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Thematic Section - Sustainability in Transportation and Logistics

Sustainability Assessment of logistics activities in a dairy: An example of an emerging economy

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Abstract

Paper aims: The objective of this paper is to evaluate the economic, social, and environmental impacts of logistics activities of a dairy producer located in Brazil.

Originality: The main contribution is to apply a quantitative approach to assessing sustainable logistics in the milk supply chain, serving as a basis for future work on this theme.

Research method: A single case study of a regional producer of dairy products in Brazil is carried out in this research. A sustainable logistics evaluation model was used that quantitatively measures the impact of transportation, storage (including inventory management and material handling activities), packaging, and acquisition activities in the economic, environmental, and social dimensions.

Main findings: It illustrates the challenge that a Small Medium Enterprise (SME) will have to expand its logistics actions, aiming to generate benefit to the consumer because of actions in the economic, environmental, and social dimensions.

Implications for theory and practice: This research expands the literature, as it brings together topics such as sustainability, logistics, supply chain, and agribusiness. The baseline is in the case study with quantitative data that allows us to answer the question of how to be sustainable now, rather than waiting for supply chains to do it first so we can discover it.

Keywords

Triple bottom line. Milk processors. Sustainable development. Supply chain management.

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1. Introduction

Sustainability in agricultural production has become an essential issue for the chain and its agents. The assessment of sustainability performance influences stakeholder decisions about how companies deal with market demand through their operational processes (Bourlakis et al., 2014). Some proposals focus on variables such as techniques, resource availability, climate, consumer demand, regulations, among others, to evaluate the effects of changes in the chains under sustainability. The purpose of these proposals is to verify the effects and strategies to guarantee the sustainability of agricultural production systems (Vayssières et al., 2009).

In agricultural production, one of the sectors that stands out in world terms due to the economic and social relevance is milk production (Dani, 2015). Milk and dairy products are an essential food group for human dietary, and milk has different ratings in terms of the level of processing (Kazancoglu et al., 2018). Although there is high consumption of raw milk (Dani, 2015), the production of other products is highlighted, such as standardized

whole milk, non-standardized whole milk, semi-skimmed milk, and skimmed milk (Kazancoglu et al., 2018). Besides the production of a large variety of processed value-added products (Dani, 2015).

Despite the tendency of food items to be produced in a complex system composed of several agents and with processes connected to supply chains (Bourlakis et al., 2014), the dairy supply chain is relatively simple. It includes three main stakeholders: dairy farming, processing and packaging, and retail (Kazancoglu et al., 2018).

However, this simplicity of chain management changes in a scenario in which milk production is concentrated in many small producers as occurs in the Brazilian context (Assis et al., 2016). At this point, the dairy supply chain becomes complex, especially when it sees logistic aspects linked to the collection in the cooling tank of the property, storage, and distribution of the milk and its derivatives, commonly performed by dairy production.

With the goal of organizational sustainability, the management of the logistics costs of the milk chain is fundamental, since the costs of collection and transportation total 30% concerning the products sold, directly affecting the economic sustainability (Dey et al., 2011; Food and Agriculture Organization of the United Nations, 2019).

From an environmental and social viewpoint, Kazancoglu et al. (2018) highlighted the impacts of logistics activity in the dairy chain. The main impacts are the increase in CO_2 emissions due to the number of trips and inefficient vehicle routing between milk collectors and processors, the inefficient use of resources due to inadequate loading of vehicles, the lack of continuous cooling of the milk tanks during transport and energy consumption due to inefficiencies during loading and movement of vehicles. Also, there are indirect aspects that affect logistics activity in the dairy chain. These are related to energy consumption, truck noise irritation, and adverse effects such as greenhouse gas emissions, water pollution, or land use.

The assessment of the economic, environmental, and social impacts of logistics activities is relevant, with the need to explore opportunities that make logistics productively efficient and sustainable (Dey et al., 2011). Therefore, this paper aims to evaluate the economic, social, and environmental impacts of the logistics activities of a dairy processor located in Brazil.

The method proposed by Campos (2018) was used to evaluate the impacts of logistics activities on sustainability, and thus, to reach the proposed objective. This method enables companies to have a global view of the sustainability impacts of transportation, inventory management, storage, material handling, packaging, and acquisition activities. Thus, this method allows the identification of impacts with higher intensity, contributing to the decision making to mitigate them.

The main contribution of this paper is to conduct a single case study to evaluate the impacts of logistics activities in a dairy producer. This point is indicated by Mariotto et al. (2014) that, despite the intense use of the case study method, reflexive and critical writings in the management area are rare in Brazilian literature and nonexistent or unknown by the researchers. Thus, the paper highlights a potential area for sustainability action. Also, it illustrates the challenge that SME (Small Medium Enterprise) will have to expand its actions to generate benefits to consumers resulting from improvements in the economic, environmental, and social dimensions.

This paper has six sections, including this introductory one containing the purpose of the research. Section 2 presents the bibliographic review, containing the relevant concepts and theories, while section 3 presents the research method. Section 4 presents the results obtained, and section 5 discusses the results identified and suggestions to mitigate the impacts of logistics activities under sustainability. Finally, section 6 brings conclusions and opportunities for future work.

2. Theoretical background

This section contains the theoretical background on sustainable logistics, dairy production chain, and studies on sustainable logistics in the dairy supply chain.

2.1. Sustainable logistics

The concept of sustainable logistics emerges as a way of integrating the three dimensions of sustainability and logistics activities. In the economic dimension, sustainable logistics aims at economic growth, efficiency, employment, and competitiveness. In the environmental dimension, the focus is on air quality, production losses, noise disturbance, management of land use, and wasteful movement. In the social dimension, the safety and health of those involved in logistics activities, access, and equity are the elements evidenced by sustainable logistics (Beskovnik & Jakomin, 2010).

Sustainable logistics helps logistics managers overcome the misuse of resources while maintaining brand value and meeting international standards and regulations established by government agencies (Dey et al., 2011).

Resource management that combines sustainability with logistics activities provides economic, environmental, and social benefits to companies. These benefits include increased asset utilization, improved customer service, increased energy efficiency, mitigation of community impacts, and improved quality of life for employees and the community (Wichaisri & Sopadang, 2013).

The use of sustainable logistics is notorious in transport activity since efficient transport networks are aimed not only at minimizing costs, but also at reducing greenhouse gas emissions, as well as at improving the quality of the service provided to the customer. Several methods have been developed to mitigate these impacts and to make the logistics network sustainable. Fuel consumption, average vehicle speed, and distance traveled are the base of these methods (Bravo et al., 2019). However, logistics is not only focused on transportation. It involves other activities, such as customer service, demand forecasting, distribution communications, inventory control, material handling, order processing, parts and service support, plant and warehouse site selection, purchasing, packaging, return handling, salvage and scrap disposal, and storage (Dey et al., 2011).

To allow companies to have an overview of the impacts caused by their logistical activities on the three dimensions of sustainability, Campos (2018) developed a method that assesses the impacts of transportation, storage activities (including inventory management and materials handling), packaging and acquisition in sustainability. Currently, it is a complete quantitative method used to evaluate sustainable logistics, considering the activities described by (Dey et al., 2011).

2.2. Milk supply chain

According to Glover et al. (2014) and Nenes et al. (2010), the milk supply chain is characterized by the presence of few agents when compared to other productive sectors. The chain consists of seven agents (Figure 1) that conduct different activities.

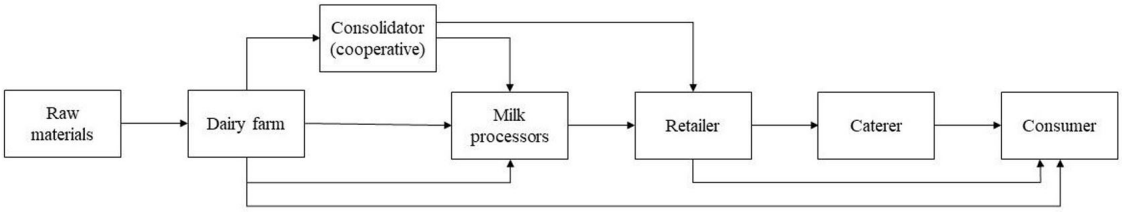

Figure 1. Milk supply chain.

