that must be considered during its implementation. While being close collaborators in certain domains, the partners are simultaneously competing against each other in other fields. Wood(2012) proposes that due to mitigating this dichotomy, the agreement between all stakeholders involved must be well defined, the parts must overcome the cultural rivalry and ensure that additional value created is shared among them. The fairly sharing of the value created among all parts is one of the main challenges;Thus, operational controls must be created to support the coordination of the activities as agreed, as well as to suppress potentially damaging opportunistic behavior. Logistics cooperation must secure agreed benefits for the parts, not only at its implementation phase, but also during all its existence (Daidj, 2017). The coopetition approach loses its mutual advantage purpose if one of members of this deal uses it to acquire any competitive advantage over the other; therefore, this is an important risk to be evaluated and mitigated in the project, implementation, operation and termination phases.

Once the challenges are overcome, the value created by the coopetitive endeavor must support strategic advantages for the parts. For a supply chain point of view, these advantages could be everything from gaining performance and service level to lower costs and carbon dioxide emission. (Sepehri & Fayazbakhsh, 2011) support the benefit of coopetitive relationship by performing a quantitative examination of a large number of random cases under different cooperation policies. They conclude that the overall supply chain benefits from higher cooperation, looking at the average members' results.

2.3 Methods for assessing the benefits of logistics coopetition

A comprehensive literature review conducted by Sheffi et al.2019 about horizontal collaboration presented various case studies where this practice drove lower logistics costs, reduction of CO_2 emissions, and improved service levels. However, as mentioned in limitations and further research, there is still room for testing those prepositions. Thus, our work adds quantitative analysis to this field of study.

According toDe Brito, Carbone, and Blanquart(2008), to succeed in the collaborative approach, it is essential to utilize a method that estimates the benefits for each participant and makes possible a comparison of the solutions for all the different stakeholders. Adding to this idea,Gonzalez-Feliu et al.(2013)states that it is necessary to have a common evaluation method based on a unique decision function to get consensus among the participant companies. We defined and agreed with all stakeholders a collective decision function representing the current performance metrics of each company. Thus, this function was assessed by a simulation model to evaluate the impact of collaborative scenarios.

Simulation models help understand how systems behave over time and to compare their performance under different scenarios (Sweetser, 1999). Additionally, simulation modeling is described as a mathematical depiction of a problem, with problems solved for various alternatives and solutions compared for decision making, drawing insights, testing hypotheses, and making inferences (Keebler, 2010). Consequently, the simulation tool best fits the answer to our research question.

According toTakoand Robinson(2015), the most common simulation techniques are Discrete Events Simulation (DES) and System Dynamics (DS), and they are widely used to model logistics and supply chain management problems. Comparing both techniques, DES models systems as queues and activities in a network where changes in state occur at discrete points of time, whereas SD models represent a system as a set of stocks and flows where the state changes occur continuously over time. In DES, entities are represented individually, and specific attributes are assigned to each entity, which determines what happens to them throughout the simulation. In contrast, in SD, individual entities are not specifically modeled, but in their place, they are represented as a continuous quantity in a stock (Brailsford & Hilton, 2001). Also,Takoand Robinson(2015) conducted a literature review to map the utilization of each simulation technique in specific Supply Chain Management problem types. Considering that our project is a mix of Distribution and Transportation Planning (DTP) and Dispatching

Rules (DR), DES were the method utilized in 95% of the related analyzed works. Therefore, considering SD and DES specific characteristics and the predominance of DES modeling in similar problems, we choose DES as our base tool for modeling and simulating the coopetition approach.

Finally, in order to have a clear and concise structure, this work is based in the eight-step simulation model development process for the design, implementation, and evaluation of logistics and supply chain proposed inManuj, Mentzer, and Bowers(2009). Following this approach, the methodology chapter of this study begins with the problem formulation, where the model objective is precisely stated and agreed upon with the stakeholders. The second step is the identification of the independent and dependent variables. In sequence, the third step is the development and validation of the conceptual model where assumptions, algorithms, and model components are validated with experts from both companies involved. The fourth step is the data collection, cleaning, preparation, and validation. The fifth step is the development of the computer-based model. The sixth step is the validation of the model with subject matter experts from both companies through a structured model walk-through and a reasonableness check of the results. The seventh step is the simulation run of the baseline and additional scenarios. Finally, the last step is the analysis and documentation of the results.

2.4 Prize size measurements

Logistics costs and service level are two widely used measurements in the supply chain field, as every company accountsfor spending and how well they provide the product or service to their customers. In theCPG logistics coopetition case addressed in this study, both companies usetransportation cost to serve and on-time delivery to track their operations; thus, this research can use these data as aneffective way to measure the size of the prize. Transportation cost isthe sum of the total freight paid to carriers to delivercustomers’ orders, while on-time delivery is the order’s lead time, which is the difference between the order’s delivery date and the order’s entry datemeasured in days.

Furthermore, this project adds a third measurement to size the prize not used in either sponsor company: the CO_2 emissions; Therefore, this paper contains the dedicated next session to explain the reason for choosing this additional measurement and the specific metric used in the calculations.

2.4.1 Carbon footprint for the logistics

Sustainability, a concept that once was solely environmentally oriented, is now supported by three main pillars: economic, environmental, and social sustainability. The BrundtlandCommissionclassified asustainable development as a “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”(Carter & Rogers, 2008, p. 363). But why should companies pay attention to it?

First, social consciousness has been more alert tothe negative environmental and social impacts of industrial activities thanbefore, indicating that sustainability can drive consumer demand. Second, studies such as Carvalho, Matos, and Gani(2013) announce a coming point-of-no-return for climate change, resource depletion, and human health problems as a result of industrial activities.In response, governments around the world have issued regulations concerning sustainability in the last few decades. The European Commission leads the world’s commitment to these matters, declaring that “Sustainable development remains a fundamental objective of the European Union under the Lisbon Treaty”(Mota, Gomes, Carvalho, & Barbosa-Povoa, 2015). Consequently, this Commission created a sustainable development strategy, as well as a broad range of policies, which continue to be updated (Mota et al., 2015), constraining industrial activities more and more.Therefore, sooner or later, either consumer demand, or regulations, or potential shareholders, or cost savingswill pressure major companies to look at their entire supply chainsfrom an intentional perspective in order to become more sustainable.

In terms of sustainability, there is a strong connection between supply chain operations and environmental impacts.The International Energy Agency estimates that 19% of global energy usage and

23% of energy-related carbon dioxide emissions are directly associated with transport activities (Bouchery, Corbett, Fransoo, & Tan, 2017). In fact, anenvironmentalproblem is a supply chain problem. For these reasons, companies often use carbon footprint to measure their environmental impacts and this study also uses carbon footprint as the third prize size measurement.

The GHG Protocol (GHG Protocol, 2013) is aguideline used in many existing methods of measuringcarbon footprint.The GHG Protocol classifies three layers for carbon footprint measurement: organization, value chain, and product carbon footprint. Anorganization's carbon footprint accounts for emissions from all owned asset activities, which includes building energy use, industrial processes, and the company's owned vehicles.The corporate value chain carbon footprint adds, on the top of that,the emissions from outside the organization's owned operations, both suppliers' and consumers' emissions, through product use emissions to end-of-life emissions.The product's carbon footprint encompasses the emissions over the whole life cycle of a given unit of product or service, from the extraction of raw materials and manufacturing to use and final reuse, recycling, or disposal(Bouchery et al., 2017).

Moreover, the GHG Protocol (GHG Protocol, 2013)divides the corporate value chain carbon footprint into 3 scopes: Scope 1 is the direct carbon emissions from assets owned or controlled by the company; Scope 2 is the indirect emissions occurringfrom the generation of purchased or acquired electricity, steam, heating, or cooling consumed by the reporting company; Scope 3 is all other upstream and downstream indirect carbon emissions as a consequence of the company's activities occurringfrom sources owned or controlled by other entities in the value chain (e.g., materials suppliers, third-party logistics providers, waste management suppliers, travel suppliers, lessees and lessors, franchisees, retailers, employees, and customers).Neither company in the studied CPG case has its own fleet;thus, both companies hire carriers to deliver their orders, so the CO_2 emission calculated for this research is the downstream scope 3 of the corporate value chain carbon footprint.

After defining what to measure, the next question is how to measure. There are several carbon footprint measurement methods. They are grouped by the level of extrapolation involved,from the most direct actual greenhouse gas (GHG) emission measurement to a methodology relying heavily on extrapolation. The four types are direct measurement, energy-based calculations, activity-based calculations, and economic input-output life-cycle assessment (EIO-LCA).Because both companies in the studied CPG case hire carriers to deliver their orders, the companies do not have a way to obtain the information needed to calculate the carbon emissions using direct measurement orenergy-based calculations. Therefore, this research uses activity-based calculations, taking into consideration the delivery information and predefined activity-based conversion factors. Thisactivity-based calculation employs the Network for Transport and Environment program (NTM, 2015), which accounts for different sizes of vehicles, percent loaded, road type, and driving conditions to propose the conversion factor and calculate the amount of CO_2 equivalent emissions.

