Supply Chain Network Design: A Case Study in a Dairy Company

Lucas Cedroni Fava[1], Mauro Sampaio[2]

Department of Industrial Engineering, Centro Universitário FEI
Av. Humberto de Alencar Castelo Branco, 3972-B - Assunção, São Bernardo do Campo - SP, Brazil
[1]lucascedronifava@outlook.com
[2]msampaio@fei.edu.br

***Abstract*— This research contributes to academic literature in the area of supply chain network optimization, involving parameters and restrictions of Brazilian operation scenario. Besides, it contributes to the professional corporative environment, with a new perspective of how a supply chain network can be constructed for a company that operates in a scenario with inventory capacity and supplier restrictions. The objective of the article is to develop a supply chain network design, aiming to determine the optimal location of a dairy distribution center and its ideal inventory capacity, considering the location of a company's facilities as a key factor for financial success, since costs such as inventory and transportation are influenced by network projects. Variables such as logistical costs, taxes, inventories, etc., are considered during the execution of the network design. This study contributes to the area of network design in the supply chain, having a quantitative and exploratory nature. A single case study was carried out in the dairy company, analyzing documents and financial information to decide on the most advantageous place for the distribution center. The Supply Chain Guru software for network optimization, developed by Llamasoft, was used to support this project. This tool has been previously studied and analyzed for this use, since it can bring relevant and complex outcomes. The result was that the optimal location for the new distribution center would be at one of the company's existing plants, which would bring an economy close to R$ 100,000 in one year of operation.**

***Keywords*—** *Supply chain network design, supply chain management, Supply Chain Guru, operational research, network optimization*

1. Introduction

A supply chain network design development is necessary inside enterprises nowadays. Supply chain management is important in the growth process of companies and, also, in academic interests, that will support enterprises to make their supply chain network more efficiently [1]. The supply chain network design, also, covers tactical decisions (in the medium term, aimed at daily operations) and strategic decisions (in the long term, interested in the network's structure and configuration) of companies [2]. The fact that the supply chain network covers inventory management, production, transportation and the administration of all facilities of the network emphasizes even more the importance of the supply chain network [3].

Companies face many challenges in order to achieve agile and efficient supply chains, since exist many alternatives that must be analyzed, even in small size problems [4]. The number of facilities that a company owns around the world deserves a huge analysis, for example. While a bigger number of facilities brings a smaller response time to the customer and a smaller transportation cost, this big quantity of facilities provides a bigger inventory cost to the company [3]. According to [5], these inventory levels and the transportation network are the strategic factors most valued by industries when deciding the location of their facilities.

The benefits that a robust supply chain network can provide, as logistic cost reduction, improvements in service quality and decreasing inventory, triggered projects and studies objectifying the supply chain network optimization, in which aim the minimization of costs (as logistics costs, production, fixed and variable cost of facilities, taxes, raw material costs, etc), or, further, the maximization of the organization's profit [6]. According to [7], optimization models aim the "best performance" of operation of company's facilities and show the possibility of changing some existing restrictions in organizations. Most of the models already developed, today, are only determinists and from a static nature. Using softwares, restrictions as inventory and production capacity, mix of materials produced per facility and transportation flows, can be disconsidered during an optimization to be possible to know what can be changed in the company to achieve the "best performance" of operation of the company.

Based on input parameters in softwares, the optimal facilities locations and the optimal inventory capacities can be calculated (focusing on the customers´ demand per location and per product) to possible changes in the supply chain network. Decision-making related to transportation flows, as the modal to be used (Full Truckload, Less Than Truckload, rail, air, ocean, etc) and the source facility of delivery for each client in the entire supply chain network, can also be checked using optimization tools. Besides, it is possible to determine the desired service level before

running the optimization, to the optimal model respects it. Network optimization models are significantly helping organizations [8], but literature that connects the supply chain management with supply chain network decisions is still scarce [9], making this research relevant in this area.

After describing the importance of the development of a consistent supply chain network, this article aims to answer the questions: what is the optimal location for a new distribution center of a dairy company? What is the optimal inventory capacity for this new distribution center? What is the influence that variables such as inventory, logistics cost, fixed and variable costs of facilities have during the construction of a supply chain design? What are the economic advantages that an enterprise has when adopting an efficient supply chain network?

The objective of this article is to determine the optimal location for a new distribution center of a dairy company. A single case study research method will be applied and the Supply Chain Guru software, from Llamasoft, will also be used to support this project. This research aims at contributing to the supply chain network optimization study, since there is a lack of literature in this area.

The authors will use interviews, documents and financial data available by the company as base of data source to be inserted in the Supply Chain Guru software and achieve the optimization model. In this article, after this introduction, the literature revision will be explained about this theme, the methodology used in this study, the results and, in the end, the conclusion of the article.

2. Literature Review

This section will be divided in: supply chain network design; and the use of technology in a supply chain network.

2.1 Supply chain network design

According to [3], there are many steps involved in a supply chain network to attend a customer order, as carriers, warehouses, retailers, customers, manufacturers, suppliers, etc. Besides, the areas that influence a customer order, like marketing, accounting and development of new products are also inside a supply chain network.

[9] argue that a supply chain management and maintenance is the planning, implementation and operations control processes of a supply chain network. According to them, the supply chain covers transportation and storage of raw materials, work in process and finished products stock, since the source location until the consumption location. [9] further highlight that the supply chain network must be seen as a whole, considering purchase, production, inventory, distribution, and logistics areas all together, and not isolated, having as a main objective the best supply chain network configuration.

[10] is another author who studied a supply chain network design, stating that the supply chain management is defined as the planning and management of all areas and tasks involved in the purchase and logistics processes of a company. [10] also argues that the coordination and relationship with partners (suppliers or customers) are also covered by a supply chain network.

2.2 The use of technology in a supply chain network

The connectivity and integration of a company's data emerged from technology, enabled the construction of a consistent supply chain network for enterprises [11]. [12] argue that it is necessary an automatically real-time network data gathering, using the big data, to reduce the risks and doubts in a supply chain network.