It starts with suppliers of raw materials. Food suppliers (ration, canned seeds, and forage) and veterinary drugs are the most relevant. Dairy farmers, which according to Food and Agriculture Organization of the United Nations (2019) are more than 150 million households, have characteristics of diversified profile and produce milk from cow, sheep, goat, and buffalo (Haddad et al., 2017; Kazancoglu et al., 2018). The production of raw milk is intended for processing, in this case, the milk processors, which takes place directly by dairy farmers or through cooperatives. The cooperatives play the role of consolidators of dairy farm production and support their operations and strategies as well as facilitate the effectiveness of their internal governance (Haddad et al., 2017; Rezende, 2017). Milk processors are categorized as large multinationals, small processors, and on-farm processors (Nenes et al., 2010). At this stage, the milk is processed after the quality tests, generating a wide range of derivatives, such as cheese, yogurt, butter, ice cream, and pasteurized milk (Dani, 2015). The distribution of the products to the internal or external market occurs through the retailers, having catering as an intermediary or not.

2.2.1. Institutional context and leading features of the dairy sector in Brazil

World milk output is expected to reach nearly 827 million tons in 2018. In South America, milk production is expected to reach 64.0 million, up 1.1% from 2017. Brazil has a production forecast for 2018 of 34.9 million tons (Food and Agriculture Organization of the United Nations, 2018). This volume of production makes Brazil the primary producer of South America (54.5% of production) and the world's sixth-largest producer (4.2% of production).

According to Food and Agriculture Organization of the United Nations (2018), in Brazil, the truckers' strike in May 2018 disrupted milk collection and feed delivery, negatively affecting production (estimated down 1.1% from 2017). The impacts are likely to remain long because it usually takes time for milk production to recover when lactating animals are without adequate food for an extended period.

However, this fact, considered an atypical event, is not the only factor that affects the management of the milk chain in Brazil. The dairy farm is considered a weak link in the chain, and this is due to four different factors. A low level of knowledge is an educational factor. The technological factors refer to the absence of equipment for milk storage and gauging. Technical factors are the lack of technical assistance programs related to herd nutrition, reproduction, genetic improvement, management, and sanitation. Commercial factors are the absence of long-term dairy partnerships (Simões & Protil, 2015).

The logistic flow of transport in milk collection between the dairy farm and the consumers is another factor to highlight in the chain, since it represents an impact on the cost of product processing and because it is a perishable item. In Brazil, Normative Instructions of 2002, 2011, and 2018 established, over time, the standards of bulk transportation (Brasil, 2002, 2011, 2018).

Normative Instruction No. 51, 2002 (Brasil, 2002) initiated the process of normalization of the milking activity, establishing minimum criteria for milk production, identity, and quality. In 2011, with the publication of Normative Instruction No. 62, Annex VI, the process of collecting raw refrigerated milk and its transportation was regulated. At this time, it was established that the pick-up of the product in trucks with tanks in the rural property should occur through the transmission system of the truck itself, directly from the cooling tank, allowing the collective use of bulk refrigeration tanks ("community tanks"), by milk producers (Brasil, 2011). Lastly, Normative Instruction No. 76 of November 2018 established new temperature ceilings to control the collection, storage, and dispatch of milk and its conservation in milk processors (Brasil, 2018).

These new legal requirements resulted in improved logistics activities within the milk supply chain, aiding in the survival of domestic dairy products (Baptista et al., 2012). Associated with these legal provisions and the competition of the foreign market, the sector, in some geographic locations of the country, began to act to rationalize the process of milk collection, investing in refrigerated trucks and defining processes of purchase only in bulk.

Correia et al. (2012) pointed out that during this change, the milk processors closed collection points, forcing dairy farms to invest in their refrigeration process, triggering the adaptation to a new reality. According to the authors, the dairy farmers had access to superior raw material, adding value to the product and the producer.

Given this context, the introduction of the concept of logistics in the milk culture results in significant cost savings in transportation. In this sense, the closure of cooling stations, improvements for producers in the refrigeration process, reduction of collection routes, and increase of the amount of cargo transported by vehicle are highlighted (Martins, 2004). The particularities that permeate the milk agroindustry are diverse and recent, with gaps for study.

2.3. Studies on sustainable logistics in the milk supply chain

Conducting a systematic review based on the main keywords of this research[1] is noted that the studies on sustainable logistics in the milk supply chain are scarce and timely. There is no favorable evolution for the construction of theory in this crucial sector of the economy.

Van Calker (2005) brought one of the first studies integrating sustainability into milk production in the Netherlands. The author proposed to quantify sustainability at the farm level and to gain insight into the effects of management measures and farming systems on all aspects of sustainability using farm-level modeling. However, its model presented a gap in not exploring the effects of sustainability under logistical aspects.

Hamprecht et al. (2005) discussed the control of sustainability in the food chain of a multinational company that has a global performance, highlighting the differences between the cereal and milk chains. Concerning the aspect of control of logistic sustainability, the work highlighted the collection on the environmental performance, where the dairy farmers must calculate the nutritional demands of their soil annually, avoiding the super fertilization. An independent body verified this. If a value higher than control limits occurs in fresh milk, there is no transportation. Similarly, from the social viewpoint, producers were required to control labor standards as a way of guaranteeing the purchase and transportation of milk.

1 Database: Web of Science, Scopus, Taylor and Francis, and Wiley. Strings: ("sustainable logistics" AND "supply chain" AND "milk"). Parameters: Period - 1999 to 2019, articles, blind review, language English.

Wilson (2010) highlighted the need to improve the management of the fleet tires of dairy pick-up and delivery trucks. According to the author, management would be a step towards establishing a long-term sustainable logistics program that would reduce manufacturing costs and improve short-term performance.

Demeter (2011) reported actions that positively affect chain reduction. Such actions occur in the Dutch milk chain. The consumer can obtain information about the product, especially the regional ones. For the organization, it is possible to adapt production to respond to market changes. These changes are associated with adjustments in the storage system of the different types of milk, changes in the system of packaging and distribution of dairy products to enable consumer involvement with the product (with the use, for example, of RFID tags - Radio-Frequency Identification), and by means of information of provenance of the product. This scenario, in development, will be fully available to the Dutch consumer between 2020 and 2025.

Svensson & Wagner (2012) described the process of implementing a sustainable business cycle in a Swedish dairy producer, which acts in three key areas: acquisition, logistics, and product governance. The acquisition plays a leading role, acting from an economic (financial) and social viewpoint in the implementation of a code of conduct with suppliers. Logistics plays a role alongside the environmental pillar of sustainability, acting on the transport and storage of products, whether raw material or delivery to the final consumer. The product governance area acts on the identification of new business opportunities and on the implementation of innovative policies that reduce the environmental impact of the product. The study highlighted the organizational differential of performance through vertical integration, which facilitated the relationship between suppliers, generating influence in the chain control. Regarding logistics, the study merely indicated that this is an activity responsible for keeping the business cycle sustainable in terms of reducing the number of cargo vehicles, fuel use, and emissions.

Bourlakis et al. (2014) evaluated the sustainability performance of the milk chain in Greece. Among the several components evaluated, some have an impact on logistics activities. Regarding the economic pillar, logistical costs have an impact mainly on milk processors due to the high cost of distribution, resulting from the distance traveled. These points reflect the environmental pillar of energy efficiency and carbon emissions. The improvement of the sustainable performance of logistics occurs due to the reduction of extra points of sales. Wholesalers, multinational dairy manufacturers, and catering companies would carry out this distribution role because they have a superior delivery capability.

Muhammad et al. (2014) have reported the critical points of dairy supply chain management in Pakistan, which has as a characteristic possessing dairy informal channels partners. In this chain, it is common to use an informal supply chain for dairy products (98% of milk collected). It suffers from waste, as in transportation, which reaches rates of 20%, resulting from leaks, lack of cooling, and inadequate storage. In the Pakistan milk chain, there is the milk collector role (registering more than 1 million collectors in the country), which conducts the collection, commercialization, and distribution activities. These agents of the chain perform milk adulteration. They also have the financial information and are exploited by farmers. In this way, the authors bring in the article the critical points that affect the milk supply chain in Pakistan. From a logistics viewpoint, the seasonal supply of milk, poor transportation infrastructure, informal channel adulteration and bargaining power of finance and information, inefficient milk collection and processing due to lack of knowledge and technology, lack of refrigeration facilities, long-distance from production to the places of consumption and profitability of the farmer and consequent fall in product quality are highlighted.