3 METHODOLOGY

The eight-step model development process proposed in Manuj et al. (2009)(see Figure 2) provides a sound framework for discrete-event simulation research: formulate the problem, specify variables, develop and validate conceptual model, collect data, develop the computer-based model, validate the model, perform simulation, and analyze results.

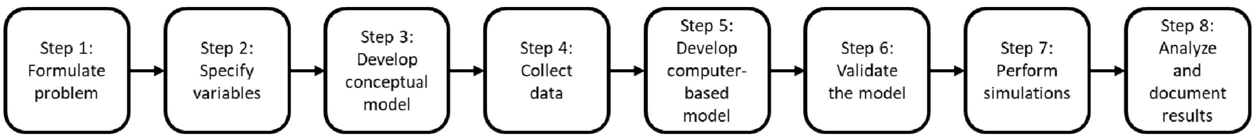

Figure 2. Eight-step model development proposed InManuj, Mentzer, and Bowers (2009)

3.1 Problem Formulation

The project evaluates the benefits for competitor companies in sharing their outbound distribution networks. Thus, we developed a discrete event simulation model, and scenarios of companies' standalone performance were compared toscenarios in which they share the same distribution network. All the analyses comprise transportation costs, service level, and CO_2 emissions: the three most important dimensions in the outbound operation of both sponsoring companies. Furthermore, the performance metrics, the scope of the model, the time frame, and the resources required were agreed upon with the companies.

3.2 Independent and dependent variables specification

An essential part of building a simulation model is to define all dependent and independent variables to be used. In essence, the outcome of the study depends on what is input into it. The dependent variables for the outbound distribution, as stated in the problem formulation, are transportation cost, service level, and CO_2 emissions. Moreover, all factors that influence the answers sought should be included as independent variables.

Costis defined as the sum of the total outbound incurred transportation cost of delivering customers' orders. Four independent variables have a direct impact on it:

- The type of carrier contract (Full Truck Load or Less than Truck Load as commonly defined FTL and LTL, respectively).
- The size of the vehicle used for FTL, as assets with different sizes, have different fixed and variable costs (seeFigure 3).
- The LTL freight ranges negotiated with carriers, as smaller deliveries incur higher costs per metric ton.
- The total distance traveled in kilometers, because the farther the vehicle travels, the more carriers spend on fuel, tires, maintenance, and others.

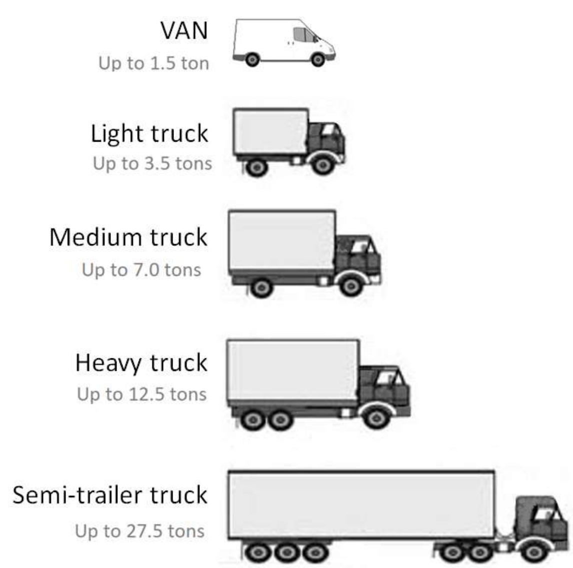

Figure 3. FTL vehicle sizes

Service level is agreed upon with all parties involved as the order's lead time, which is the difference (measured in days) between the order's delivery date and the order entry date. Furthermore, this dependent variable has two independent variables:

- The type of carrier contract selected (LTL or FTL), since LTL frequently demands consolidation and cross-docking operations.
- The total distance traveled in kilometers, because the farther the vehicle travel, the more time it takes.

Carbon dioxide emission, the last dependent variable, is measured by metric tons of CO_2 molecules dispersed into the atmosphere. The framework for calculations is the NTM - Network for Transport and Environment method (NTM, 2015). Moreover, three independent variables influence it:

- The type of vehicle used, as assets with different sizes, has different engines and weights (seeFigure 3).
- The total load of the shipment.
- The total distance traveled in kilometers, because the farther the vehicle travel, the more CO_2 it emits.

Both dependent and independent variables were validated with subject matter experts from the sponsoring companies to guarantee the consistency and enable the conceptual model development.

3.3 Conceptual model development and validation

The conceptual model was designed according to the outboundtransportation processes of both companies, and information came from personnel interviews where all the related activities and inputs and outputs were mapped (seeFigure 4).

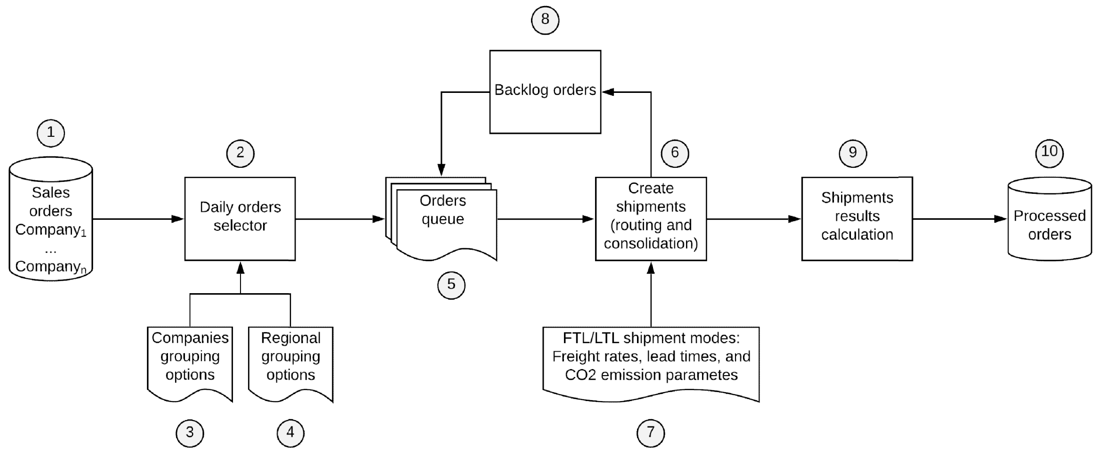

Figure 4. Simulation model structure

Each process or function is numbered and detailed below. The cylinder forms represent databases, the rectangles represent functions, and the rectangles with a wavy base represent a single document or a collection of documents.

(1) Sales orders database

The database consists of one yearof sales orders (2019) of the two companies involved and encompasses the full Brazilian operation. The sales orders carry information regarding customer geographical localization, distribution center of origin, company grouping specifications, delivery date, and size in kilograms. More details about the databases are presented in Section3.4.

(2) Daily orders selector function

This function controls the simulation clock and, for each day, executes a query in the orders database selecting all available orders scheduled to be shipped on that specific day. The selected orders are classified in groups that can be shipped together according to the companies' grouping options and Regional grouping options (see functions 3 and 4) and are stored in the orders queue (see function 5).

(3) Companies grouping options

This parameter is used to set companies'grouping specifications, whether an order can be shipped together with orders from other companies or not. For instance, if an order is set with “G00”, the simulator can consolidate the order with other “G00” orders.

For this study, where two companies are considered, the baseline scenariois set with “G01” for company A orders and “G02” for company B orders, not allowing the simulator to consolidate orders from both companies. In contrast, for the collaborative scenarios, “G00” is set for all orders allowing the simulator to consolidate orders from both companies (see Table 1).

If more than two companies are considered in the simulation, this parameter can define subgroups of companies that can be shipped together. For example, if four companies are considered, it is possible to create a group join orders from companiesA, B, and C but not company D. Therefore, the simulator is permitted to create shipments with orders from the first three companies. However, the orders from company D must be shipped separately.

Table 1. Companies grouping options:

group_ID	group_name	group_description
G00	All	All companies
G01	Only_COMP01	Only Company A
G02	Only_COMP02	Only Company B

(4) Regions grouping options

This parameter defines the physical regions where orders can be consolidated and shipped together. For this study, the Brazilian mesoregion distribution is utilized (seeFigure 5). A mesoregion is a territorial division grouping together various cities in proximity and with common characteristics. The mesoregions were created by the Brazilian Institute of Geography and Statistics (IBGE) and are commonly used for grouping in distribution network strategy.

