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COLLABORATIVE LOGISTICS AND ECO-EFFICIENCY INDICATORS: AN ANALYSIS OF SOY AND FERTILIZER TRANSPORTATION IN THE PORTS OF SANTOS AND PARANAGUÁ

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ABSTRACT

The present study aims to investigate the use of collaborative logistics between soybean export and fertilizer import operations in the main logistical corridors in the state of Mato Grosso to the ports of Santos and Paranaguá, aiming to identify, analyze and propose an indicator of eco-efficiency that seeks to reduce the financial and environmental impacts of this practice. For that, two scenarios were analyzed, namely: base and ideal. In the ideal scenario, the entire imported fertilizer load participates in collaborative logistics. The base scenario was defined by applying a questionnaire to 96 drivers working in the ports of Santos and Paranaguá, thus identifying the incidence of trucks that return loaded from the port areas with fertilizers. Comparing the base scenario with the ideal scenario, the potential impact regarding the costs of road transport of fertilizers is around R$ 14,696,509.89 in the port of Santos and R$ 11,806,055.10 in Paranaguá, totaling R$ 26,502,564.99. In the ideal scenario, there was a reduction in CO_2 emission during 2018 in the order of 29.48 kg CO_2 per ton transported in the port of Santos, with the reduction obtained in Paranaguá was 14.38 kg CO_2 per ton.

Keywords: Collaborative Logistics; Agricultural Commodities; Eco-efficiency; Indicators.

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1. INTRODUCTION

The expansion of intercontinental markets and increasing competition has driven companies to migrate from pure and exclusive private jobs, pushing their boundaries to partnering with other organizations, thus resulting in significant flexibility to enhance competitiveness and reach common interests. This view is understood as collaboration and thus evidences an instrument capable of providing competitive advantage and enabling all joint businesses of companies to prevail and thrive, as it has benefits such as cost reduction, operational flexibility, forecast accuracy, among others (FERREIRA; FERREIRA; PALHARES, 2015).

A sustainability factor in supply chains is transportation. In most developed countries, roads are the main mode of transportation; therefore, it represents a significant part of the global environmental impact of logistics. Therefore, to optimize the use of vehicles is a very effective improvement for sustainability, creating both environmental and economic benefits (MCKINNON; BROWNE; WHITEING, 2012).

The environmental results from better vehicle use are reducing greenhouse gas (GHG) emissions, traffic levels, noise and urban congestion. Vehicle sharing, as a means of collaborative transportation, can increase the utilization rate of trucks, reducing the number of trips that a vehicle would make empty, generating environmental advantages (MCKINNON; BROWNE; WHITEING, 2012).

It is in this context that Collaborative Logistics arises, which, by the essence of its foundation, represents collaboration between partners in the logistics chain (suppliers, customers, consumers or other participants). Everyone involved works and collaborates with the project or service in question. This is a joint effort, characterized by the high degree of commitment formalized among all members, always showing the greater objective of being effective in the actions taken, mitigating losses and optimizing the resources used (BOWERSOX *et al.*, 2014).

By addressing issues related to the economic and environmental problems that such practices cause to the market and to the environment, many concepts can be related to this context. This research focuses on eco-efficiency, which is increasingly becoming a key requirement for business success. The perspective of eco-economic efficiency, commonly known as eco-efficiency, emerged in the 1990s as a practical approach to the broader concept of sustainability. Eco-efficiency is the reduction of resource intensity and minimization of

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environmental impacts caused by the production of products or services, along with the creation of value through continuous process improvement. Therefore, its basic idea is to produce more with less impact on the environment.

Given the importance of the transportation sector in greenhouse gas emissions and the possibility of applying the concept of collaborative logistics seeking to reduce CO_2 emissions and transportation costs, the purpose of this research is to estimate the environmental benefits, focusing on reducing CO_2 emissions and transportation cost, from the logistic collaboration between the export flows of soy produced in the state of Mato Grosso through the ports of Santos and Paranaguá and importation of fertilizers by these ports destined for the state of Mato Grosso, thus implying the optimum use of the vehicles in the operation. Therefore, we evaluated the hypothesis that the collaboration between these two product streams would enable environmental gains generated from the reduction of CO_2 emissions and transportation costs.