In 2017, two articles were published focusing on one of the dimensions of the triple bottom line and tangentially acting on logistic aspects. Haddad et al. (2017) highlighted the organizational challenges faced by a Moroccan cooperative to obtain financial sustainability. Regarding the logistic aspects, the actions occurred in the storage activities (using aluminum tanks for storage and transportation of raw milk), transportation (with an increase in the frequency of collections, initiatives to improve traceability), and processing (with producer-supplied milk separation and quality testing). Powell et al. (2017) studied the application of methods to reduce waste in the Norwegian dairy chain, focusing on environmental sustainability. Logistics activities associated with loss of raw material in the movement between the links were highlighted, mainly in the processing link.

Kazancoglu et al. (2018) focused their study on the minimization of losses in the milk supply chain in Turkey, using prediction techniques to identify potential losses that affect chain sustainability. The results indicated a set of factors that affect the logistics activities of milk, such as the unbalanced relationship between dairy farmers and milk processors, which leads to environmental problems related to dairy farmers' milk collection. Milk processors look for producers in a wide geographic area and therefore travel long distances to obtain raw milk. Besides, the milk processors do not fill the desired quantity at once, increasing the number of trips. This unbalanced collection negatively affects vehicle utilization, where pickup truck tanks are generally not loaded efficiently, resulting in high-energy use for tank cooling.

The particularities that permeate the milk supply chain are diverse and recent, as discussed in the surveyed articles. Kazancoglu et al. (2018) indicated gaps in the literature regarding the reduction of losses and wastes that result in a growing problem due to its environmental, social, and economic impacts. An opportunity to explore is the study of sustainable logistics in the dairy supply chain, specifically in the relationship between dairy farmers and milk processors. Although the sustainability of the milk supply chain is thematic, the identified studies superficially explore its dimensions, as well as not go through all the logistics activities advocated in its concepts.

3. Methodology

The case study is the methodology applied to meet the objective of this research. This method becomes valid since it meets the theoretical proposal indicated by Yin (2017) and Voss et al. (2002), in which the investigation takes place on a contemporary phenomenon little explored in the context of real life. By acting on a theme whose literary focus is limited, either by its conceptual level (sustainable logistics) or by the object of research (dairy), this research is called exploratory (Voss et al., 2002; Yin, 2017).

This research is empirical by gathering data collected in the field through structured interviews, conducting a documentary analysis of literature, and internal documents provided by the organization. The collection of data of diverse types contributes to the reliability, allowing the interaction between the diverse sources of evidence and supporting the propositions (Mariotto et al., 2014). The data are quantitative in the function of the types of variables collected and are represented descriptively, establishing the causal relationship when possible (Miles et al., 2018). The analysis has an inductive characteristic, since it occurs from the specific level to the general one, although with limitations in the generalization of the results because it is only one unit of analysis (Miles et al., 2018; Yin, 2017).

The conduction of the case study followed five stages (Figure 2): case selection, procedures for data collection, selection of the instrument for data collection, analysis of the data collected, discussion and suggestive of mitigating the impacts assessed.

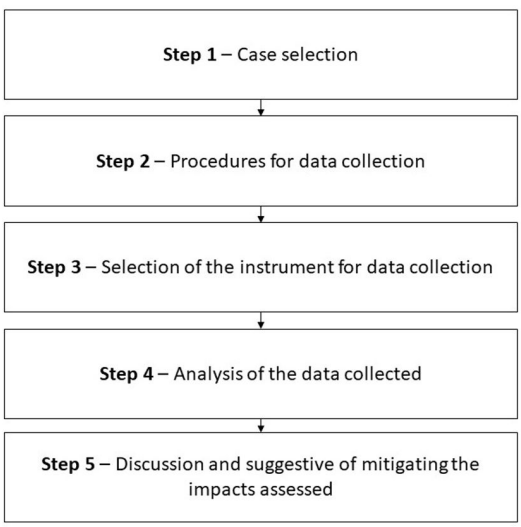

Figure 2. Case study steps. Source: Adapted from Yin (2017) and Voss et al. (2002).

The case study happened between September and October 2018 in a dairy located in the state of São Paulo, Brazil. The choice of this unit is because Brazil occupies the position of fourth world producer of milk, with the state of São Paulo accounting for 5% of this production. The respondents of the survey were two responsible for the logistic area's focus of the research, which occupy the position of logistics analyst, inventory, planning and production control, and packaging leader (Step 1). The interviews lasted 2 hours each (Step 2). They included the analysis of documents presented and a guided tour of the unit.

The instrument for collecting and analyzing the results (Step 3) was the method to evaluate the impacts of logistic activities on sustainability proposed by Campos (2018). Many methods assess the logistics activities

impacts only on the environmental dimension (e.g., Palander (2017)). Others simultaneously evaluate the economic and environmental impacts of logistics activities (e.g., Tappia et al. (2015)). The method of Tan et al. (2010) assesses the impacts of a logistics activity on the three dimensions of sustainability.

The method proposed by Campos (2018) allows companies to have an overall vision of the impacts on the three dimensions of sustainability, enabling the identification of impacts with higher intensity and consequently contributing to decision-making processes to mitigate them. Furthermore, this method is used to calculate impacts and integrate the three dimensions of sustainability as a whole. Existing methods do not consider these dimensions together.

The method is composed of 25 quantitative indicators categorized in terms of logistic activity, assessed impact, and sustainability dimension. The method uses seven indicators to evaluate the impacts of transport activity, nine indicators for storage activity (including the inventory management and material handling activities in warehouses), five indicators for packaging activity, and four indicators for acquisition activity.

The indicators used are universal, based on papers containing indicators/impacts and the references containing information to calculate the impacts. Some of the values used in the indicators for calculating impacts derive from technical reports, simulations, national and international legislation, and case studies found in the literature (Campos, 2018; Campos et al., 2019). Other values come from the application of a questionnaire structured in nine sections (Table 1).

Table 1. Structure of the questionnaire.

Section	Description	Purpose
1	Company identification and characterization	The information contained in this section aims to characterize the company surveyed
2	Road transport characterization	The information contained in this section aims to characterize the road transport of the company surveyed
3	Perceptions of road transport impacts on sustainability	To verify the degree of importance of the impacts caused by road transport on the sustainability of the company surveyed
4	Warehouse characterization, inventory management, and materials handling equipment	The information contained in this section aims to characterize warehouses, inventory management and material handling equipment used in the company surveyed
5	Perceptions of impacts on sustainability due to the storage, inventory management, and material handling	To assess the significance of impacts on sustainability caused by storage, inventory management, and material handling
6	Packaging characterization	The information contained in this section aims to characterize the packaging used during logistics operations in the company surveyed
7	Perceptions of packaging impacts on sustainability	To verify the degree of importance of impacts on sustainability caused by the packaging of the company surveyed
8	Acquisition characterization	The information contained in this section aims to characterize the acquisitions made by the company surveyed
9	Perceptions of the impacts of acquisitions on sustainability	To verify the degree of importance of impacts on sustainability caused by the acquisitions of the company surveyed

Source: Campos (2018) and Campos et al. (2019).

The impacts evaluated by indicators were classified to describe the impact intensity of logistics activities on sustainability. Impacts classified as Category 5 have the least impact on sustainability, and those classified as Category 1 have the most significant impact (Table 2).

Radar graphs show the results, where the scales, which represent the impact categories, have the same origin, and the axes of the graph represent the evaluated impacts. As bigger the area obtained in the graph, lower is the impact caused by the company on sustainability, having a sustainable balance between economic, environmental, and social efficiency (Step 4).

Table 2. Classification of impacts on sustainability.

Category	Impact on sustainability
5	Very low
4	Low
3	Medium
2	High
1	Very High

Source: Campos (2018).

Finally, in Step 5, based on data analysis carried out in the previous stage and the literature review, a discussion and indicative were carried out to mitigate the impacts of dairy logistic activities on sustainability.

4. Case results

The dairy under analysis belongs to a group active in the food supply chain. With more than 55 years of activities, the company can process 11 million liters of milk per month and works in the production of packaged milk and its derivatives, especially cheeses. Distributors and other sales channels, such as pharmacy networks, convenience stores, and small retail, carry out the distribution of the products.