Figure 5. Mesoregion territorial division

(5) Orders queue

The orders queue function stores groups of orders defined by function threeandmerges them with backlog orders (see function 8), respecting the grouping parameters, that were not shipped in previous periods. All the order groups are sent to the routing and consolidation process (see function 6).

(6) Create shipments (routing and consolidation)

This function creates FTL and FLT shipments for the order groups from the Orders queue, considering the available shipment modes defined in the shipment modes function(see function 7). The threshold for whether an order will be shipped in FTL or LTL considerers the minimum shipment weight of the smaller FTL vehicle available for the region.

For LTL shipments, the simulator selects the less expensive LTL freight rate available for the region that bears the weight and number of drops constraints.

For FTL shipments the simulator utilizes an order grouping heuristic to allocate the orders in the vehicles with minimum cost. The heuristic considers all the vehicle types available in the region and selects the less expensive vehicle that attends the weight and number of drops constraint.

(7) FTL and LTL shipment modes

The FTL and LTL shipment modes function selects, considering the destination region and the origin DC of the orders group, all the transportation options available (see Table 2). The transportation options consist of different vehicle types for FTL (seeFigure 3) and freight rate ranges for LTL.

Every shipment mode has costs, transit time, and CO_2 emission parameters. Costs are defined by fix_cost, the cost per vehicle shipped, stop_cost, the cost per delivery, dist_cost, the cost per distance, wt_cost, the cost per kilogram shipped, and min_cost, a minimum total cost to ship. Transit time is defined in days from the shipment to the delivery. The CO_2 emissions calculation is defined by two parameters, the FC_empty, and FC_full, they represent the fuel consumption in liters for the vehicle type traveling one-kilometerdistance. Also, every shipment mode has restrictions parameters: min_wt.,and max_wt. as the minimum and maximum weight in kilograms that the shipment mode can handle and max_drops as the maximum number of deliveries (see Table 2).

Table 2.Example of shipment modes for a specific region

ID	DC_ID	region	Description	mode	min_wt (kg)	max_wt (kg)	max_drops (stops)	t_time (days)	fix_cost ($)	stop_cost ($/stop)	dist_cost ($/km)	wt_cost ($/kg)	min_cost ($)	FC_empty (l/km)	FC_full (l/km)
T000061	DC001	R0061	FTL1 - Semi	FTL	12500	27500	3	1	0	392.97	4.4684	0	1,916.91	0.268	0.505
T000198	DC001	R0061	FTL2 - Heavy	FTL	7000	12500	4	1	0	325.09	3.4239	0	1,681.50	0.218	0.328
T000275	DC001	R0061	FTL3 - Medium	FTL	4000	7000	5	1	0	306.03	2.8922	0	1,412.46	0.167	0.210
T000294	DC001	R0061	FTL4 - Light	FTL	1500	4000	7	1	0	283.61	2.7270	0	986.48	0.118	0.136
T000302	DC001	R0061	FTL5 - VAN	FTL	200	1500	9	1	0	244.12	2.4353	0	682.13	0.102	0.128
T000361	DC001	R0061	LTL1 (>7000)	LTL	7000	999999	999999	3	0	0	3.7204	0.2715	0	0.218	0.328
T000498	DC001	R0061	LTL2 (4000,7000)	LTL	4000	7000	999999	3	0	0	2.6872	0.3326	0	0.167	0.210
T000635	DC001	R0061	LTL3 (1500,4000)	LTL	1500	4000	999999	3	0	0	1.9844	0.4240	0	0.118	0.136
T000772	DC001	R0061	LTL4 (<1500)	LTL	200	1500	999999	4	0	0	1.5587	0.5140	0	0.102	0.128

(8) Order backlog function

The order backlog function takes every order that was not shipped due to not achieving the minimum shipment size in the routing and consolidation function (see function 6). It sends them back to the order queue function (see function 5).

(9) Shipment results calculation

The shipment results calculation distributes the costs, distances and CO_2 emissions of the shipment to their specific orders. The distribution of the values is proportional to the weight of the orders.

(10) Processed orders database

This database stores information about all the shipped orders for scenario analyses and comparisons. At the end of the simulation, a function creates a CSV (comma-separated values) file with all the order information for further analysis.

3.4 Data gathering and treatment

Once the dependent and independent variables, as well as the conceptual model, are defined, the required datasets can be specified. Each company uploaded from its Enterprise Resource Planning System (ERP) five datasets from January 1to December 31, 2019: customers' orders (15,608 records), outbound shipments (4,301 records), freight cost table (324 records), list of transit times per point of delivery (165 records), and less than truckload and full truckload contract policies (39 records). A detailed description of each dataset is shown below:

- Customers' orders indicate how many kilograms each specific customer is buying, and when and where it must be delivered. This information is relevant to define the daily input of the simulation system.

- Outbound shipments dataset is vital for comparison between the output of the simulation with the actual shipments of the past.
- The updated freight cost table is relevant tothe total cost calculation. For every event unit of the discrete event simulation, the simulation must be able to calculate the cost of the shipment.
- The list of lead time and transit times per point of delivery support the calculation of the customers' deadline for having the product in house. Every customer has a list of lead time agreed with each industry where define how many days from the order's sent date to delivery arrival date. Similarly, every carrier has a list of transit times or the duration between the truckload date and the date of delivery.
- LTL and FTL contract rules are requested not only to categorize the price range of each load but also to make the system able to identify how the order could be organized and thus share the same cargo load.

Appropriate data treatment is as important as the data collection itself. For the simulation, the third normalization of all databases was applied. The third normal form is a method to analyze and refine the structure of data to make it integral and unique, avoiding unnecessary repetition and possible overloads in the database managing. We structured the data to be easily accessed by the computer-based model (see Figure 6).

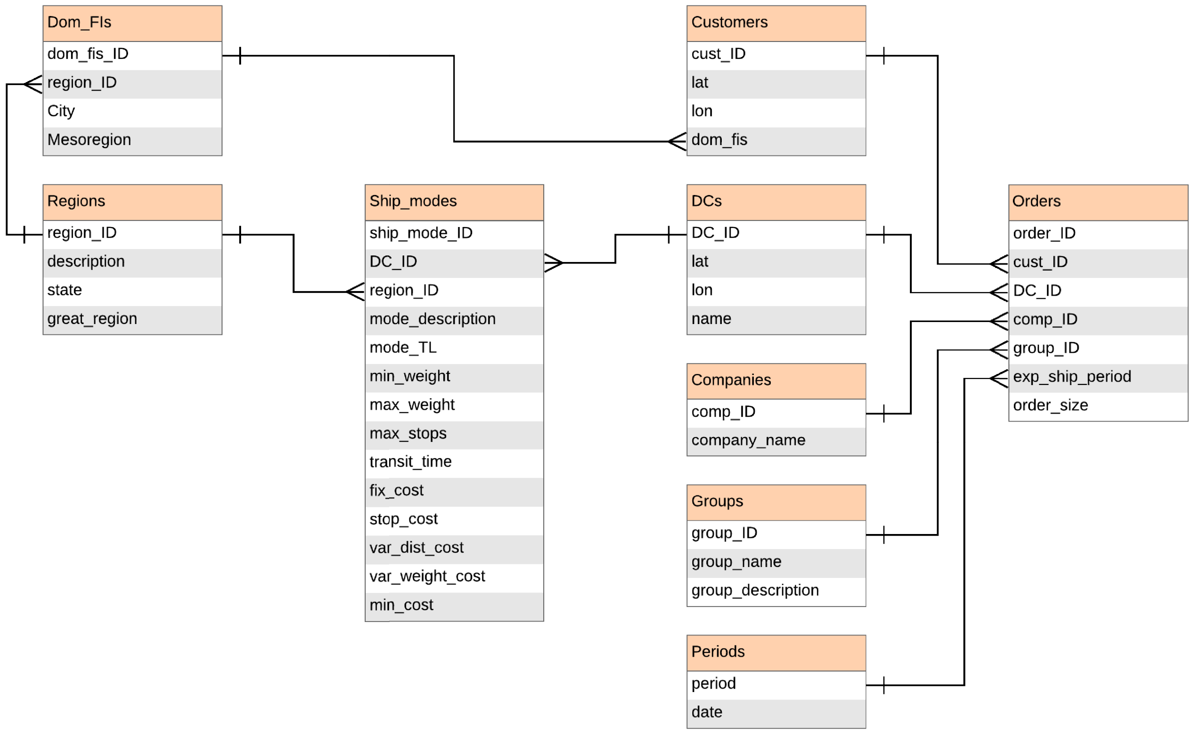

Figure 6. Data structure

The Dom_Fis and Regions tables define the country's regional subdivision. They are utilized by the function 4 "Regions grouping options" of the simulation model (see section 3.3) to group the orders that can be shipped together. The Ship_modes table is the input for the document number 7 "FTL and LTL shipment modes" of the simulation model (see Table 2). The table Groups is described in detail in document 3 "Companies grouping options" of the simulation model (see section 3.3). The Orders table holds all the sales orders from all companies that will be processed in the simulations (see database 1 in section 3.3). Finally, the tables Customers, DCs, Companies, and Periods, contain additional information used for the results analysis (see section 3.8).