Some of these challenges can be overcome using technology [13]. The use of tools, like ERPs (Enterprise Resource Planning) and optimization software are solutions that facilitate a fast and effective decision-make in a supply chain network, because they can store a huge quantity of an enterprise data and create an analysis of these data. The processing and analysis of these data is considered fundamental, by [14], to assure precise and relevant results to determine the optimal operational model of a supply chain network. The use of these technologies is also considered important by [15], who state that the use of software and optimization tools as a necessity to the development and innovation of structured supply chain networks.

3. Methodology

This article discusses a supply chain network design for a dairy company in the state of São Paulo. Therefore, it is considered a single case study research, with quantitative scope, since the data collected and results obtained are based on mathematical optimization methods.

For data collection, face-to-face interviews were conducted with managers from various sectors in the company, such as logistics, administration, financial, commercial, operations, among others. The data obtained were collected both in the distribution center and in the factories to facilitate the understanding of all the entities of the company. Information about monthly production by plant, production and inventory capacity, monthly inventory levels, fixed costs and operating variables, classification of product families, yields of raw materials by product family, transport prices, among others, are examples of data collected for the progress of the project.

In addition, the company's ERP system was also used as the basis for much of the data collection, since it stores monthly information on a large scale from previous years to the present day. All these data, after being collected, were validated by the managers of the company under study. The current period of data collected for the study was from August of 2016 to July of 2017.

To support this project, the Supply Chain Guru tool, developed by Llamasoft, was used since this software can bring relevant results during the optimization of a supply chain network. Face-to-face and material courses provided by Llamasoft for mastery of the tool were used, as well as the support from members of the company for any questions and difficulties.

4. Results

This section will first explain the context of the dairy company and then show the results for two scenarios: Baseline, which specifies how the dairy company operates, as well as the main costs of its supply chain network; and Scenario 1, which shows the company's optimized network, with the new distribution center already found.

4.1 Case of the dairy company

The dairy company has four factories in Brazil: one in the state of São Paulo (the largest of them), two in the state of Goiás, and the other in the state of Mato Grosso. The company's sole distribution center is in the city of São Paulo. The company has about 100 finished products for sale, all of them derived from milk. There are several milk suppliers (also considered in this study) and each of them supplies milk to one of the four factories. The dairy company is responsible for the transportation of the raw material from the suppliers to the factories. Today, most of the production in the factories is transferred to the distribution center and then sold to consumers. Few sales are made directly from the factories to the customers.

4.2 Facilities' and customers' locations

The company's facilities were divided into suppliers, factories and distribution center, in addition to the consideration of customers. Table 1 shows this division of facilities with their respective names used for the project.

Table 1. Division of facilities

FACILITY NAME	KIND OF FACILITY
MFG_Bravalat	Factory
MFG_Portelandia	Factory
MFG_SanMarino	Factory
MFG_Rancharia	Factory
DC_Neolat	Distribution Center
SUP_Bravalat	MILK Supplier
SUP_Portelandia	MILK Supplier
SUP_SanMarino	MILK Supplier
SUP_Rancharia	MILK Supplier
SUP_Parmesao	FAMILY 7 Supplier

As Table 1 shows, the dairy company has four factories and a distribution center. In addition, the company has many suppliers of the MILK product, however, for the present study, the suppliers were divided into four groups according to their respective raw material supply plant. Therefore, the supplier SUP_Bravalat, for example, is made up of all the actual suppliers of the MILK product that supply the MFG_Bravalat factory. Another vendor considered in the study is SUP_Parmesao, which provides the FAMILY 7 product for the MFG_Rancharia factory to use it as raw material for the FAMILY 9 product. In addition to the facilities, more than 1,500 customers were considered, scattered throughout Brazil, and had a demand greater than 50Kg in the period under study.

The location of suppliers, factories, distribution center and consumers were located on the map by their latitudes and longitudes found by the software itself. Figure 1 shows the location of the company facilities.

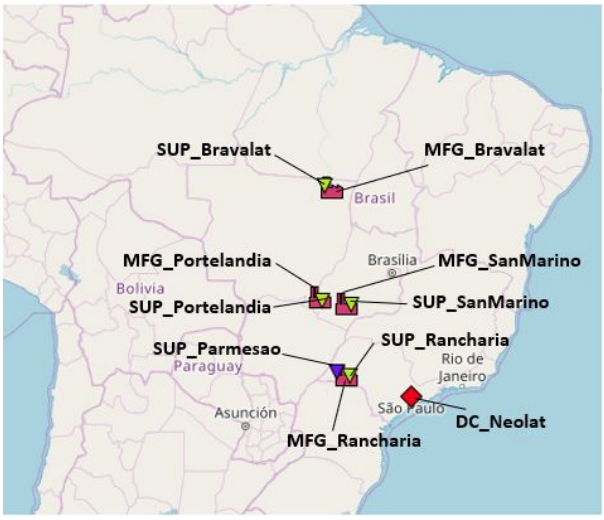

Figure 1. Facilities locations

Figure 2 shows where the customers (delivery points) of the company are located, according to the demand of each of them.

Figure 2. Customers locations

In Figure 2, it is evident that the company's demand is concentrated in the southeastern region of the country, specifically in the state of São Paulo. Thus, Figure 3 shows the map of the city of São Paulo with the clients, using a scale according to the demand of each consumer.