4.1. Impacts of transportation activity of products

The first logistic activity evaluated is transportation. The road modal is the only means used to transport products and operates from 20 to 24 hours a day. Third parties represent 90% of the contracted fleet. The organizational fleet is composed of one own light truck (payload of 3.5 to 7.5 tons) and nine third-party light trucks (payload of 3.5 to 7.5 tons). Figure 3 depicts the results of the evaluation of this activity.

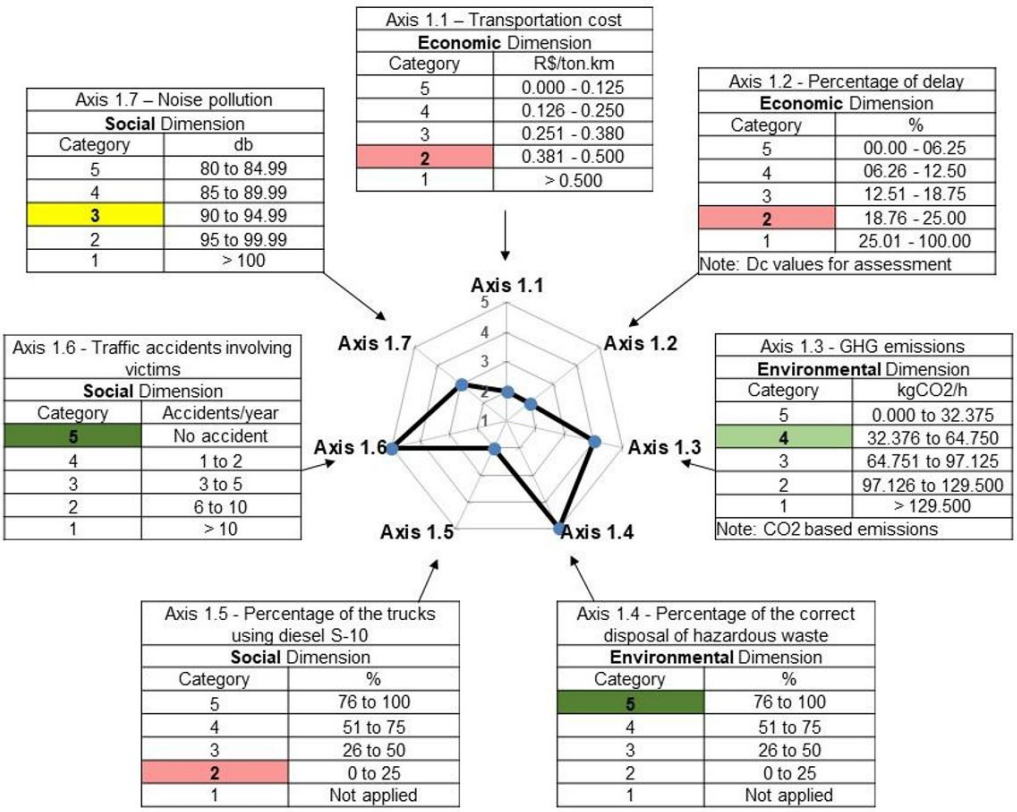

Figure 3. Evaluation of the impacts of the dairy industry's transportation of products.

The evaluated company made available the total expense generated by truck, not providing the variables to calculate the impacts of the transport activity on the economic dimension. An adjustment method of this information calculates an operating expense per vehicle of R$ 0.49 per kilometer, representing a high impact on sustainability (Axis 1.1). This result is consistent with market values. The cost of delay caused by road congestion represents a high impact on sustainability, interfering up to 25% in the value of transport operating expenses (Axis 1.2).

Regarding the environmental impacts of transport, the vehicles that make up the fleet emit an average of 54 kg of CO_2 per hour, representing a low impact on sustainability (Axis 1.3). Waste disposed of in transportation

operations has a very low impact on sustainability (Axis 1.4), because the company already reuse 85% of these wastes or discard them correctly.

When assessing the use of the S-10 diesel used by the fleet, which generates lower concentrations of GHG, only 25% of the vehicles are operating with S-10 diesel, representing a high impact on sustainability (Axis 1.5). In the last five years, the company has not recorded accidents involving victims with personal injuries or fatalities during the transportation of products, with the impact classified as very low (Axis 1.6). In the records of the noise tests of the trucks used by the company, the motors operating in 75% of its power represent an average sound intensity of 93 decibels; value classified as medium impact (Axis 1.7). This result is consistent with the information contained in technical manuals available in the literature.

4.2. Impacts of storage activity

Storage includes aspects of inventory management and material handling. The organization has a non-automated compact warehouse (<10,000 m^2), which operates seven days a week, 24 hours a day, with employees working hours of 45 weekly hours. Figure 4 depicts the results of the evaluation of this activity.

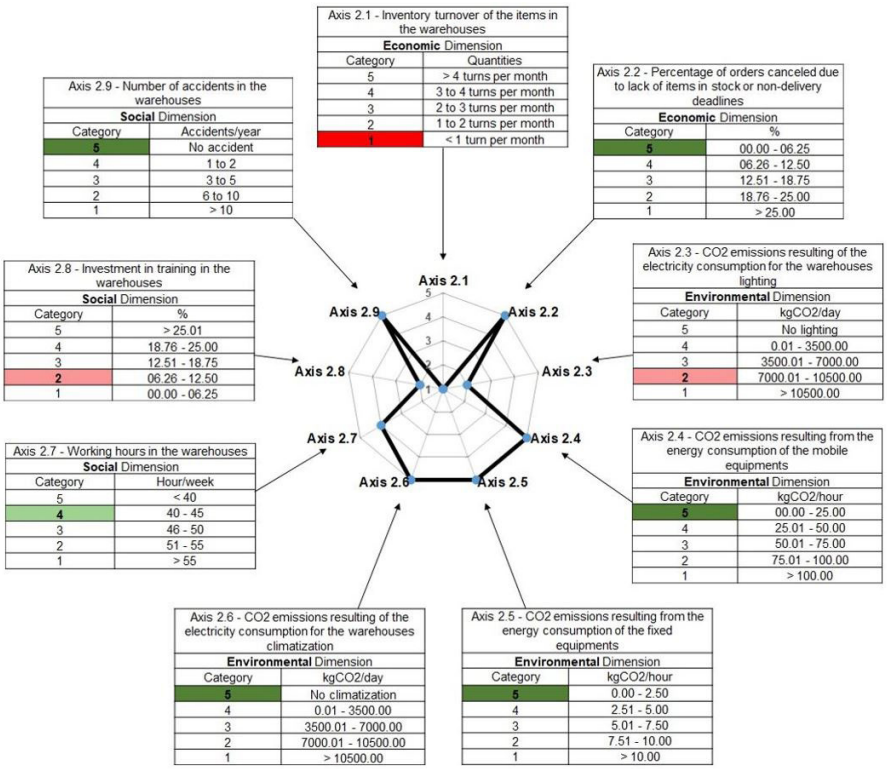

Figure 4. Evaluation of the impacts of the dairy industry's storage.

For the impacts of the storage activity on the economic dimension in the dairy industry, there is an ample possibility of improvement of inventory management, indicated mainly by the number of reduced inventory turnover (currently 0.99 per month – Axis 2.1).

Raw milk is a product that has several characteristics of an agro-industrial item (Akridge et al., 2012; Chandrasekaran & Raghuram, 2014). It is the primary raw material for the production of the derivatives, with high perishability, seasonality of production and which transmits quality and safety to the consumer. Such characteristics bring complexity in management that, when inadequate, negatively affects this dimension.

Even by-products produced by the dairy industry lack care due to the components' validity and the complexity of the management of the demand mix. The agroindustry employs the use of final product stocks to protect itself from the variation of consumption, and this results in low inventory turnover and, consequently, additional costs that impact the economic dimension, causing a loss to the organization.

On the other hand, this level of inventory allows the organization to have a low impact on losses (Axis 2.2), which is currently less than 5%.

There is a high impact on the environmental dimension resulting from the high consumption of electric energy for lighting and refrigeration of the warehouses (Axis 2.3), with a consumption of 21,000 kWh/day generating the emission of 8,578 kg CO_2/day.