3.5 Computer-based model development and verification

Instead of utilizing traditional simulation software, we developed the model with Python[1]language. This decision was made because Python is open source, making it free to use and distribute. Additionally, the language is flexible and allowed the model design to mimic exactly both companies'outbound deliveries planning processes.

We developed the simulation model with object-oriented programing, wheresales order, customer, DC, company, region, delivery, and shipment, were created as interrelated objects. This structure facilitated interaction among the objects and made the code clean and simple. For instance, when calculating shipment costs, it was possible to access and directly modify the delivery and sales orders associated with the shipment.

All the distances were calculated by the haversine formula, which determines the great-circle distance between two points on a sphere given their longitudes and latitudes. The Brazilian circuity factor of 1.23 was multiplied by the haversine to approximate the actual road traveling distances (Ballou, Rahardja, & Sakai, 2002).

During model building, the code was checked by a different person than the one who programmed the function. Moreover, the inputs and outputs of each modelwere compared with ones calculated manually. Finally, short runs of the model were compared with historical data to ensure the model was correctly representing companies' behavior.

3.6 Model Validation

We compared the main results of the scenario "S00 – Baseline" with the historical data provided by both companies. As the model has the objective of being a simplified version of reality, containing not all but

[1]Python is an object-oriented, interpreted, and interactive programming language.

the most impactful factors and process, it was not expected to achieve precisely the same results. However, as shown in Figure 7, the simulation results differ from the historical data in a range of -4% to +4%, which demonstrates a very accurate representation.

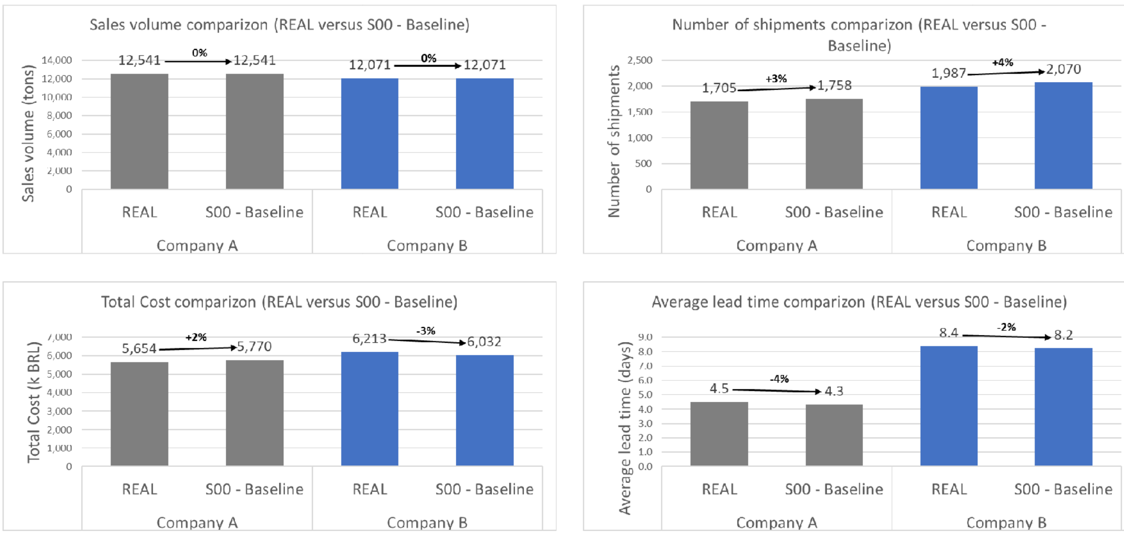

Figure 7. Baseline model validation

Comparing the total volume of the customers' sales orders, the same volume that was processed in the historical database was processed through the model (see Figure 7). Therefore, no sales orders were left behind by the simulationand guaranteed the conservation of flow (same amount of orders in and out of the model).

Additionally, Figure 7 presents the validation of other main results. The number of shipments created by the model differs by +3% for Company A, and -2% for Company B and the total costs differs by +2% for Company A, and -3% for Company B. Those minordifferences inpercentages could indicate that the shipment creation process of Company A is slightly more efficient than the model. Likewise, the shipment creation process of Company B could be minimally less efficient than the model. However,as the differences are not significant, and all the study inferences rely on the comparison of the “S00 – Baseline” scenario with other scenarios of the same model, those differences with the historical data do not jeopardize the study.

3.7 Simulation

In total, we conducted 20 runs of the simulation model (see Table 3). The runs were a combination of four different scenarios and five different subsets of sales orders.This scenario analysisreveals the benefits of the coopetition approach and the impact of possible collaborative policies in leveraging the results (see section 4.2). The subsets are defined to showhow the benefits of the coopetition approach evolve as the companies participating have more similar customers (see section **Error! Reference source not found.**).

The first scenario is the "S00 – Baseline", where all the sales orders from both companies are processed, but the model is not allowed to aggregate orders from both companies in the same shipment (see function 3 of section 3.3). The following three scenarios, "S01 - Simple Collaborative", "S02 - Regional delivery schedule", and "S03 - Customer delivery schedule," are the collaborative scenarios used evaluate the quantitative benefits of the coopetition approach (see section 4.2).

Table 3. Simulation model runs

Simulation model runs				
Run	**Scenario**	**Subset**	**Total weight (tons)**	**Subset representativeness (% total weight)**
01	S00 - Baseline	All customers	24,612	100%
02	S01 - Simple Collaborative			
03	S02 - Regional delivery schedule			
04	S03 - Customer delivery schedule			
05	S00 - Baseline	Orders of shared customers +75% other customers	21,649	88%
06	S01 - Simple Collaborative			
07	S02 - Regional delivery schedule			
08	S03 - Customer delivery schedule			
09	S00 - Baseline	Orders of shared customer +50% other customers	18,687	76%
10	S01 - Simple Collaborative			
11	S02 - Regional delivery schedule			
12	S03 - Customer delivery schedule			
13	S00 - Baseline	Orders of shared customers +25% other customers	15,725	64%
14	S01 - Simple Collaborative			
15	S02 - Regional delivery schedule			
16	S03 - Customer delivery schedule			
17	S00 - Baseline	Only shared customers	12,762	52%
18	S01 - Simple Collaborative			
19	S02 - Regional delivery schedule			
20	S03 - Customer delivery schedule			

The first subset consists of the sales orders from all customers and represents the benefits for the two studied companies. However, to have greater similarity, the second subset considers all the sales orders from the shared customers, the ones that both companies serve, and the sales orders from randomly selected,75% of the other customers. As a result, the representativeness of the shared customers is higher in comparison to the first subset. However, the consequence is that the total volume of the sales orders considered is lower, representing 88% of the total volume. The third subset follows the same structure of the second but considers 50% of the other customers, while the fourth subset considers 25%, and the last subset only considers the sales orders from the shared customers, representing 100% of customer share.

3.8 Methods of Analysis

To analyze the output of the 20 runs of the simulation model, comparing and contrasting results to make aquantitative assessmentof the coopetition approach, we develop an automated analyzing tool with Microsoft Excel. Every run of the Python model generates a .CSV file containing information about the shipment, costs, service level, and CO_2 emission for each sales order. In sequence, the Power Query Excel add-on searches for new files in a specific folder and adds then to a database where results from all runs are stored. Finally, a Pivot table accesses the database with sales orders from every run and execute the analysis and comparisons.

This analysis method allowed us to compare the results of costs, service level, and CO_2 emissions at a granular level, understanding the impacts of the scenarios and policies on each sales order, and therefore, each customer, region, company, shipment mode, and vehicle type. The Chapter 4 presents the findings.

4 RESULTS

This chapter offers the main findings of the study, discussing the quantitative benefits of the coopetition approach are and how it can be leveraged by implementing collaborative policies. Section 4.1 presents the preliminary analysis of the simulation model, where overall data from each company are presented. Section 4.2 describes in detail each scenario we ran, with results and general benefits and implications. Finally, section 4.3 discusses the benefits in-depth and explains their drivers.

4.1 Preliminary analysis

The project utilizes one year of sales orders data from the Brazilian operation of the two competitors CPG companies, denominated in this study as Company A and Company B. The demand volumes and total freight account of both companies are similar (see Figure 8). Although the demand and costs are similar, this is not a pre-requisite for companies to adopt the coopetition approach.