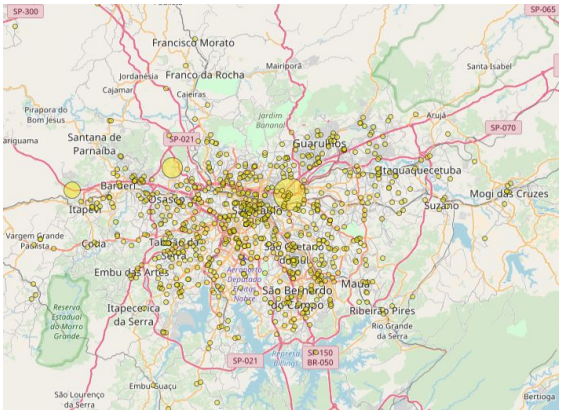

Figure 3. Customers in São Paulo city

The total sales for the period studied by product family is shown in Table 2. It should be noted that sales in Table 2 refer to all the company's facilities.

Table 2. Total sales per product Family (in Kg)

FAMILY 1	2.518.664
FAMILY 2	513.039
FAMILY 3	74.498
FAMILY 4	437.494
FAMILY 5	2.375.216
FAMILY 6	231.369
FAMILY 7	159.074
FAMILY 8	1.594.473
FAMILY 9	506.736
FAMILY 10	531.736
FAMILY 11	360.040
FAMILY 12	582.938
FAMILY 13	306.773
FAMILY 14	10.662
MILK (in liters)	3.208.225

Table 2 shows that FAMILY 1 and FAMILY 5 products have the highest sales volume in kilograms in the period under study, exceeding the mark of two thousand tons. Next, the product FAMILY 8 stands out with about one thousand and six hundred tons of sales. The only product with unit of measure in liters is the MILK, that also is used like raw material. This product obtained a sale in excess of three thousand tons of liter from June 2016 to July 2017.

4.3 Baseline

This scenario explains the current mode of operation of the company, without an optimization based on the optimal model of performance, yet. Flows between facilities and for consumers, production, stock levels, input and raw material yield, among others, are some of the subsections that will be addressed.

4.3.1 Production per facility

This subsection shows the monthly production levels of each facility per product family. Figure 4 shows the MFG_Bravalat factory productions.

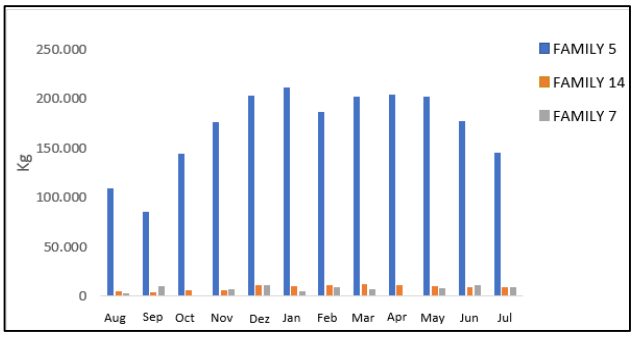

Figure 4. Monthly production of MFG_Bravalat factory

Figure 4 shows that the MFG_Bravalat factory produces only the products: FAMILY 5, FAMILY 14 and FAMILY 7, with the FAMILY 5 product being the most part of this production, reaching a peak of more than two hundred tons in January of 2017. FAMILY 14 and FAMILY 7 are produced on a smaller scale throughout the period.

Figure 5 shows the monthly productions of the MFG_Portelandia factory.

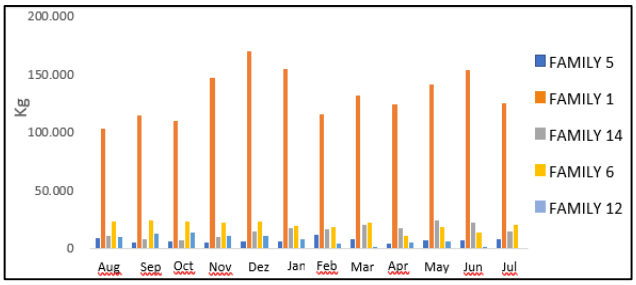

Figure 5. Monthly production of MFG_Bravalat factory

As shown in Figure 5, the production at MFG_Portelandia plant is based on the products: FAMILY 5, FAMILY 1, FAMILY 14, FAMILY 6 and FAMILY 12. The largest production is from FAMILY 1, reaching a peak of almost one hundred and seventy tons in December of 2016. The other products are produced at a lower scale level.

Figure 6 shows the monthly production of the MFG_SanMarino factory.

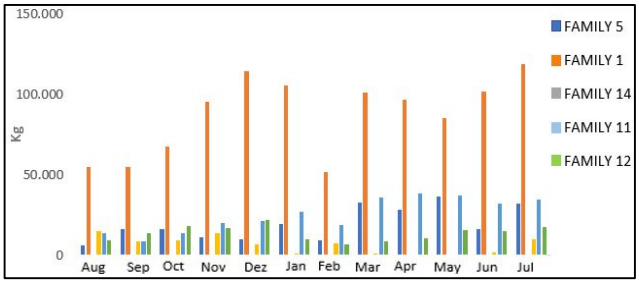

Figure 6. Monthly production of MFG_SanMarino factory

Figure 6 shows the products that are produced in the MFG_SanMarino factory: FAMILY 5, FAMILY 1, FAMILY 14, FAMILY 2, FAMILY 11 and FAMILY 12. As well as the installation of MFG_Portelandia, the factory MFG_SanMarino also has the product FAMILY 1 as the one of greater production, reaching a maximum production of about one hundred and twenty tons.

Figure 7 shows the monthly production of the MFG_Rancharia factory.

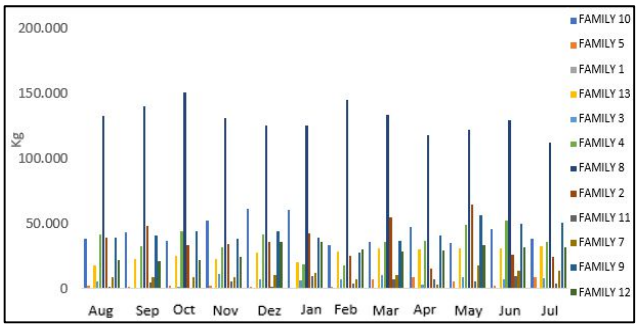

Figure 7. Monthly production of MFG_Rancharia factory

The MFG_Rancharia factory is the facility with the largest variety of the company production, as shown in Figure 7. The products FAMILY 10, FAMILY 5, FAMILY 1, FAMILY 13, FAMILY 3, FAMILY 4, FAMILY 8, FAMILY 2, FAMILY 11, FAMILY 7, FAMILY 9 and FAMILY 12 are produced in this factory. The product with the highest level of production is the family of FAMILY 8, coming close to the mark of one hundred and fifty tons in some months.