However, regarding environmental impacts resulting from the storage activity, the company is in Category 5 due to the low emission of pollutants by mobile equipment, emitting 2.87 kg CO_2 per hour (Axis 2.4). This results from the use of electric forklifts that have the lowest CO_2 emission rate compared to other types of forklifts. The non-use of fixed equipment (Axis 2.5) and the non-use of air conditioning systems in the warehouses (Axis 2.6) also have very low impact.

The impact on the social dimension is very low concerning diseases and injuries affecting the health and safety of employees (Axis 2.9). The impact is low concerning working hours (Axis 2.7), since employees work 45 hours a week, in compliance with current labor standards. Investments in training by the company are 10% of sales (Axis 2.8), which results in a high impact on sustainability.

4.3. Impacts of packaging activity

Packaging activity is essential because they have characteristics such as protect and contain, unitize and apportion, communicate and offer convenience, as well enable logistics and environmental efficiency, impacting supply chain performance (Pålsson, 2018). During logistical operations, the company uses cellulose packaging (50%) and plastic packaging (50%). Figure 5 depicts the results of the evaluation of this activity.

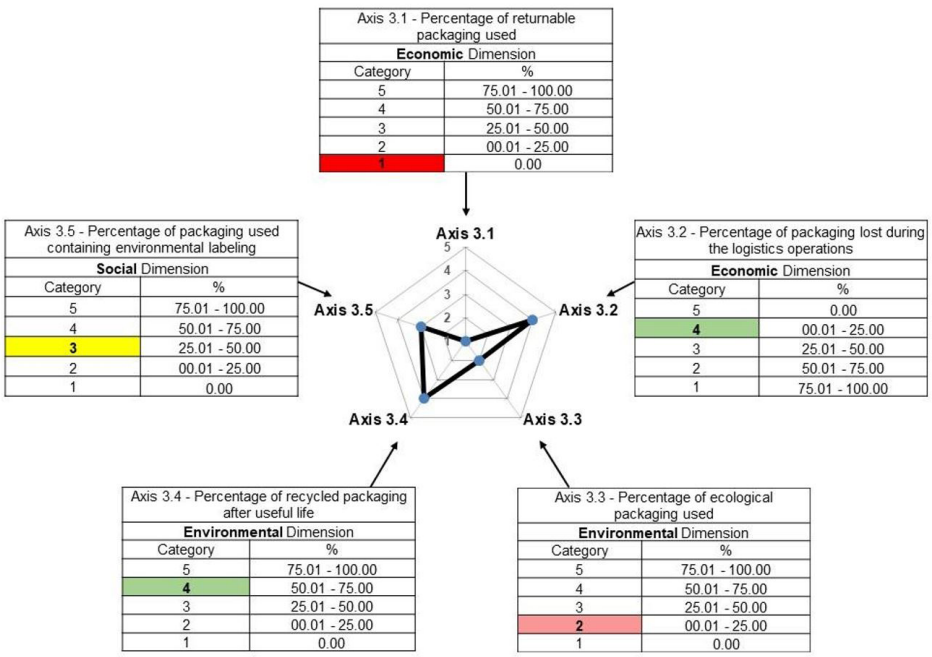

Figure 5. Evaluation of the impacts of the dairy industry's packaging activity.

Regarding the impact of the packaging activities on the economic dimension, due to legal reasons, the company does not use returnable packaging (Axis 3.1) for the storage of raw material or finished products, which generates a high impact on the acquisition of new materials. On the other hand, the activity has a low impact on the economic dimension due to the loss of 25% of the packaging during logistics operations (Axis 3.2).

Regarding impacts on the environmental dimension, the activity has a high impact due to the low use of eco-friendly packaging (Axis 3.3), represented by 25%. The packaging activity also presents a low environmental impact due to the regular disposal, through recycling of 75% of the packages after the useful life (Axis 3.4).

In the social dimension, the organization makes use of packaging with labeling containing Green Seal (Axis 3.5), which occurs for cellulose packaging, which accounts for 50% of the volume. In this way, there is a

medium impact on sustainability by not providing information to customers on the correct manufacture and disposal of products.

4.4. Impacts of the acquisition activity

The acquisition activity evaluates aspects related to the purchase of products and inputs from local suppliers, with environmental or social certification, as well as the risks that these aspects bring to the organization and society from the economic, social, and environmental viewpoint. Figure 6 depicts the results of the evaluation of this activity.

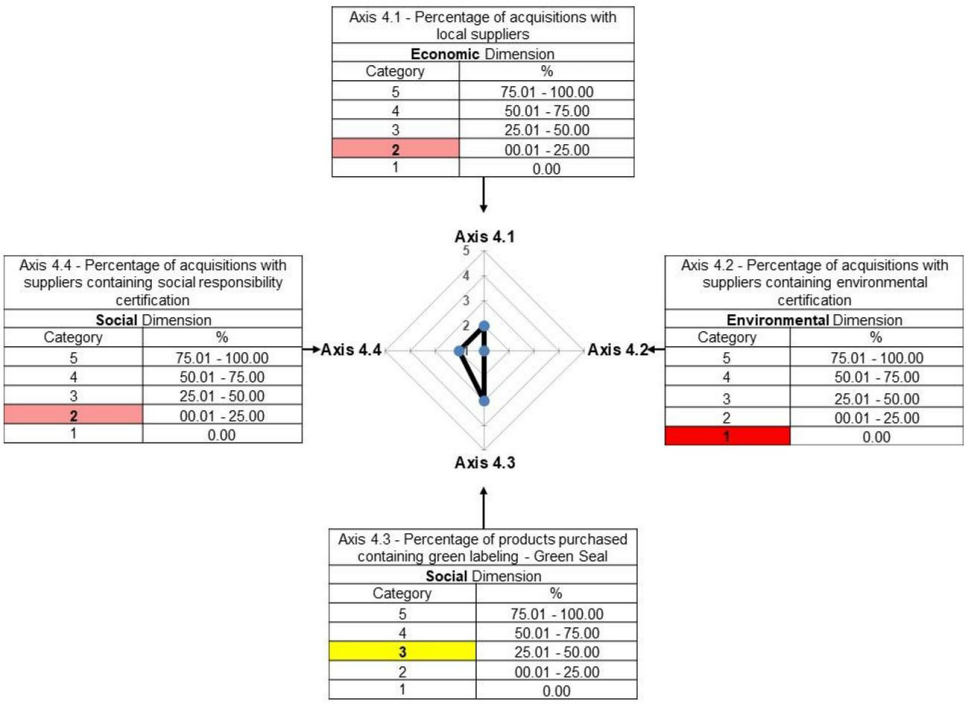

Figure 6. Evaluation of the impacts of the dairy industry's acquisitions activity.

Regarding the impact of the acquisition activities on the economic dimension, 75% of the acquisitions are carried out with national suppliers (located within a radius greater than 200 km from the production unit) and 25% with local and regional suppliers (located within a radius of 200 km from the production units). In this way, there is a high impact due to the low percentage of acquisition with local suppliers (Axis 4.1).

From the viewpoint of the environmental dimension, the organization has a very high impact by not making acquisitions with suppliers that present environmental certification (Axis 4.2).

As for the social dimension, the products acquired by the company with environmental labeling are in the range of 50%, allowing some of the customers to obtain information on the manufacture and disposal of the products (Axis 4.3). Also, the dairy industry has a high social impact, since only 25% of the purchases occur with suppliers with social responsibility certification (Axis 4.4).

5. Discussion of results and recommendations for mitigation of impacts

Among the economic impacts caused by the logistic activities evaluated (Figure 7), two axes present very high impact: mismanagement of inventories, causing costs for companies (Axis 2.1) and the non-use of returnable packaging preventing the reduction of material cost, material waste during logistical operations and the consumption of natural resources (Axis 3.1). There is also a high impact on three axes: transportation costs that interfere in product cost (Axis 1.1), delay cost generated by road congestion (Axis 1.2), and expenses and impacts arising from the purchase of products from distant suppliers (Axis 4.1).