1.1. Overview and perspectives of soy and fertilizers in Brazil

The participation of soy in Brazilian agribusiness is relevant because it symbolizes a milestone in the process of evolution of the national agribusiness. Its influence is so remarkable that it clearly shows the division of this process into two parts: first, a subsistence agriculture and then, the presence of soy with the characterization of business agriculture. For this reason, soybean implantation in Brazil has taken areas in several regions of the country, becoming a factor of economic and social development. It is worth noting, however, that since 2014, soybeans have come to lead the country's export agenda with 14% of exports (DALL'AGNOL, 2016).

The significant increase in soybean production in Brazil is largely due to the expansion of cultivated areas, which left the south of the country and gained other regions, but it must not be forgotten that productivity also contributed to this achievement. However, the average agricultural yield for soy has reached a level of productive equilibrium, where average yield is optimized by the support that comes from the level of performance and availability of key production resources and also by the degree of technology employed, commercially and economically propagated as feasible (CONAB, 2018).

In analyzing the soybean landscape in Brazil, we note that the country is the main exporter and the second largest producer in the world, behind only the United States. Soybean cultivation is present in all regions of the country, but with greater representation in the

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Midwest region, which holds approximately 50% of national production, with the state of Mato Grosso being the largest producer, followed by the states of Paraná and Rio Grande do Sul (COÊLHO, 2018).

Conab's (2018) statistical records consolidate soybeans as the main product in Brazil's agribusiness performance and traditionally motivates the increase of national grain production. This crop's data for the 2018/19 harvest are shown on Table 1.

Table 1: Comparative soybean scenario – crops of years 17/18 and 18/19

INDICATOR	**CROP**		**VARIATION**	
	2017/18	**2018/19**	**Absolute**	**%**
Area (ha x 1.000)	35.149	36.125	976	2,78
Production (t x 1.000)	119.282	119.267	- 15	- 0,01
Productivity (kg/ha)	3.394	3.302	- 92	- 2,71

Source: Adapted from Conab, (2018).

The Ministry of Agriculture, Livestock and Supply reported that exports of the soy complex for October 2018 increased 78.8% compared to the same month of the year before, representing $ 2.62 billion. Much of this value is driven by soybean exports, which hit a record volume in October, with 5.35 million tons, which also reflected a record value for October of US $ 2.11 billion (BRAZIL, 2018).

From this point, we note that agricultural productivity growth correlates with the use of a set of inputs: chemical fertilizers, which can be defined as an organic or mineral product, synthetic or natural, and which provide with more plant nutrients to the ground. However, it is observed that there are numerous obstacles to distribution until reaching the final consumer, highlighting the logistical bottlenecks, as well as the seasonality of trucks in the ports. A known problem due to this imbalance between supply and demand is the fluctuation of freight prices throughout the year, directly impacting the final value of the product.

Although a major producer of agricultural commodities, Brazil has soils with low nutrient rates, making it dependent on fertilizer application to ensure the quality of agricultural production, as previously described. However, the country is not self-sufficient in the production of fertilizers, thus depending on the importation of these products, making it vulnerable to international market price variations, which directly impacts the costs of domestic agricultural production (TEIXEIRA, 2010).

According to data from the National Fertilizer Diffusion Association (ANDA, 2018), Brazil is the 4th largest consumer of nitrogen and the 3rd for phosphorus in the world. Despite

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these data, Brazilian fertilizer production is restricted to only 3% of all world production, thus making it a major importer of soil nutrients Anda (2018). Figure 1 shows the fertilizer load delivered to the domestic market from 2015 to 2018.