4.3.2 Stock levels

This subsection demonstrates the inventory level of the entire network, with the units of measure products in kilograms. Figure 8 shows, first, the stock of the entire network in the period studied.

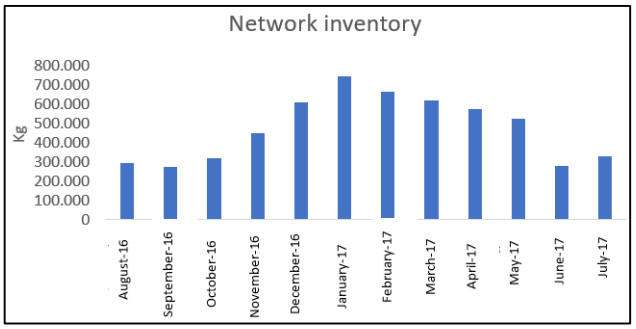

Figure 8. Network inventory

On the one hand, Figure 8 shows that, with current production levels and the dairy company's current demand, the company's peak stock reached seven hundred and forty tons in January of 2017. Meanwhile, the lowest inventory levels were in September of 2016 and June of 2017, with less two hundred and eighty tons.

On the other hand, Figure 9 shows the stock of the company's only existing distribution center: DC_Neolat.

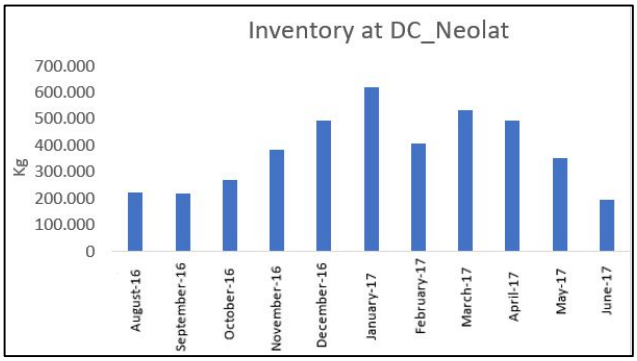

Figure 9. Inventory level at DC_Neolat in Baseline scenario

By Figure 9, the maximum stock reached by the distribution center was in January 2017, with more than six hundred tons.

Figure 10 shows the inventory evolution of the MFG_Rancharia factory, the facility of the company with more varieties of products and higher level of production of the entire network.

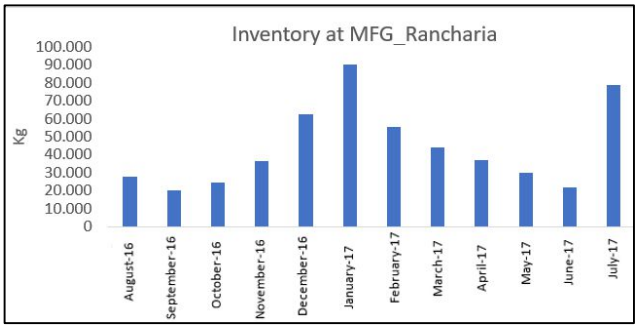

Figure 10. Inventory level at MFG_Rancharia in Baseline scenario

MFG_Rancharia factory achieved ninety tons of products in stock in January of 2017, as shown in Figure 10, and with an average stock smaller than DC_Neolat distribution center.

After consulting with company managers, the cost of inventory storage was used as 12% over the cost of production for all products in all facilities of the supply network.

4.3.3 Inbound and outbound flows

In this subsection, flows between the facilities of the dairy company (inbound) and flows to the outbound customers will be presented.

Figure 11 shows the map with the internal flows of the network, between the factories and the distribution center.

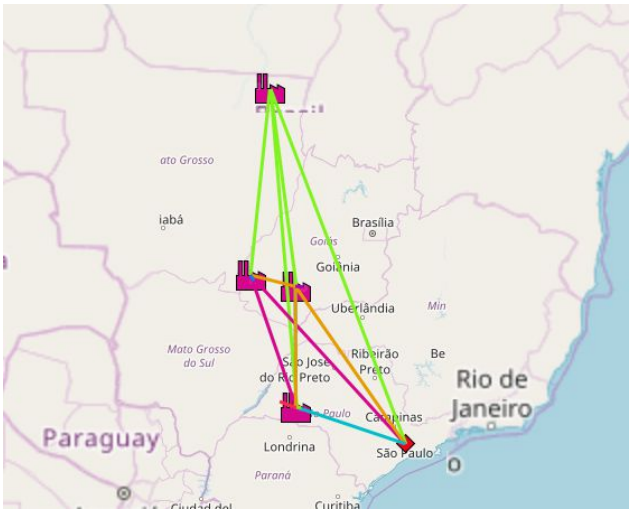

Figure 11. Network´s inbounds between factories and the distribution center

Figure 11 shows the current internal flows in the company's supply chain network: MFG_Bravalat, MFG_Portelandia, MFG_SanMarino and MFG_Rancharia send most of the production to the DC_Neolat distribution center. In addition, there is also a flow between factories of some products, necessary to meet certain local demands of some factories. The factory that receives most products from other factories is MFG_Rancharia.

Table 3 shows the number of products that transited between these facilities during the study period.