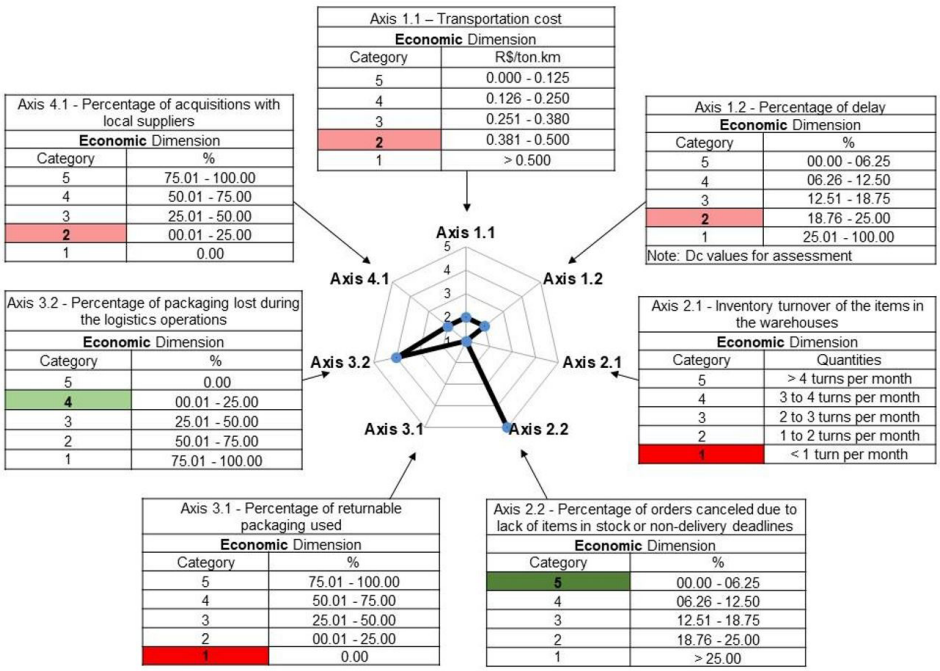

Figure 7. Economic impacts of the dairy industry's logistics activities.

It is worth evaluating in this dimension that the mismanagement of inventories occurs due to an organizational option to protect itself from the oscillations of demand, characteristics of the milk supply chain, as pointed out by (Kazancoglu et al., 2018), and that happens by customers' profile, a fact that charges the organization financially. The use of returnable materials finds a legal impediment to the dairy chain, generating the need for constant acquisition of new materials. The high operating expenses mentioned in the literature (Bourlakis et al., 2014; Kazancoglu et al., 2018) is one of the problems faced in the milk supply chain, due to the various small producers dispersed over a wide area, which hinders the process of management and optimization of the collection. Because it is in the Midwest of the state of São Paulo, the distribution of dairy products has a logistical impact, since, to reach the main consumer markets, it is necessary to travel long distances. This location similarly influences the process of acquiring the items, because, for some items in the chain, there are only suppliers located far from the factory location.

Regarding the environmental impacts caused by logistics activities of the dairy industry (Figure 8), the company has a very high impact because it does not carry out acquisitions of suppliers that present environmental certification (Axis 4.2). Besides, two axes present a high impact. Firstly, the high consumption of electric energy for lighting the warehouses (Axis 2.3) and, then, the non-use of eco-friendly packaging preventing the people's awareness about the concept of green consumption (Axis 3.3).

The improvement in the environmental dimension in high impact items can be solved. The replacement of store lighting by economical light bulbs (e.g., LED type) is a viable alternative that brings positive financial impacts to the organization, also positively affecting the economic dimension. Regarding the acquisition of ecological packaging, there is currently a concern in this market for the development and disposal of this type of product, whether it is carried out in an environmentally correct manner (Svensson & Wagner, 2012). In this way, the organization can act on the development of new suppliers of plastic packaging, which represent 50% of the acquisition process.

Regarding the social impacts caused by the dairy industry's logistics activities (Figure 9), three axes present critical impacts on the social dimension. The concentration of GHG in the air emitted by fuel used (Axis 1.5). The lack of investment, causing a lack of clarity and simplicity in operations (Axis 2.8). Also, the risks to society arising from products and services offered by suppliers not containing social responsibility certification (Axis 4.4).

The reduction of the social impact related to the concentration of GHG emitted is conditional on updating the organizational fleet. For the organization, it is necessary planning of replacement of the trucks to respect the financial situation of the organization, not affecting the economic dimension. Besides, the dairy industry

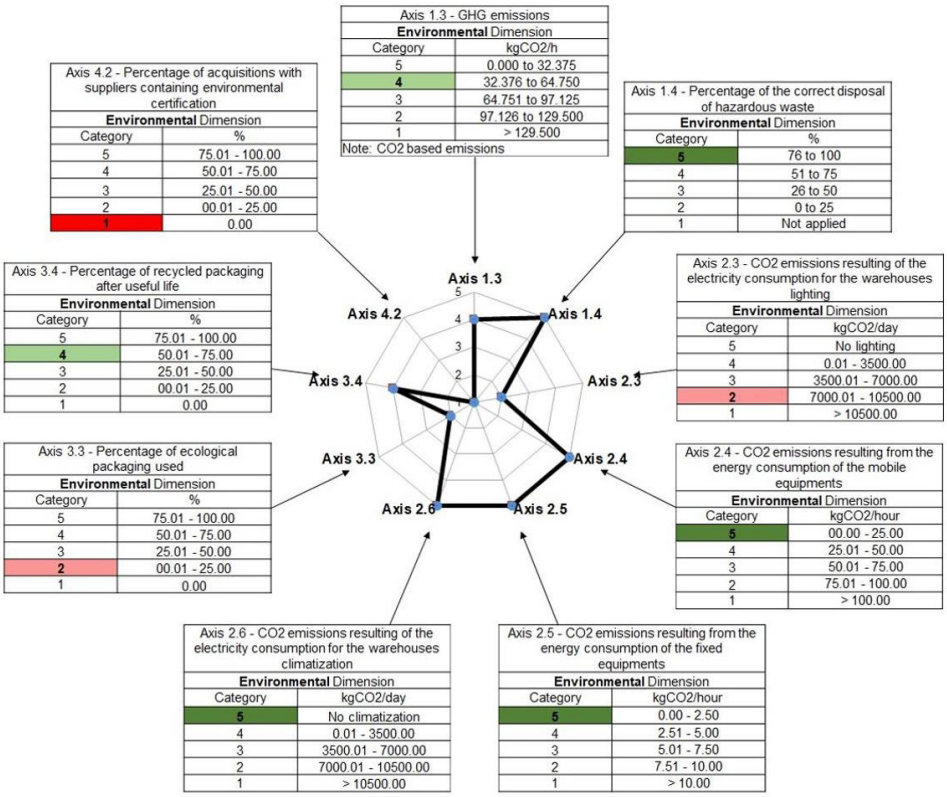

Figure 8. Environmental impacts of the dairy industry's logistics activities.

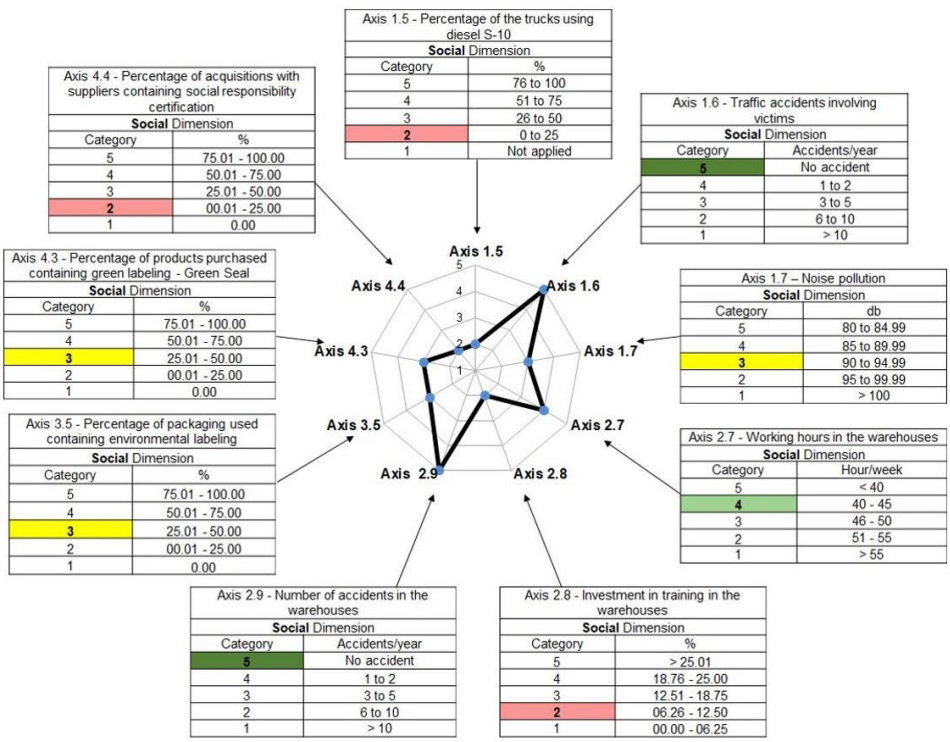

Figure 9. Social impacts of the dairy industry's logistics activities.

will benefit from trucks with better performance per kilometer wheeled, which will positively affect the cost of the product. As for environmental aspects, there is currently a consumer market concern about the origin of the products purchased, not disrespecting the standards related to social responsibility (Demeter, 2011; Svensson & Wagner, 2012). In this way, the organization can act on the development of new suppliers for acquisition, concentrating only on certified suppliers. Finally, the organization must improve the organizational environment by conducting a superior and adequate volume of training, which helps to involve staff, and this is a continuous process (Richards, 2017).