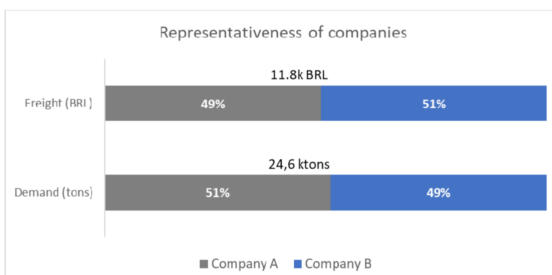

Figure 8. Representativeness of companies

Even thoughboth companies are competing for the same consumer market, Company A works with a more indirect distribution strategy, where big retailers, cash and carry, and wholesalerscustomersare served directly. The small retailers are served through distributors. With this strategy, Company A has a larger average drop-size and serves fewer points of deliveries. On the other side, Company B works with a more direct distribution strategy, where the small retailers are also served from company’s DCs. This strategy generates more deliveries and a smaller average drop size. As a result of this difference in strategy, only 235 of the points of deliveries are served by both companies. However, although the companies differ in the strategy of serving directly small retailers, all the larger customers are shared; therefore, 52% of the total demand of companies residesin shared customers (seeFigure 9).

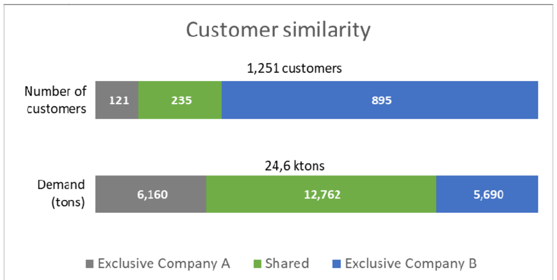

Figure 9. Customer similarity

Besides the customers, due to market standards, both companies have similar agreed regional transit times with carriers and similar policies regarding the minimum weight for shipment. Also, the available FTL vehicle types and the LTL ranges are common, and the freight rates are compatible. Therefore, for the sake of the simulation, the parameters considered in the shipment modes table are the average of both companies' factors.

Finally, the geographical plot of customers shows that there is a combination of regions with customers of only one company, regions with shared customers, and regions with exclusive customers from the two companies (see Figure 10). This diverse profile creates the opportunity to understand the benefits of the coopetition in different regional configurations.

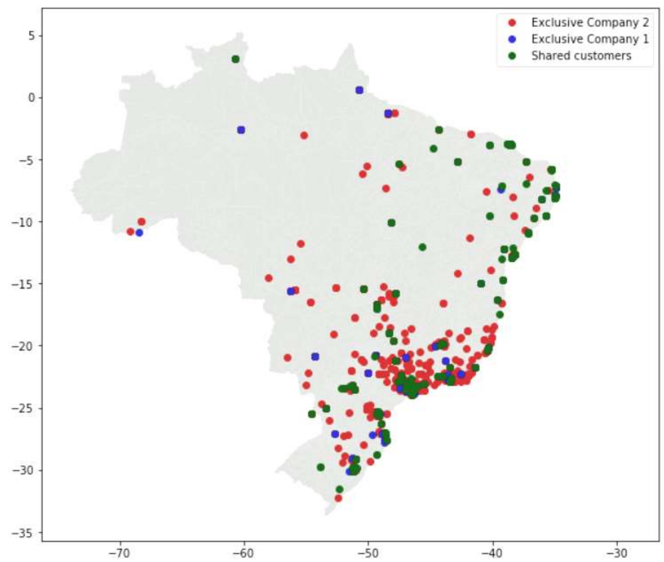

Figure 10. Plot of customers

4.2 Scenarios

To evaluate the impacts on costs, service level, and CO_2 emissions of the coopetition approach, we created four scenarios.In the “S00 – Baseline” scenario, companies’ current performance is calculated to serve as a comparison base for the collaborative scenarios. After that, we ran three collaborative scenarios -- "S01 – Simple collaborative", "S02 – Regional delivery schedule", and "S03 – Customer delivery schedule" -- with different types of coopetition contract alignments to identify the benefits and determine what policies could be implemented in order to leverage the results.

4.2.1 Scenario "S00 - Baseline”

The “S00 – Baseline”scenario runs all the sales orders from both companies without allowing the model to ship deliveries of different companies together. This scenario has two main objectives.First, to validate the model, checking the feasibility of the solution proposed and comparing the results with the historical data from both companies (see section 3.6);second, to serve as a comparison baseline to evaluate the possible improvements generated by each of the collaborative scenarios.

4.2.2 Scenario "S01 – Simple collaborative”

The “S01 – Simple Collaborative” scenario enables the model to ship orders from both companies together. However, as no collaborative policy is implemented, the gains rely only on the coincidence of companies shipping to the same customer or the same region on the same day. Although this scenario presents a 4.2% reduction in costs, a 4.6% reduction in average lead times, and a 3.9% reduction in total CO_2 emissions, the benefits are not impressivebecause the demand coincidence is not frequent and less than one-third of the shipments have sales orders from both companies.

The objective of this scenario is to mimic two companies starting a coopetition contract, but without changing their distribution policies, which is the most common approach but not the most beneficial. Partnering with a direct competitor may bring several managerial implications, and for most companies, benefits of the order of 5% do not justify taking those risks. Thus, it is critical for the success of the coopetition to implement collaborative policies to leverage the benefits. The next two scenarios simulate the impact of companies adopting policies to increase the synergy of their deliveries.

4.2.3 Scenario "S02 – Regional delivery schedule”

Considering the vastness of the Brazilian territory and the non-homogeneously distributed demand, companies tend to define specific weekdays to serve each region. Therefore, they can aggregate demand and drive more efficient shipments. As the definition of the schedules is an individual decision, there is no coordination, and only in 16 out of the 137 mesoregions do both Company A and Company B share precisely the same weekdays. For instance, considering the mesoregion "AGRESTE PERNAMBUCANO" in the countryside of Pernambuco state, Company A delivers every Monday and Wednesday, and Company B delivers every Tuesday and Thursday. As a result, they are sending vehicles to the same region on different days.

The "S02 – Regional delivery schedule" scenario simulates the impact of the implementation of a shared regional delivery schedule, where companies agree to ship to each region on the same weekdays. This agreement is accomplished by analyzing for each mesoregion which weekdays condense the highest demands and defining those days as the collaborative days. In consequence, the sales orders are reprogrammed to the closest collaborative days to possibly be shipped together.

This collaborative policy increases the percentage of shared shipments, shipments that have sales orders from both companies, from 31% in the "S00 – Baseline" scenario to 43% in the "S02 - Regional delivery schedule" scenario. With this improvement, the total costs are reduced by 11.9%, the average lead time is reduced by 5.9%, and the CO_2 total emissions are reduced by 11.4%.

Adjusting regional delivery schedules demands alignment with sales teams and with customers, so it may not be an easy change. However, by comparing the results of the scenario "S01 – Simple collaborative" and the scenario "S02 – Regional delivery schedule" per mesoregion, it is possible to evaluate the specific impact of the regional delivery schedules alignment. So, if both companies adjust only the delivery days of 19 out of the 137 mesoregions, they can get 80% of the total cost reduction. Figure 11 shows a plot of the percentage of the total cost reduction from S01 to S02 on the Y-axis and the number of mesoregions to adjust the delivery schedules on the X-axis.

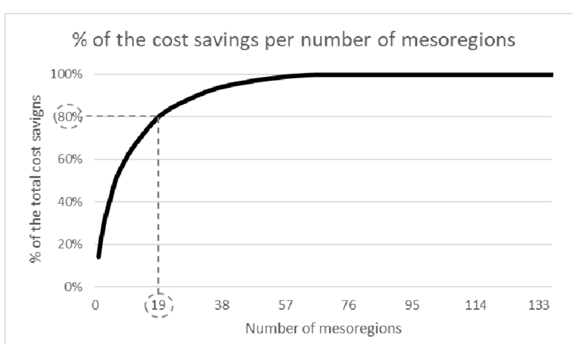

Figure 11. % of cost savings per number of mesoregions

4.2.4 Scenario "S03 – Customer delivery schedule”

As shown in Figure 9, 19% of the customers are served by both companies, and they represent a meaningful 52% of the total demand. However, like the regional schedules, there is no coordination among companies to deliver to the customers on the same weekdays. Company A may deliver to a customer on Mondays with a half-loaded FTL vehicle, and Company B may deliver to the same customer on Tuesdays with another half load FTL vehicle.

The scenario “S03 – Customer delivery schedule”is an improvement of the scenario "S02 – Regional delivery schedule", where companies also agree to book and deliver to their shared customer on the same weekday.The new policy is modeled by checking, for each shared customer, whether it has sales orders to each company programmed to be delivered in the same week. If so, the second sale order is anticipated to match the first sales order delivery date and be delivered together.