Table 3. Quantity of product in transit of the inbound flows (in kg) of the Baseline scenario

From/To	MFG_Bravalat	MFG_Portelandia	MFG_SanMarino	MFG_Rancharia	DC_Neolat
MFG_Bravalat		74	40.407	40.755	2.041.287
MFG_Portelandia				38.370	1.716.774
MFG_SanMarino		516		222.574	1.333.700
MFG_Rancharia			8.991		4.337.638

Table 3 shows that the DC_Neolat distribution center receives more than nine thousand tons of products, which represents 96.4% of the company's total transfer. Most of these products come from the MFG_Rancharia factory, the company's largest production facility, as seen in subsection 4.4.1. Among the production centers, this is the factory that also receives more finished products, with more than three hundred tons in the period. The other facilities receive lower quantities compared to DC_Neolat and MFG_Rancharia.

The flows to end consumers (outbounds) are now shown in Figure 12.

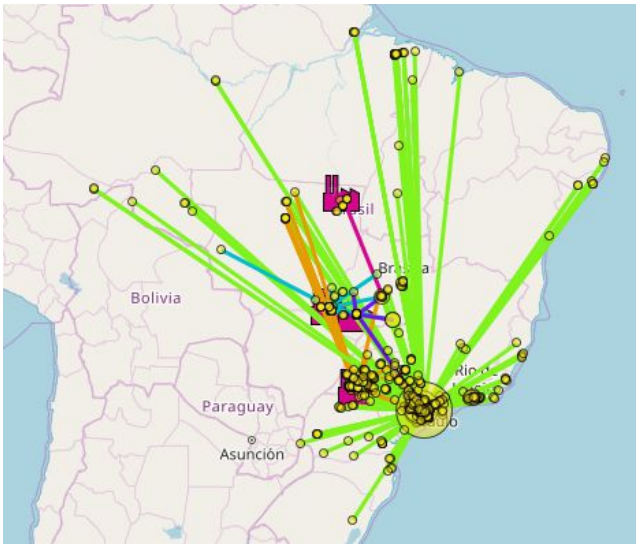

Figure 12. Outbound flows of the Baseline scenario

Figure 12 shows that most of the outbound flows are originated from DC_Neolat. Clients away from the facilities, located in the north and northeast of Brazil, receive products from carts of the only distribution center of the dairy company. The company's factories meet a low demand of customers that are located close to their respective facilities.

Starting with a view of the state of São Paulo, where there is the concentration of the demand of the company, Figure 13 reveals the outbound flows in this region.

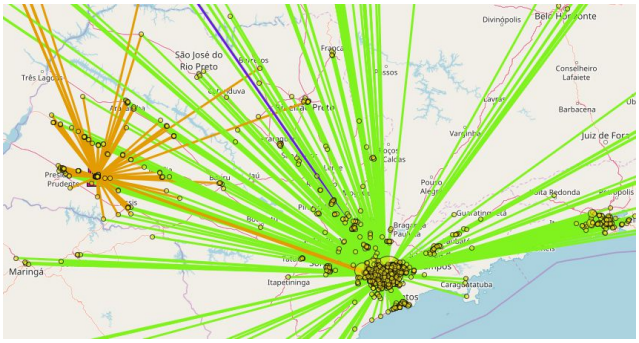

Figure 13. Outbound flows of the state of São Paulo in the Baseline scenario

Figure 13 shows a large concentration of customers in the city of São Paulo, but also consumers spread throughout the state. By Figure 13, most of these consumers are served by DC_Neolat, even those that are in the interior of the state of São Paulo, closer to MFG_Rancharia. In this scenario, the MFG_Rancharia factory serves some local customers, who receive goods from the plant and distribution center, depending on the time of year.

Table 4 shows the quantities, in kilograms, of products that left each of the company's facilities for delivery to consumers.

Table 4. Quantity of products delivered in outbound flows in the Baseline scenario (in kg)

Outbound flows	
DC_Neolat	9.310.333
MFG_Bravalat	8.348
MFG_Portelandia	314.238
MFG_Rancharia	154.315
MFG_SanMarino	415.321

DC_Neolat distribution center delivers 91.3% of consumer products, with over 9,000 tonnes, as shown in Table 4. Manufacturing centers represent a low share of outbound flows compared to the distribution center.

4.3.4 Baseline financial balance

After an analysis of production, stocks, suppliers and sales, we arrive at a final balance sheet of the dairy company for the period from June 2016 and July 2017, for the Baseline. Table 5 shows this financial report.

Table 5. Baseline financial balance (in R$)

Baseline						
Fixed Operation Cost	Production Cost	Transportation Cost	Inventory Cost	Total Cost	Total Revenue	Total Profit
20.251.000	122.320.808	6.047.843	691.843	**149.311.495**	**192.170.748**	**42.859.252**

Table 5 shows that the company's total profit in the period under study was R$ 42,859,252, considering the fixed cost of facilities, production, transportation and inventory costs and total revenue of the company. Production costs represent the largest part of the company, with over one hundred and twenty-two million reais spent in the period, followed by fixed installation costs (R$ 20,251,000) and transport costs (R$ 6,047,843). It is also complemented that the fixed cost of the facilities (being considered of the four factories and of the distribution center) were values provided by the managers of the companies, obtained during the interviews.

4.4 Scenario 1

Scenario 1 presents the dairy company's supply chain network optimized, being considered an optimal scenario of operation, aiming the maximization of the company's profit. Sales to final consumers were considered the same as those of the Baseline. For this optimization, some constraints had to be adopted by company determination, such as production levels and availability of raw materials from suppliers. This will be depthly explained in the following subsections.

4.4.1 Production per facility

For scenario 1, the monthly production and the variety of products produced from each facility had to be kept equal to the values of the Baseline, shown in subsection 4.2.1. This is because, today, the company works with contracts and agreements with suppliers of the MILK product, and it must receive monthly quantities of this product predetermined. Furthermore, considering that the MILK product has a short shelf life, the managers of the company affirm that the monthly production levels of the factories must be maintained, being thus considered as a restriction to the model under study, specifically to Scenario 1. It means that the monthly production of this scenario is the same as in subsection 4.2.1.