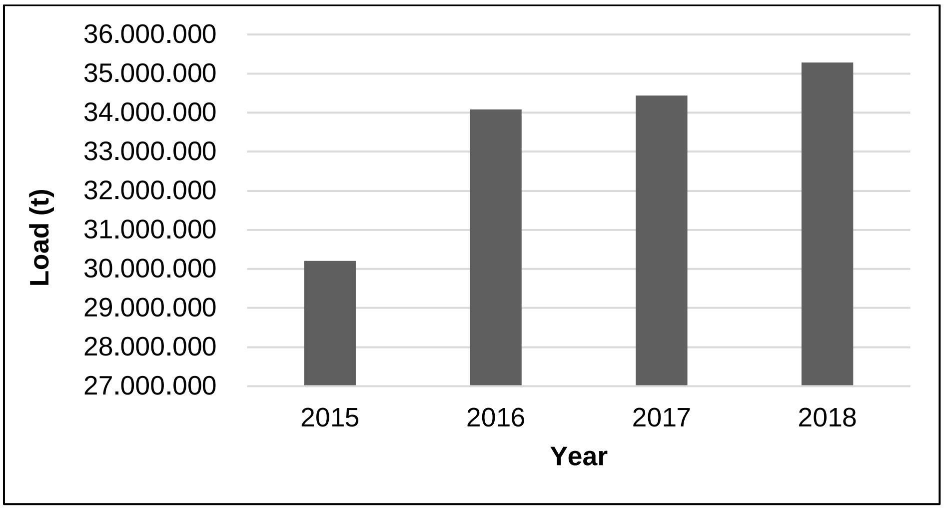

Figure 1: Fertilizer load history delivered to the domestic market (2015 - 2018)
Source: Adapted from Anda, (2018).

We can see on Figure 1 that the load of fertilizers delivered to the domestic market in 2015 corresponded to approximately 30 million tons, while in 2018 this load increased to over 35 million tons. Between 2016 and 2017, the total load of fertilizers delivered to the market increased by only 1%. In Brazil, it is known that the growth of agricultural productivity depends directly on the use of these inputs.

Despite the heavy dependence, approximately 70% of the products used come from the international market, and in 2017 Brazil consumed approximately 34 million tons of fertilizers, of which 23.9 million tons were imported.

The load of fertilizers delivered to the domestic market is concentrated from August to November, with a peak demand in 2018 of approximately 5 million tons delivered in a single month. From November onwards, we noticed the drop in delivery, with the lowest demands in April and May.

This fact directly reflects the transportation costs, as it raises the price of freight. Agricultural inputs (in the form of intermediate products or raw materials) are purchased overseas at prices that are formed via the international market, arising from worldwide demand and supply.

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1.2. Collaborative Logistics

Collaborative logistics is best known in the Brazilian freight transportation scenario as return freight, which in turn is nothing more than the integration, through the same transportation equipment (truck), between product flows in opposite directions. In the case of soybean and fertilizers, it is noteworthy that the main destination of Brazilian soybeans is exportation, that is, it is destined for the port areas, while fertilizers have approximately 75% of their volume coming from imports and aimed to be applied on producing farms (SNA, 2019).

The municipality of Sorriso (MT) can be used as an example, which is the largest exporter of grains in Brazil and at the same time has one of the largest demands for fertilizers in the country, and the flows of these two products have opposite directions, i.e., the grains originate in the municipality and are directed to the port areas, for later exportation. Fertilizers, on the other hand, originate in port areas, from imports, and intended for agricultural application in the municipalities of the state of Mato Grosso. Thus, the collaborative logistics presents a great cost reduction potential, optimizing the use of fuels in the operation.

In the international literature, collaborative logistics is treated as a form of company strategy to reduce costs and increase its efficiency. Chung *et. al* (2018) described collaborative logistics as a functional collaboration that leads to integration economies, coordinating interdependent activities. Still in this line, Carvalho *et al.* (2016) believed that collaboration in the logistics process can simplify and make process development time and quality more effective by exploiting the knowledge of specific people of these processes working within the organization.

In the supply chain circuit, collaborative logistics has become a new relationship trend among the main players involved, as it provides benefits to the organization's strategic plans. This practice provides cost reduction, service level increase, inventory reduction, operations flexibility and business consolidation (ZHOU; HUI; LIANG, 2011).

Therefore, the collaborative logistics stands out as a different conception of the organizations' performance, either by the way of performing the activities in which the joining of forces strengthens the competitiveness, as well as strengthening the supply chain, in order to offer the consumers advantages by the aggregation of value to products. This is about providing benefits to everyone who participates in the logistics process. However, alignment of strategic purposes with partners is necessary for success.