This most refined collaborative policy significantly increases the percentage of shared shipments from 43% in the "S02 – Regional delivery schedule" scenario to 57% in the “S03 – Customer delivery schedule” scenario. This improvementdrives cost reductions of 21.4%, average lead time reduction of 8.5%, and total CO_2 emissionreductionsof 19.1%.

Adjusting customers’ delivery schedules requiresalignment with sales teams and with the customers involved, so it may not be an easy change. However, by comparing the results of the scenario "S02 – Regional delivery schedule" and the scenario “S03 – Customer delivery schedule” per customer, it is possible to evaluate the specific impact of the customer delivery schedules alignment. So, if both companies adjust only the delivery days of 65 out of the 235shared customers, they can get 80% of the total cost reduction. Figure 12shows a plot of the percentage of the total cost reduction from S02 to S03on the Y-axis and the number of shared customers to adjust the delivery schedules on the X-axis.

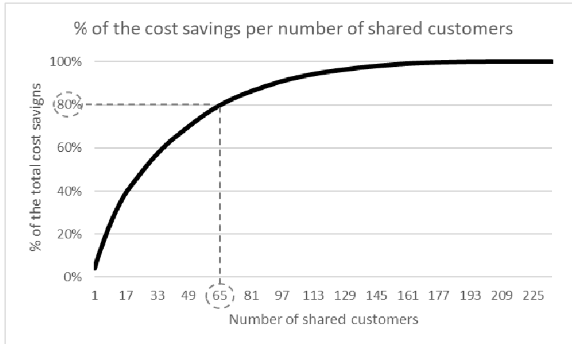

Figure 12. % of cost savings per number of shared customers

4.3 Coopetition benefits and key drivers

As presented in section 4.2, the benefits for companies adopting the coopetition approach without implementing specific collaborative policies are not impressive, ranging from 4 to 5% of reductions in cost, lead times, and CO_2 emissions. Considering the managerial implications related to partnering with a competitor, those results may not be enough to compensate for the risks. However, the results can be significantly leveraged if the companies agree to adjust at least part of their regional and customer delivery schedules.

In terms ofthe outbound transportation costs, the implementation of the competition approach drives an average reduction of 5.5% (see Figure 13). With the implementation of a shared regional delivery schedule, the average cost reduction achieves 14.5%, which may be much more attractive. In addition, if both companies create a process to schedule the deliveries of their shared customers on the same days, the average cost reduction reachesa meaningful 25.5%. In the consumer package goods industry, the transportation costs range from 3% to 10% of the net sales. Therefore, the 25.5% reduction may drive from 0.8% to 2.6% of additional contribution margin, which may be an impactful competitive advantage.

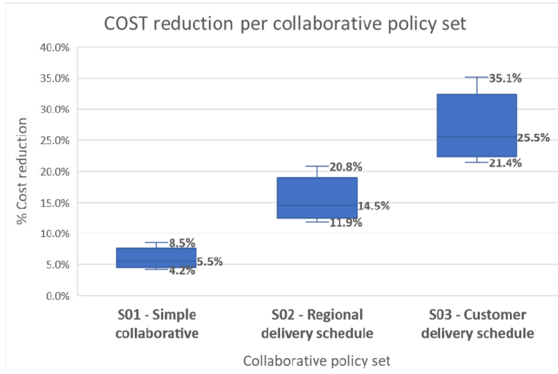

Figure 13. Cost reduction potential per collaborative policy set

In terms of the delivery lead times, the implementation of the competition approach drives an average 5.7% reduction in the average lead times (seeFigure 14). With the implementation of a shared regional delivery schedule, the average lead time reduction reaches7.1%. Moreover, if both companies create a process to schedule the deliveries of their shared customers on the same days, the average lead time reduction goes to a significant9.7%. The reduction of the lead times can generate a value perception among the customers because it helps them reduce their inventory levels and improve their on-shelf availability. Also, for products with low shelf-life, the reduction in lead time increases the number of days that the product can be sold. All these service level benefits may generate more sales volume to the companies, increasing market share and profits.

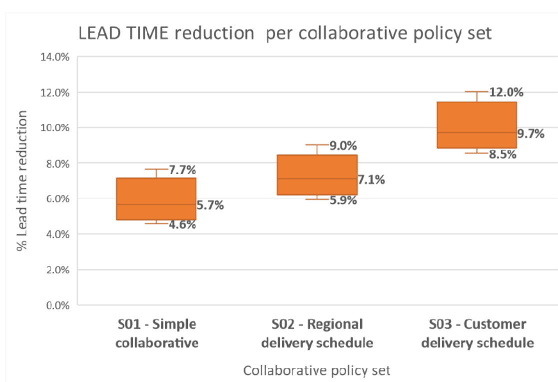

Figure 14. Lead time reduction potential per collaborative policy set

In terms ofthe CO_2 emissions, the implementation of the competition approach drives an average reduction of 5.3% (see Figure 15Figure 14). With the implementation of a shared regional delivery schedule, the average emissions reduction achieves 14.3%. Also, if both companies create a process to schedule the deliveries of their shared customers on the same days, the average emissions reduction goes to a considerable23.4%. A CO_2 emission reduction of this order may radically change the total carbon footprint of the company.

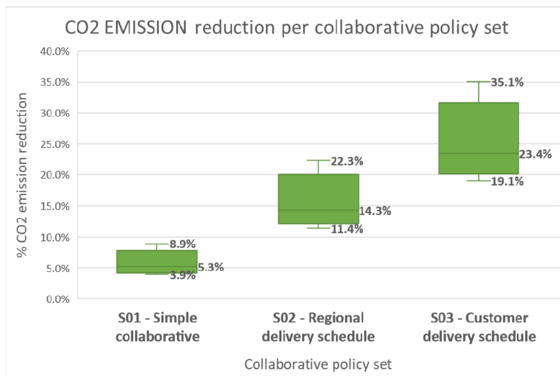

Figure 15. CO_2 emission reduction potential per collaborative policy set

The main driver of cost, service level and CO_2benefitsof the coopetition approach is the increase in the percentage of shared shipments. A shared shipment is a vehicle dispatched with sales orders from both companies. In the “S00 – Baseline” scenario, the percentage of shared shipments is zero because the model is not allowed to aggregate sales orders from both companies. By allowing the model to create shipments together (scenario “S01 – Simple Collaborative”) the percentage goes to 31% and by implementing collaborative policies (scenarios “S02 – Regional delivery schedule” and “S03 – Customer delivery schedule”), as shown in Figure 16, the percentage of shared shipments increases to 57%.

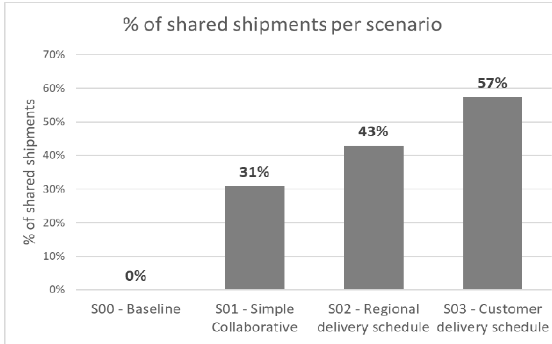

Figure 16. % of shared shipments per scenario

We conducted a set of linear regressions to understand the relations between the dependent variables (cost, average lead time, and CO_2 emission) with the percentage of shared shipments, andwe found a high positive correlation for all three variables. Figure 17presents a linear regression and a scatter plot of the percentage of shared shipments on the X-axis and the percentage cost reduction from each model run to the baseline scenario on the Y-axis. The potential cost reduction can be predicted by the percentage of share shipments with a very accurate R^2 of 0.9421 (in the range of 30% to 100%).

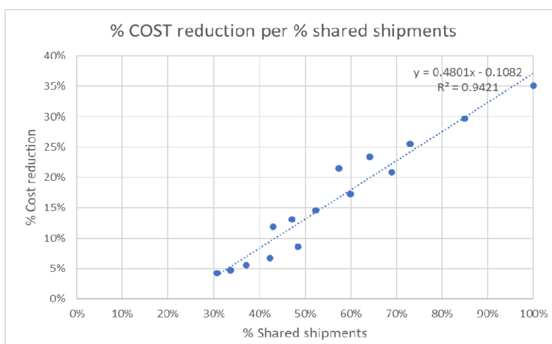

Figure 17. % cost reduction per % of shared shipments

The same cost behavior can be seen in the average lead time. Figure 18 presents a linear regression and a scatter plot of the percentage of shared shipments on the X-axis and the percentage average lead time reduction from each model run to the baseline scenario on the Y-axis. The potential lead time reduction can be predicted by the percentage of share shipments with a very accurate R^2 of 0.9641 (in the range of 30% to 100%).