4.4.2 Inbound and outbound flows

Unlike production, inbound and outbound flows were freed of constraints in order to achieve the optimal solution for flows between facilities and end customers. Figure 14 shows the outbound flows from Scenario 1.

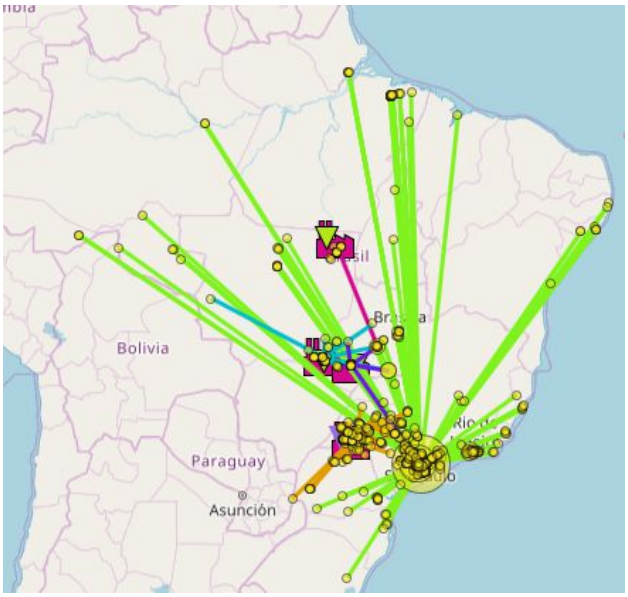

Figure 14. Outbound Flows of Scenario 1

Figure 14 shows that DC_Neolat would still be responsible for delivering the majority of the network clients, whether located in the Southeast region or even in the North and Northeast regions. The factories of MFG_Bravalat, MFG_Portelandia and MFG_SanMarino would also only deliver to occasional customers, located near the facilities. The MFG_Rancharia factory would serve most consumers located in the interior of the state of São Paulo and even in the state of Paraná. Focusing on the state of São Paulo, where there is the largest concentration of the demand of the company, Figure 15 shows the outbound flows for that region.

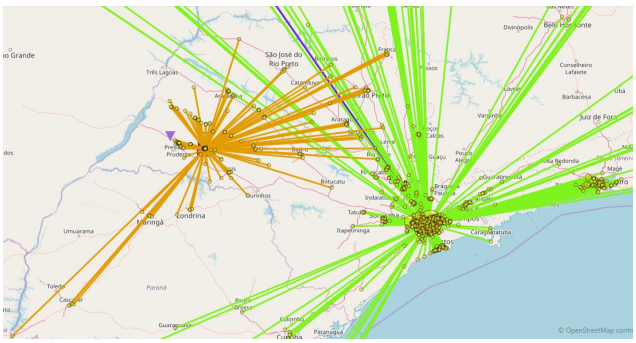

Figure 15. Outbound flows for the state of São Paulo in Scenario 1

Figure 15 shows the fact that the MFG_Rancharia plant would carry out outbound flows to customers in the interior of the state of São Paulo and some in Paraná. Thus, the distribution center DC_Neolat would not deliver to consumers in those regions, MFG_Rancharia being responsible for those flows.

Table 6 now shows the quantity of products delivered per facility in Scenario 1.

Table 6. Quantity of products delivered in outbound flows in Scenario 1 (in kg)

Outbound flows	
DC_Neolat	8.936.949
MFG_Bravalat	8.348
MFG_Portelandia	310.548
MFG_Rancharia	527.699
MFG_SanMarino	419.011

Table 6 shows that DC_Neolat would deliver almost 9,000 tons of products to customers in Scenario 1. MFG_Rancharia factory would deliver about five hundred and thirty tons of goods in that period. The factories of MFG_Portelandia and MFG_SanMarino would deliver approximately three hundred and ten, four hundred and twenty tons. Finally, MFG_Bravalat would make few outbound flows, with 8 tons in all period.

For these outbounds, the required inbound flows are the same as shown in Figure 11: factories shipping goods to the DC_Neolat distribution center and there is an internal flow between the manufacturing centers themselves. What would change in relation to the Baseline, would be the quantities transported in these flows, as shown in Table 7.

Table 7. Quantity of product in transit in Scenario 1 for inbound flows (in kg)

From/To	MFG_Bravalat	MFG_Portelandia	MFG_SanMarino	MFG_Rancharia	DC_Neolat
MFG_Bravalat		74	40.407	116.548	1.965.494
MFG_Portelandia				201.227	1.550.474
MFG_SanMarino		516		220.010	1.339.708
MFG_Rancharia			8.991		4.200.340

For Scenario 1, DC_Neolat distribution center would continue to receive most of the production from the factories, but there would be a decrease compared to the Baseline scenario, which would receive about 94% of the transfers, as shown by Table 8. The factory MFG_Rancharia (responsible for making more outbounds than in the Baseline scenario) would receive more than five hundred and thirty tons of product from other facilities. MFG_Bravalat, MFG_Portelandia and MFG_SanMarino would receive the same transfer quantities from the Baseline scenario.

Considering that the MFG_Rancharia manufacturing center will have bigger flow of inbounds and outbounds in Scenario 1, Figure 16 presents these flows in this facility in detail, with the quantity per product and with the origin or destination.

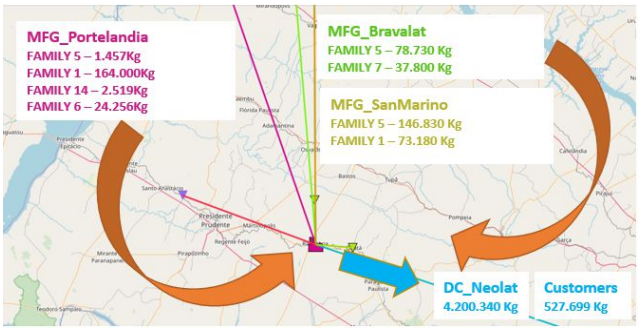

Figure 16. Inbound and outbound flows at MFG_Rancharia plant

Figure 16 highlights the flows involved in the inbound (from company facilities) and outbound flows of MFG_Rancharia, which would then become a distribution center for the company.