Figure 10 presents the results of the impacts of the dairy industry on the three dimensions of sustainability. The logistics activities of the company present the intensity of impact equal to 3.67 in the environmental dimension and 3.22 in the social dimension. This means that most of the evaluated impacts have low to medium intensity sustainability. In the economic dimension, the impact intensity is equal to 2.43, which indicates that most economic impacts evaluated have medium to high intensity in sustainability.

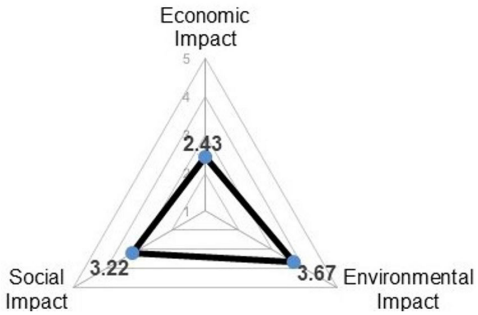

Figure 10. Impacts on the three dimensions of sustainability of the dairy industry's logistics activities.

6. Conclusion

The main objective of this research was to evaluate the economic, social, and environmental impacts of the logistic activities of a dairy industry located in Brazil. This evaluation was based on the model proposed by Campos (2018) and Campos et al. (2019), which quantitatively measures the impacts of transportation, storage (contemplating the activities inventory management and material handling), packaging, and acquisition in sustainability. The findings are based on a single case study and the findings cannot be generalized. There is a need for more empirical studies on the milk supply chain to evaluate sustainable logistics performance. The results showed that this dairy industry influences sustainability differently for each of the dimensions of the triple bottom line.

In the economic dimension, the company has impacts on the sustainability of medium to high intensity, while in the environmental and the social dimensions, most impacts are of low and medium intensity. It is interesting to note that the possible recommendations of the organization to reduce these impacts go through actions to be conducted in the short, medium, and long term.

In the short term, replacing lamps with more efficient models will bring gains to the economic dimension with lower energy costs as well as positive impacts on the environmental dimension. Also, in the short term, the conduction of training will bring benefits to the warehouse's management (social dimension), with trained employees generating fewer losses to the production process, favoring the economic dimension.

In the medium term, the organization can implement studies to improve demand management, deepening knowledge related to consumer profiles (social dimension). This will benefit the inventory management process, enabling accurate sizing and reducing inventory maintenance costs (economic dimension). Another action plan is a study to optimize collection points and routes, as performed by (Haddad et al., 2017). The chain has a high number of milk producers, which would positively affect losses due to delays due to stoppages (economic dimension), besides the reduction of GHG emission (environmental dimension). It also acts under the social and environmental dimensions by developing new suppliers committed to the supply of packaging with Green Seal and acting with social responsibility.

In the long term, the study indicates that replacing trucks with vehicles that accept less polluting fuels will bring benefits to the environmental dimension; however, planning should be well done to not affect the organization's financial issues (economic dimension).

Based on these research results, there are three main contributions of this paper to the literature. The first one is the application of a quantitative evaluation model that portrays the assessment of the dimensions of sustainable logistics in the milk supply chain. The second one refers to impacts ranging from low to high intensity on the triple bottom line applied to the organization studied. Last but not least, the third one refers to the needed for other studies to evaluate sustainable logistics in the dairy chain aiming to envisage collective improvement actions.

This research expands the literature since it brings together themes such as sustainability, logistics, supply chain, and agribusiness. It was based on a single case study with quantitative data that allow answering the question of how to be sustainable now, rather than waiting for supply chains to do it first so we can discover it. At this point, the research contributes positively to the sustainable supply chain, as proposed by Pagell & Shevchenko (2014). Conducting the study in an emerging country (Brazil) and participant in the BRIC is relevant for academics from developing countries (Gunasekaran et al., 2014).

Additionally, the development of this work relies on the fact that studies on sustainable logistics in the milk supply chain are scarce and all kind of contribution to the theory is relevant. We understand that although the studies that conduct case studies are subject to criticism due to methodological limitations, this research strategy offers the possibility of developing new theories and increasing the understanding of real and contemporary events. We believe that in this field, this work can be considered one of the first studies in that direction. Another point to consider is that this paper presents a quantitative approach to state-of-the-art literature, usually based on qualitative studies when it addresses sustainable logistics in the milk supply chain. This case study was conducted using a robust method for data collection and analysis. The necessary rigor was applied for the presentation of results and the generation of conclusions supported by the evidence. Although it cannot be generalized, it provides enough information for replication, allowing other case studies to be conducted in a group of companies in the same segment leading to results that may eventually be generalized. As for recommendations for additional search, we suggest conducting multiple case studies across a more significant number of companies in the same segment to evaluate the economic, social, and environmental impacts of logistics activities and the way each company deals with the subject.

References

Akridge, J. T., Barnard, F., & Dooley, F. (2012). *Agribusiness management*. New York: Routledge, Oxon.

Assis, J., Ferreira, J. D., Martins, H. H., & Schneider, M. B. (2016). Cadeia produtiva do leite no Brasil no contexto do comércio internacional. *Revista de Ciências Empresariais*, *17*(1), 63-93. http://dx.doi.org/10.25110/receu.v17i1.5199.

Baptista, A. E., Silva, W. A. C., & Araújo, E. A. T. (2012). Sistema de controles internos em empresas de laticínios da região do Alto Paranaíba/MG. *Custos e @gronegócio on Line, 8*(4), 100-126. https://doi.org/10.5935/2238-6416.20120060.

Beskovnik, B., & Jakomin, L. (2010). Challenges of green logistics in Southeast Europe. *Promet – Traffic&Transportation, 22*(2), 147-155.

Bourlakis, M., Maglaras, G., Gallear, D., & Fotopoulos, C. (2014). Examining sustainability performance in the supply chain: The case of the Greek dairy sector. *Industrial Marketing Management*, *43*(1), 56-66. http://dx.doi.org/10.1016/j.indmarman.2013.08.002.

Bravo, M., Pradenas, L., & Parada, V. (2019). An evolutionary algorithm for the multi-objective pick-up and delivery pollution-routing problem. *International Transactions in Operational Research*, *26*(1), 302-317. http://dx.doi.org/10.1111/itor.12376.

Campos, R. S. (2018). *Proposta de um método para avaliação dos impactos das atividades logísticas na sustentabilidade* (Dissertação de mestrado). Universidade Metodista de Piracicaba, Piracicaba. Retrieved in 2019, March 15, from https://www.unimep.br/phpg/bibdig/aluno/visualiza.php?cod=1838

Campos, R. S., Simon, A. T., & Martins, F. C. (2019). Assessing the impacts of road freight transport on sustainability: A case study in the sugar-energy sector. *Journal of Cleaner Production*, *220*, 995-1004. http://dx.doi.org/10.1016/j.jclepro.2019.02.171.

Chandrasekaran, N., & Raghuram, G. (2014). *Agribusiness supply chain management*. New York, NY: CRC Press. http://dx.doi.org/10.1201/b16704.

Correia, L. F. M., Pinto, A. M., Perez, R., Alves, M. P., & Carvalho, A. F. (2012). Custos de coleta de leite e avaliação da eficiência em indústrias de laticínios. *Revista do Instituto de Laticínios* Cândido Tostes, *67*(388), 15-24. http://dx.doi.org/10.5935/2238-6416.20120060.