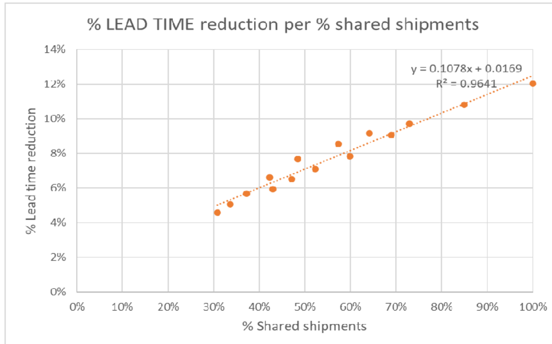

Figure 18. % lead time reduction per % of shared shipments

Finally, the CO_2 emission has the same behavior as costs and lead time. Figure 19 presents a linear regression and a scatter plot of the percentage of shared shipments on the X-axis and the percentage CO_2 emission reduction from each model run to the baseline scenario on the Y-axis. The potential CO_2 reduction can be predicted by the percentage of share shipments with a very accurate R^2 of 0.9683 (in the range of 30% to 100%).

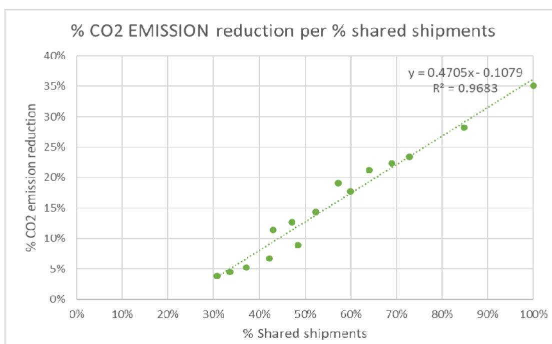

Figure 19. % CO_2 emission reduction per % of shared shipments

The average weight of the shipments increases with the increase in the percentage of shared shipments, causing migration from LTL shipments to FTL shipments. As shown InFigure 20the utilization of FTL shipments increases as more collaborative scenarios are implemented. As the FTL shipments are less expensive, the total costs decrease. Also, the FTL shipments go directly from the origin point to the destination, and therefore, they have a lower transit time compared to LTL shipments, reducing the average lead times. In addition, the FTL shipments are more efficient and generate less CO_2 emissions.

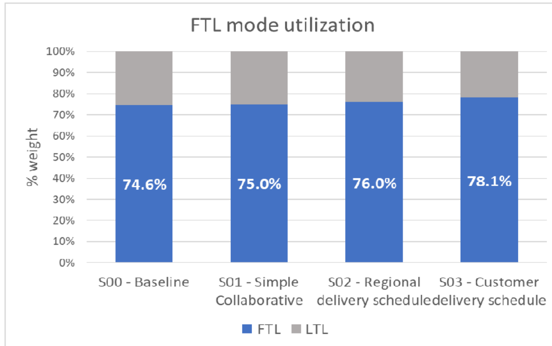

Figure 20. FTL utilization per scenario

Another effect of grouping sales orders from both companies is the increase in the FTL vehicle capacity utilization (see Figure 21). With this type of contract, the shipper pays a fixed amount for the trip independently of the size of the load. So, by increasing the vehicle capacity utilization, the total number of vehicles utilized to ship the sale volume is lower. Therefore, with fewer vehicles, the total costsand the CO_2 emissions decrease.

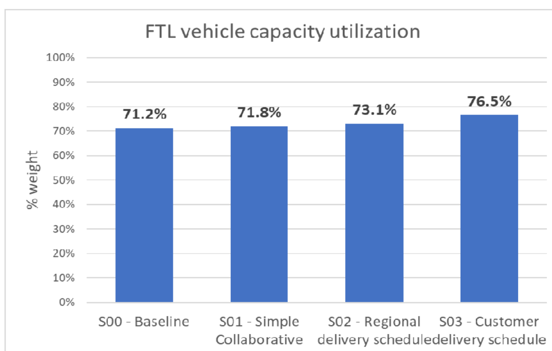

Figure 21. FTL vehicle capacity utilization per scenario

An additional effect of the increase in the percentage of shared shipments is the utilization of larger vehicles (see Figure 22). For FTL contracts, the shipper may select the optimum vehicle type. So, with larger shipments generated by the implementation of collaborative policies, the utilization of larger vehicles increases. For instance, the FTL1 – semitruck, which can handle loads up to 27.5 tons (see Figure 3), represents 67.7% of the total weight in the “S00 – Baseline” scenario and increases to 82.1%

of the total weight in the ”S03 – Customer delivery schedule” scenario. The utilization of larger vehicles decreases costs and CO_2 emissions due to their higher efficiency compared to smaller vehicles.

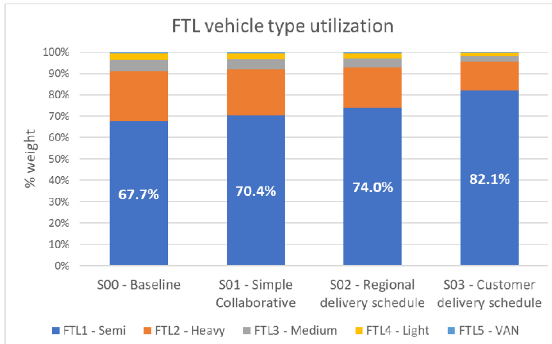

Figure 22. FTL vehicle type allocation per scenario

A further effect of grouping sales order from both companies is the utilization of larger rates on LTL shipments (see Figure 23). For LTL operations, the density of the deliveries plays a key role in the efficiency and, consequently, in the costs.

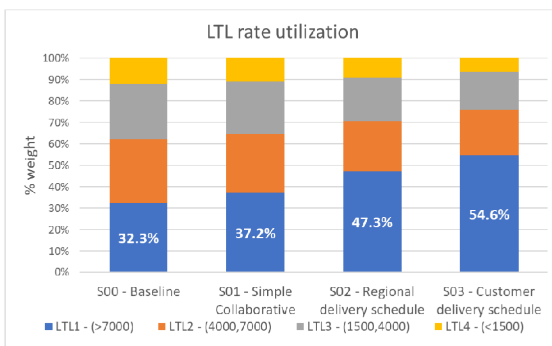

Figure 23. LTL rate range allocation per scenario

Generally, the LTL contracts have specific costs per ranges of weight, and those values decrease as the size of the load increases. For instance, the “LTL1 - (>7000)” rate, which considers loads larger than 7 tons, represents 32.3% of the total weight in the “S00 – Baseline” scenario and increases to 54.6% of the total weight in the ”S03 – Customer delivery schedule” scenario. The increase in efficiency drove by the higher density decrease costs and CO_2 emissions.

5 DISCUSSION

Asidefrom the benefits specified in Chapter 4, managerial recommendationsand roadblocksare inherent in the logistics coopetition relationships, which will be addressed in this chapter. Both matters will be briefly discussed, along with their respective overcomes.

5.1 Benefits and managerial recommendations

As outlined in Chapter 4, the results show significant benefits to the partnering competitors once they decide to apply logistics coopetition.At the beginning of the implementation, the involved companies have to align in terms of how much of their logistics policies they were willing to change to build the collaborative policy set and leverage the benefits. Depending on this agreement, they could share different ranges of benefits.This research has proposed three main collaborative policyscenarios for this CPG case:

(1) "S01 – Simple collaborative": where companies do not change any logistics policies;
(2) "S02 – Regional delivery schedule": where the partnering companies align delivery regions to be dispatched only in certain weekdays;
(3) "S03 – Customer delivery schedule": where the partnering companies align shared delivery schedules for shared customers.

The case data not only support the idea that there are different ranges of benefits depending on the chosen collaborative policyscenariothe companies are willing to implement, but also provide an estimation of these benefits.If the partnering companies do not come up with any policy agreement, mentioned above as the simple collaborative scenario, they acquire modest benefits: an average of 5.5% cost reduction, 5.7% lead time reduction and 5.3% of CO_2 emission reduction, as shown in **Error! Reference source not found.**, Figure 14, and Figure 15, respectively. Although these ranges are welcome in any supply chain efficiency initiative, they are not enough to make rival companies break the coopetition paradigm; therefore, some level of negotiation is required to jumpstart a logistics coopetition style contract, where companies should open internal concessions to agree with a collaborative policy to increase the benefits and overcome the paradigm.