4.4.3 Stock levels

This subsection presents the monthly stock levels of DC_Neolat and MFG_Rancharia for Scenario 1. The inventories of these two facilities will be shown, as they will become the distribution centers of the dairy company. First, Figure 17 shows the DC_Neolat stock level.

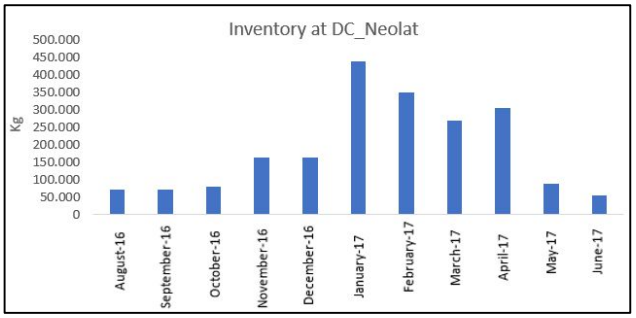

Figure 17. Inventory at DC_Neolat for Scenario 1

Figure 17 shows that the peak inventory in DC_Neolat for Scenario 1 would be approximately of four hundred and thirty-eight tons in January of 2017. It shows that the new MFG_Rancharia distribution center would decrease the stock of DC_Neolat, since that this stock peak in

DC_Neolat would decrease by almost thirty percent over the Baseline scenario. Figure 18 now shows the stock level in MFG_Rancharia for Scenario 1.

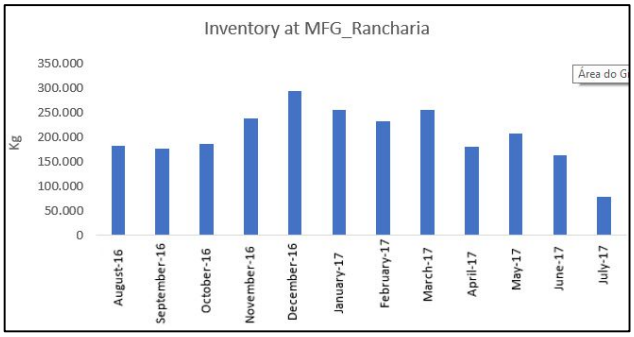

Figure 18. Inventory level at MFG_Rancharia for Scenario 1

According to Figure 18, the stock peak at the MFG_Rancharia facility would be close to three hundred tons in December of 2016. It means that this stock peak would almost triple in relation to the Baseline scenario and would significantly decrease the stock level in DC_Neolat plant.

4.4.4 Scenario 1 financial balance

Following the same analysis made for the Baseline scenario, after productions, stocks, suppliers and sales approaches for "scenario 1", a final balance is constructed for the period from August of 2016 to July of 2017. This balance sheet is shown in Table 8.

Table 8. Scenario 1 financial balance (in R$)

Scenario 1						
Fixed Operation Cost	Production Cost	Transportation Cost	Inventory Cost	**Total Cost**	**Total Revenue**	**Total Profit**
20.251.000	122.320.808	5.951.278	691.448	**149.214.536**	**192.170.748**	**42.956.213**

Table 8 shows that the total cost of the company in this scenario is R$ 149,214,536 for the period under study. Most of this cost comes from production costs and fixed operation costs, which were the same as those of the Baseline scenario. Transportation costs totalized less than six million reais; and inventory costs were R $ 691,448. Total revenue from the company's sales was the same as that of the Baseline, with R $ 192,170,748, reaching a total profit of R$ 42,956,213 for the period under review.

4.5 Comparation between baseline and scenario 1

Table 9 presents a comparison of the final balance of the two scenarios studied in the article.

Table 9. Comparation between the financial balance of the Baseline and Scenario 1

	Fixed Operation Cost	Production Cost	Transportation Cost	Inventory Cost	**Total Cost**	**Total Revenue**	**Total Profit**
Baseline	20.251.000	122.320.808	6.047.843	691.843	**149.311.495**	**192.170.748**	**42.859.252**
Scenario 1	20.251.000	122.320.808	5.951.278	691.448	**149.214.536**	**192.170.748**	**42.956.213**

The main difference between the results of the two scenarios studied was the opening of the new distribution center in the MFG_Rancharia plant, in Scenario 1. This resulted in a decrease of R$ 96,960 in the total operating cost of the company, resulting from a large part of the transportation cost and another portion of the cost of inventory, as shown in Table 9.

Opening the new distribution center, some customers were served by MFG_Rancharia and no longer by DC_Neolat, which resulted in a reduction of R$ 96,566 in transportation costs and R$ 394 in inventory costs compared to the Baseline scenario. The fixed costs of the facilities and the production cost were the same in both scenarios, since the facilities used were the same (the new distribution center is in an existing facility) and the monthly productions were also considered the same (restriction to the model).

In addition, MFG_Rancharia started receiving more products from other facilities in Scenario 1 to transport goods to consumers. It caused an increase of the stock of this facility to almost three hundred tons in this scenario, while the peak inventory at DC_Neolat was about four hundred and thirty-eight tons.

Compared with the Baseline, the peak stock in MFG_Rancharia increased by almost three hundred and thirty percent and in DC_Neolat it decreased by twenty-nine percent in Scenario 1.

5. Conclusion

This article contributes, therefore, to the study of optimization of supply chain networks in academics literature. There are few articles in brazilian academic literature that study supply chain network design considering parameters and restrictions of Brazil. Thereby, there is an opportunity of articles and studies in this area. Besides, this study contributes to the professional corporative environment, showing a new vision of how a supply chain network can be constructed in a scenario with inventory capacity and supplier restrictions. It consists of a single case study, in which the main objective is to determine the optimal location of a new distribution center for a dairy company. Issues related to the required inventory capacity of this distribution center, influences of variables in the study, and economic advantages are also addressed.