Dani, S. (2015). Introduction to food supply chain. In S. Dani (Ed.), *Food supply chain management and logistics: From farm to fork* (1st ed., pp. 1-18). London: Kogan Page Publishers.

Demeter, R. M. (2011). *Innovations in the dairy chain: Bio-economic analysis of novel breeding opportunities* (Doctor thesis). Wageningen University, Wageningen. Retrieved in 2019, March 7, from http://edepot.wur.nl/188948

Dey, A., Laguardia, P., & Srinivasan, M. (2011). Building sustainability in logistics operations: A research agenda. *Management Research Review*, *34*(11), 1237-1259. http://dx.doi.org/10.1108/01409171111178774.

Food and Agriculture Organization of the United Nations. (2018). *Dairy market review*. Rome: FAO.

Food and Agriculture Organization of the United Nations. (2019). *Milk production*. Rome: FAO. Retrieved in 2019, March 13, from http://www.fao.org/dairy-production-products/production/en/

Glover, J. L., Champion, D., Daniels, K. J., & Dainty, A. J. D. (2014). An Institutional Theory perspective on sustainable practices across the dairy supply chain. *International Journal of Production Economics*, *152*, 102-111. http://dx.doi.org/10.1016/j.ijpe.2013.12.027.

Gunasekaran, A., José, C., Jabbour, C., & Beatriz, A. (2014). Managing organizations for sustainable development in emerging countries: an introduction. *International Journal of Sustainable Development and World Ecology*, *21*(3), 195-197. http://dx.doi.org/10.1080/13504509.2014.915439.

Haddad, N. O., Ton, G., Sraïri, M. T., & Bijman, J. (2017). Organizational challenges of moroccan dairy cooperatives and the institutional environment. *International Journal on Food System Dynamics*, *8*(3), 236-249. http://dx.doi.org/10.18461/ijfsd.v8i3.835.

Hamprecht, J., Corsten, D., Noll, M., & Meier, E. (2005). Controlling the sustainability of food supply chains. *Supply Chain Management*, *10*(1), 7-10. http://dx.doi.org/10.1108/13598540510578315.

Kazancoglu, Y., Ozkan-Ozen, Y. D., & Ozbiltekin, M. (2018). Minimizing losses in milk supply chain with sustainability: An example from an emerging economy. *Resources, Conservation and Recycling*, *139*, 270-279. http://dx.doi.org/10.1016/j.resconrec.2018.08.020.

Mariotto, F. L., Zanni, P. P., & Moraes, G. H. S. M. (2014). What is the use of a single-case study in management research? *Revista de Administração de Empresas*, *54*(4), 358-369. http://dx.doi.org/10.1590/S0034-759020140402.

Martins, R. S. (2004). Development of a logistic tool to optimized the milk supply of an agricultural cooperative. *Gestão & Produção*, *11*(3), 429-440. http://dx.doi.org/10.1590/S0104-530X2004000300014.

Miles, M. B., Huberman, A. M., & Saldana, J. (2018). *Qualitative data analysis: A methods sourcebook* (4th ed.). London: SAGE Publications.

Brasil. Ministério da Agricultura Pecuária e Abastecimento. (2002, setembro 19). *Regulamento de Inspeção Industrial e Sanitária de Produtos de Origem Animal (Instrução Normativa n° 51, de 19 de setembro de 2002)*. Diário Oficial da República Federativa do Brasil.

Brasil. Ministério da Agricultura Pecuária e Abastecimento. (2011, dezembro 29). *Coleta de leite cru refrigerado e seu transporte a granel (Instrução normativa n° 62, de 26 de dezembro de 2011)*. Diário Oficial da República Federativa do Brasil.

Brasil. Ministério da Agricultura Pecuária e Abastecimento. (2018, novembro 26). *Dispõe sobre os Regulamentos Técnicos que fixam a identidade e as características de qualidade que devem apresentar o leite cru refrigerado, o leite pasteurizado e o leite pasteurizado tipo A (Instrução normativa n° 76, de 26 de novembro de 2018)*. Diário Oficial da República Federativa do Brasil.

Muhammad, Z., Akhter, S. N., & Ullah, M. K. (2014). Dairy supply chain management and critical an investigations on dairy informal channel partners in Pakistan. *IOSR Journal of Business and Management*, *16*(3), 81-87. http://dx.doi.org/10.9790/487X-16358187.

Nenes, G., Panagiotidou, S., & Tagaras, G. (2010). Inventory management of multiple items with irregular demand: A case study. *European Journal of Operational Research*, *205*(2), 313-324. http://dx.doi.org/10.1016/j.ejor.2009.12.022.

Pagell, M., & Shevchenko, A. (2014). Why research in Sustainable Supply Chain Management should have no future. *The Journal of Supply Chain Management*, *50*(1), 44-55. http://dx.doi.org/10.1111/jscm.12037.

Palander, T. (2017). The environmental emission efficiency of larger and heavier vehicles: A case study of road transportation in finnish forest industry. *Journal of Cleaner Production*, *155*(1), 57-62. http://dx.doi.org/10.1016/j.jclepro.2016.09.095.

Pålsson, H. (2018). *Understanding and managing the economic and environmental impacts of packaging in supply chains* (1st ed.). London: Kogan Page Publishers.

Powell, D., Lundeby, S., Chabada, L., & Dreyer, H. (2017). Lean Six Sigma and environmental sustainability: The case of a Norwegian dairy producer. *International Journal of Lean Six Sigma*, *8*(1), 53-64. http://dx.doi.org/10.1108/IJLSS-06-2015-0024.

Rezende, M. L. (2017). *Governança em um laticínio da região Sul do Estado de Goiás sob a ótica da economia dos custos de transação (ECT)*. Catalão, Goiás: Universidade Federal de Goiás.

Richards, G. (2017). Role of warehouse manager. In G. Richards (Ed.), *Warehouse management: A complete guide to improving efficiency and minimizing costs in the modern warehouse* (1st ed., pp. 26-40). London: Kogan Page Publishers.

Simões, A. R. P., & Protil, R. M. (2015, Julho 28). Revelação das preferências dos produtores de leite na escolha de um laticínio: uma abordagem Multicritério. In *53° Congresso da Sober* (pp. 1-17). João Pessoa: Embrapa.

Svensson, G., & Wagner, B. (2012). Implementation of a sustainable business cycle: The case of a Swedish dairy producer. *Supply Chain Management*, *17*(1), 93-97. http://dx.doi.org/10.1108/13598541211212230.

Tappia, E., Marchet, G., Melacini, M., & Perotti, S. (2015). Incorporating the environmental dimension in the assessment of automated warehouses. *Production Planning and Control*, *26*(10), 824-838. http://dx.doi.org/10.1080/09537287.2014.990945.

Tan, K. S., Daud Ahmed, M., & Sundaram, D. (2010). Sustainable enterprise modelling and simulation in a warehousing context. *Business Process Management Journal*, *16*(5), 871-886. http://dx.doi.org/10.1108/14637151011076511.

Van Calker, K. J. (2005). *Sustainability of dutch dairy farming systems: a modelling approach* (Doctor thesis). Wageningen University, Wageningen.

Vayssières, J., Guerrin, F., Paillat, J. M., & Lecomte, P. (2009). GAMEDE: A global activity model for evaluating the sustainability of dairy enterprises Part I - Whole-farm dynamic model. *Agricultural Systems*, *101*(3), 128-138. http://dx.doi.org/10.1016/j.agsy.2009.05.001.

Voss, C., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. *International Journal of Operations & Production Management*, *22*(2), 195-219. http://dx.doi.org/10.1108/01443570210414329.

Wichaisri, S., & Sopadang, A. (2013, December 10-13). Sustainable logistics system: A framework and case study. In *2013 IEEE International Conference on Industrial Engineering and Engineering Management* (pp. 1017-1021). Bangkok, Thailand: IEEE. http://dx.doi.org/10.1109/IEEM.2013.6962564

Wilson, D. (2010). Tire management: a key sustainable logistics building block. *Dairy Foods*, *111*(2), 62.

Yin, R. K. (2017). *Case study research and applications: Design and methods* (6th ed.). Thousand Oaks: SAGE Publications.