The study focused on two groups of policies: regional delivery schedule and customer delivery schedule scenarios. In terms of the region-based policy, companies acquire moderate benefits: average of 14.5% cost reduction, 7.1% lead time reduction, and 14.3% of CO_2 emission reduction, shown in **Error! Reference source not found.**, Figure 14, and Figure 15, respectively. Companies willing to start the partnership agreeing on a consensual expedite weekday standard, defining which weekday they all should expedite orders of a certain geographic destination region. Consequently, orders for the same destinationregions from different companies tend to be shipped in the same weekday, leveraging the truck sharing. This policy has a medium impact on implementation of the partnership since it is a one-time negotiation between partners.This internal managerial implication needs to be addressed before the implementation by re-aligning delivery schedule standards with customers, sales and customer services teams, and renegotiate capabilities with 3PL providers.

Another more intricate solution, but also better in terms of benefits, is to move toward a customer-based policy, inwhich companies acquire high benefits: average of 25.5% cost reduction, 9.7% lead time reduction and 23.4% of CO_2 emission reduction, shown in **Error! Reference source not found.**, Figure 14, and Figure 15, respectively. In this case, all involved companies align not only aregion-based policy but also align with their shared customers to deliver the orders from all partners together in the same truck at the same time. This concession impliesa more complex managerial implication that requires more elaborate measures; it implies a high impact on the implementation of the partnership since companies will need to change their daily transportation routing process besides the one-time implementation negotiation. On top of the delivery schedule standards re-alignments, companies have to come up with a unified truck scheduling solution. Some customers have some level of electronic data interchange for booking the delivery schedules, such as EDI or an internet site scheduling system. Others still use telephone calls. Either way, coopetition partnering companies need to develop a unified solution responsible for booking the truck delivery schedule, in the name of all the partners without running the risk of having one to get the invoice information from another.

5.2 Overcome the roadblocks

On the one hand, the logistics coopetition case promises great benefits. On the other hand, practice shows some roadblocks for implementing a collaborative relationship. The survey developed by Saenz, Ubaghs, and Cuevas (2014) revealed that organizational culture is the most important concern of the senior executives. As the company management has a vital role drive the company culture, Saenz et al.(2014) draw the cause-effect relationship between the lack of support by company management and the consequent people'sbehavior of not prioritizing the project among other routine activities. Consequently, this lack of support opens prerogative to excuses such as lack of resources, a lack of time to prepare the data requested adequately or fear of worsening the service level, for example.The coopetition approach is a supply chain strategic move; thus, this approachhas toprovide support to the company planned business strategy and be desired by the senior management team. This research develops a regression tool to support the reader to estimate the benefits of this move, which will enrich the business case and make it more likely to be approved by the senior management team.

The lack of trust between partners and the lack of alignment between the mental models of the partners involved are further examples of these roadblocks (Saenz et al., 2014).To overcome these situations,Saenz et al.(2014)propose the creation of interorganizational learning practices through the absorptive capacity (AC) theory, which provides a suitable starting point for exploring the connection between interorganizational and intraorganizational learning processes.

An additional frequent barrier that happens in the initial phase of a logistics coopetition contract assessment is the difficulty of agreeing to the terms of the very collaboration, as described in Section5.1.

To address this issue, this capstone project develops a regression toolto support companies willing to partner up in the logistics coopetition approach to bring estimated benefits to the negotiation table. The estimated benefits concerning transportation costs, service level and carbon emission, along with three pre-proposed collaborative policy scenarios,enabling partnering companies to rationalize the decisions and to agree toconsensualpolicies.

Cooperation must secure agreed benefits sharing for all parties, not only in its implementation phase but also throughout its entire existence(Daidj, 2017). Therefore, the partnering companies must agree to effective controls, mechanisms to suppress potentially damaging opportunistic behavior from any party, and clear entering and leaving rules to sustain the coordination of shared activities. A fair sharing of the benefits is vital to avoid future break-up of the collaborative partnership. There are many methods for benefits distribution, such as Nash equilibrium, game theory, simple split by weight, etc. Companies willing to create a coopetition relationship have to agree on the most appropriate method for their particular case prior to the beginning of operations.

While a logistics horizontal collaboration between non-competitors proposes an exchange of information under total transparency between competitors it could result in a potentially damaging opportunistic behavior by any of the parties. Therefore, to address this potential hazard, companies can invite an additional company to play a neutral role, also called the facilitator or trustee. This additional company acts in situations to overcome the lack of trust. This facilitator can work as a supply chain coordinator to centralize the information and be the “information firewall” between the parties to avoid strategic information sharing. Additionally, this trustee can aggregate other important functions to leverage the established coopetition partnership, such as being the responsible party to secure proper gain share, be an outsourced company to manage all orders and schedule the deliveries in the name of all the partners andbean outsourced freight auditing service. These additional functions potentially bring financial benefits to the partnership.

6 CONCLUSION

Supply chains continuously face pressure to increase efficiency and differentiation to support business continuity. A not yet fully explored way to face this challenge is coopetition, where two competitor companies decide to partner on specific functions to get benefits and differentiate themselves from other companies. This project used data from two world-renowned food manufacturing companies in Brazil as a case study to evaluate the quantitative benefits of the coopetition approach in terms of transportation cost, CO_2 emissions, and service level.

Using a simulation model as thequantitative method, this study demonstrates that the supply chain coopetition can drive significant business advantages. The decrease in outbound transportation costs can range from 5% to 25%, the reduction on average lead time can range from 6% to 10%, and the drop in total CO_2 emissions can range from 5% to 23%.However, this research also shows that if companies adhere to the coopetition approach without implementing collaborative policies in order to increase the percentage of shared shipments, the overall benefits stay in the 5% band, which may not be enoughfor companies to decide to get onboard. As a result, firms need to agree to changeat least part of their regional and customer delivery schedules to match each other, thus improving their synergy and achieving the full potential of coopetition.

We identified two opportunities for further study. First, as the data utilized came from two competitor companies with similar size and scale, it would be valuable to run the model with companies of different sizes to understand the impacts, relations, and quantitative benefits. Second, as the model developed is flexible and can be applied to simulate the potential for more than two companies, it would be worthwhile for the following studies to utilize data from other competitors to understand how the players benefit from additional entries.

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APPENDIX

The table below shows the general results of each model run with absolute figures of total costs, average lead times, and total CO_2 emissions. It also shows the percent reduction of each variable in comparison with the “S00 – Baseline” scenario.

Runs results										
Run	Scenario	Subset	Total weight (tons)	Total cost (mio BRL)	% cost reduction	Lead time AVG (days)	% lead time reduction	CO_2 (tons)	% CO_2 reduction	% shared shipments
01	S00 - Baseline	All customers	24,612	11.8		6.5		1,745		0.0%
02	S01 - Simple Collaborative			11.3	-4.2%	6.2	-4.6%	1,677	-3.9%	30.8%
03	S02 - Regional delivery schedule			10.4	-11.9%	6.1	-5.9%	1,546	-11.4%	43.0%
04	S03 - Customer delivery schedule			9.3	-21.4%	5.9	-8.5%	1,412	-19.1%	57.3%
05	S00 - Baseline	Orders of shared customers +75% other customers	21,649	10.4		6.5		1,480		0.0%
06	S01 - Simple Collaborative			9.9	-4.7%	6.2	-5.1%	1,414	-4.5%	33.6%
07	S02 - Regional delivery schedule			9.0	-13.1%	6.1	-6.5%	1,292	-12.7%	47.1%
08	S03 - Customer delivery schedule			7.9	-23.4%	5.9	-9.2%	1,167	-21.2%	64.1%
09	S00 - Baseline	Orders of shared customer +50% other customers	18,687	9.0		6.5		1,235		0.0%
10	S01 - Simple Collaborative			8.5	-5.5%	6.1	-5.7%	1,170	-5.3%	37.2%
11	S02 - Regional delivery schedule			7.7	-14.5%	6.0	-7.1%	1,059	-14.3%	52.3%
12	S03 - Customer delivery schedule			6.7	-25.5%	5.9	-9.7%	946	-23.4%	72.9%
13	S00 - Baseline	Orders of shared customers +25% other customers	15,725	7.5		6.5		959		0.0%
14	S01 - Simple Collaborative			7.0	-6.7%	6.0	-6.6%	895	-6.7%	42.3%
15	S02 - Regional delivery schedule			6.2	-17.2%	6.0	-7.8%	790	-17.7%	59.9%
16	S03 - Customer delivery schedule			5.3	-29.7%	5.8	-10.8%	689	-28.2%	84.9%
17	S00 - Baseline	Only shared customers	12,762	6.1		6.5		712		0.0%
18	S01 - Simple Collaborative			5.6	-8.5%	6.0	-7.7%	649	-8.9%	48.5%
19	S02 - Regional delivery schedule			4.8	-20.8%	6.0	-9.0%	553	-22.3%	69.0%
20	S03 - Customer delivery schedule			4.0	-35.1%	5.8	-12.0%	462	-35.1%	100.0%