As a method of solving this problem, it was used the software Supply Chain Guru, from the company Llamasoft. This tool is based on optimization methods, using operational research equations. For the present study, the objective function used was to maximize the company's profits.

Interviews were carried out with the employees and managers of the company, from the production, logistics, marketing, sales, financial and administrative areas for data collection, as well as the use of secondary data extracted from the company's ERP. The period analyzed was from August of 2016 to July of 2017, totalizing one year of operation of the dairy company. For this study, two scenarios of the company were considered: the Baseline, in which presents the current mode of operation of the company, without an optimization based on an optimal model of performance; and Scenario 1, in which the optimized dairy company supply chain network is presented, being considered the optimal scenario of operation and considering, also, all restrictions imposed on the model.

Considering all the restrictions imposed by the company on the model, the results achieved were considered consistent and satisfactory for its use by the company studied. The new optimum distribution center is in an existing facility: MFG_Rancharia, which until then, was a factory that produced most of the production of the company. The use of an existing facility leads to a minimum increase in the monthly fixed cost of the facility and is disregarded in this study.

The new distribution center would need a storage capacity of about 300 tons in Scenario 1 to be able to support the company's entire network production and deliver products to consumers during the network's peak inventory, in December of 2016. As a result, the DC_Neolat distribution center would have a peak of about four hundred and thirty-eight tons in January of 2017, dropping approximately one hundred and eighty tons compared to the stock peak of the Baseline scenario.

The opening of the new distribution center would yield an economy of almost one hundred thousand reais within the period of one year of operation for the dairy company. This economy would originate mainly from transportation costs, which would decrease by R$ 96,565.00. In addition, the distribution center at MFG_Rancharia would allow the company to approach its customers, making it possible to improve the service level of the company.

Thus, it is recommended that the dairy company increase the inventory capacity of the MFG_Rancharia factory, to enable this facility to carry out some outbound flows, and then become the company's second distribution center. It is also suggested that the stock capacity in this facility is approximately 500 tons, even though the peak inventory in MFG_Rancharia, seen in this study, reached 300 tons, since the company has been growing in the market in recent years and this investment in expansion is something to be considered in the long term. Besides, with an increase in sales in the coming years, a stock capacity of five hundred tons would be enough to cover this increase, since the values and variables in this study were seen in the current period of one year of operation of the company.

Future studies may focus on topics that are more specific or broader than the proposed work, performing analyzes initiated in this study about the theme of supply chain network design.

References

[1] Govindaraju, Basu; Jeyasingam, John; Habib, Mamun et al, *A Structural Equation Model for the Study of Sustainable Performance by Private Universities in Malaysia*. International Journal of Supply Chain Management, Vol 8, No. 1, pp. 32-42, 2019.

[2] Zokaee, S.; Jabbarzadeh, A.; Fahimnia, B.; Sadjadi, S. J., *Robust supply chain network design: an optimization model with real world application*. Annals of Operations Research. Vol. 257, No. 1, pp. 15-44, 2017.

[3] Chopra, Sunil; Meindl, Peter, *Supply Chain Management: Strategy, Planning and Operations*, Pearson Education, São Paulo, 2006

[4] Zhukov, Pavel V.; Silvanskiy, Alexander A.; Mukhin, Kirill Y. et al, *Agile Supply Chain Management in Multinational Corporations: Opportunities and Barriers*. International Journal of Supply Chain Management, Vol 8, No. 1, pp. 416-425, 2019.

[5] Mangiaracina, Riccardo; Song, Guang; Perego, Alessandro, *Distribution network design: a literature review and a research agenda*. International Journal of Physical Distribution & Logistics Management, Vol 45, No. 1, pp. 506-531, 2015.

[6] Fadoli; Sam'un Jaja Raharja; Margo Purnomo et al, *Supply Chain Management Issue: Development Science Techno Park (STP) Through Small, Medium Enterprises (SMEs), Case Study of Puspiptek Serpong Indonesia*. International Journal of Supply Chain Management, Vol 8, No 3, pp. 958-965, 2019.

[7] Kummar, Sameer; Nottestad, Daniel A., *Supply Chain analysis methodology – Leveraging optimization and simulation software*. OR Insight, Vol 26, No 1, pp. 87-119, 2013.

[8] Shapiro, Jeremy, *Modeling the supply chain*, Cengage Learning, Belmont, 2006.

[9] Melo, M. Teresa; Nickel, Stefan; Saldanha-da-gama, Francisco. *Facility location and supply chain management–A review*. European journal of operational research. Vol. 196, No 1, pp. 401-412, 2009.

[10] Grant, David, *Logistics Management*, Editora Saraiva, São Paulo, 2017.

[11] Z.K.Radzhabova; O.R.Radzhabov; M.M.Osmanov et al, *Globalization of Supply Chain Management and International Relations in World Economic*. International Journal of Supply Management, Vol 8, No 3, pp. 363-368, 2019

[12] Seve, E.; Pesic, J.; Delezoide, C.; Bigo, S.; Pointurier, Y., *Learning process for reducing uncertainties on network parameters and design margins*. Journal of Optical Communications and Networking. Vol 10, No. 1, pp. 298-306, 2018.

[13] Waller, Matthew A.; Fawcett, Stanley E., *Data science, predictive analytics, and big data: a revolution that will transform supply chain design and management*. Journal of Business Logistics, Vol. 34, No. 1, pp. 77-84, 2013.

[14] Hazen, Benjamin T. et al, *Data quality for data science, predictive analytics, and big data in supply chain management: An introduction to the problem and suggestions for research and applications*. International Journal of Production Economics, Vol 154, No 1, pp. 72-80, 2014.

[15] Eskandarpour, Majid et al, *Sustainable supply chain network design: an optimization-oriented review*. Omega, Vol 54, No. 1, pp. 11-32, 2015.