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Achieving collaboration effectiveness requires a strong predisposition to trust among partners as they will share strategic information about their business. By exchanging information such as inventory levels and sales forecasting, companies can reduce cycle times, fulfill orders faster, reduce excess inventory, and improve forecasting accuracy and customer service (ALMEIDA; VIEIRA, 2013).

It is clear that commercial and economic issues, the possibility of cost reduction and increased competition are factors that lead companies to invest in collaborative logistics, as it operates within the company's organizational and strategic process, with the prospect of get answers to their plans, and expect operational benefits.

1.3. Eco-efficiency

Eco-efficiency comprehends a wider field than environmental protection, contamination control and traditional ways of addressing the liability issues of the productive sectors. This approach is usually associated with regulations and controls, as well as with additional costs for companies, which in most cases cannot assume or transfer this to the prices of their products.

Eco-efficiency clearly points not only in the direction described above, but also in the treatment of natural resources (raw materials and energy inputs). It is an approach that aims at the operation of companies, not only focusing on externalities (emissions, effluents and waste), which would be the traditional way of approaching the subject. Thus, this concept has two facets: natural resources and environmental contamination (NASCIMENTO, 2012).

As regards natural resources, one of the aspects that clearly differentiates eco-efficiency from other sustainability approaches (such as clean production, for example) is the importance attached to specific topics in the use of natural resources as elements of economic development.

Regarding indicators, they aim to measure the relationship between the environmental and financial functioning of a company, for certain environmental problems. Thus, it can be understood that the indicators are considered as a tool for decision making, evaluation of the company's operation and communication for internal and external investors (RINCÓN; WELLENS, 2011).

WBCSD (2000) structured eco-efficiency indicators provide a range of possibilities that cover the broad set of environmental aspects related to the production and use of products and services, including options to measure the "Value" of products or services. Combined, they can be used to describe the eco-efficiency of a company. All indicators are not necessarily

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applicable to all companies. Then, each company must evaluate its own business to determine what are "Business Specific" applicable and useful to management and external stakeholders, as well as generally applicable indicators.

1.4. The potential of logistics in reducing greenhouse gases (GHG)

Companies around the world are continually looking for competitive advantage. In the intensified pursuit of operational efficiency, focusing on lower costs and shorter lead times, environmental issues are often put aside. As a result, environmental aspects run the risk of becoming a future threat if their effects are not identified and measured in the same way as time and cost analyzes are done. The challenge of today's logistics management is determining how to incorporate environmental management principles into its daily decision-making process (ABBASI; NILSSON, 2012).

The transport sector's response to the challenge of reducing emissions is an irreversible shift towards sustainable transport with low CO_2 emissions. However, the alternatives in question generate economic advantages by increasing the efficiency of transportation activities, reducing the level of energy dependence and the relative consumption of fuel. Several of these measures can also bring positive reflexes in terms of travel safety, mitigating the risk of accidents (BARTHOLOMEU; PÉRA; CAIXETA-FILHO, 2016).

Considering the scenario in which the large CO_2-emitting transport sector is evident, an analysis by Palak, Ekșioğlu and Geunes (2014) about the repercussion of cargo handling activities in a distribution chain, involving a reduction scheme among the actions observed one of the most noteworthy actions was the determination of the limit for CO_2 emissions, which implies the choice of the most appropriate mode for carrying out transport operations, especially when there is a regulatory measure to be complied with.

Fuel costs represent about 30% to 40% of the operational cost of road freight transportation. In addition, it is important to highlight that logistics cooperation is one of the easiest ways to improve the environmental impact associated with road transportation. For example, Ubeda *et al.* (2011) studied the resolution of a green logistics problem in a Spanish retailer by integrating the collection and delivery activities on joint routes of the same fleet of vehicles.

2. MATERIALS AND METHOD

The soybean flows used for the present study originated in the state of Mato Grosso and in 2014, 2015, 2016 and 2017, they accounted for approximately 50% of national soy exports

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(MDIC, 2019). We evaluated the 2018 database of the Ministry of Industry, Foreign Trade and Services (MDIC) for the export flows of soy originated in the state of Mato Grosso and imports of fertilizers destined to the same state.

We obtained more information on the freight that would be necessary for this research with the Mato Grosso Institute of Agricultural Economics (IMEA) and the National Association for the Dissemination of Fertilizers (ANDA). Their reports referring to the year 2018 gave us information regarding the freights on the routes necessary for this study, as well as the validation of the estimates for the routes without precise information.

2.1. Evaluated Scenarios

In this research we compared two scenarios: Base Scenario, considering the percentage of trucks that currently return loaded from each of the ports that import fertilizers and exports soybean; and Ideal Scenario, in which all imported fertilizer participates in collaborative logistics, differently from what happens today.

For the development of this stage of the research, it was necessary the participation of truck drivers who carry out the studied routes, as well as obtaining different data, which are described below. Thus, in order to verify the incidence of collaborative logistics, a questionnaire created by the researcher of this study was applied, aiming to collect information characterizing the profile of the trucks used, the fuel consumption (loaded and empty), incidence and the impediments faced by truck drivers to carry out return shipping.

For the definition of the necessary quantity of applied questionnaires, we used the methodology proposed by Hoffman (1991). Initially it was possible to collect 154 responses, coming from truck drivers who traveled different routes and transported the most diverse types of products (grains, sugar and fertilizers), however, the responses of 96 drivers who took the delimited route were part of the study research and that commonly transported soy and fertilizers.

The questionnaire aimed to characterize the trucks, as well as to identify the incidence of collaborative logistics and their construction took place after the recognition of three variables: truck, routes and return freight. The questions regarding the truck aim to characterize the interviewee's vehicle. The load capacity of the trucks increases as axles are added to the set. The questions that characterize the routes practiced by this driver, have as main objective to obtain the average fuel consumption for such routes (round trip) and to identify the point of origin and the destination port. The questions referring specifically to return freight, seek to

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identify the representativeness of the return freight operation between soybeans and fertilizer, and also to make a qualitative approach of the limitations of the larger-scale implementation of collaborative logistics.

For the application of the questionnaire, a search was first carried out in different vehicles specialized in transport in order to find a carrier that covered the universe to be studied, from the search in sources such as the yearbook of the National Transport Confederation (CNT), National Land Transport Agency (ANTT) and specialized magazines in the area, identified the second largest national cargo road carrier, headquartered in the city of Maringá, in the state of Paraná, and with offices spread over different cities in Brazil, thus enabling the researcher's visit to the offices located in Santos/SP and Paranaguá/PR to apply the questionnaires. The company has a fleet of more than 1,600 trucks dedicated exclusively to transporting grain and is present in 19 states.

As a result of these factors, for this research it was evaluated that the fuel consumption by trucks on the highways must be taken into account from the responses obtained in the application of the questionnaires, with the average consumption of the loaded truck being 1.97 km/L and the average consumption of the empty truck is 2.95 km/L.

Regarding the conversion of fuel consumption into CO_2 emissions, it was carried out using the GHG Protocol methodology, which is the international accounting tool most used by governments and companies to understand, quantify and manage greenhouse gas emissions. It serves as the basis for almost all GHG standards and programs in the world (International Standards Organization (ISO) to The Climate Registry), in addition to hundreds of GHG inventories prepared by companies around the world (IRMA, 2017).

As for the ideal scenario, it is evident that the maximum return load per port is precisely your imported fertilizer load, therefore, in the fourth column of Table 2, the relationship between the loads of fertilizer imports compared to soybean exports by port is presented, obtained from the Ministry of Industry, Foreign Trade and Services database (2019). Thus, the maximum load that can be integrated in a collaborative logistics between soy and fertilizer as destination/origin in the state of Mato Grosso is 19.87% in the port of Paranaguá and 1.42% in the port of Santos.

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Table 2: Representativeness of the fertilizer imports compared with soy exports

Port	Soy Exports (t)	Fertilizer Imports (t)	Representativeness
Santos	8.951.457,87	127.456,66	1,42%
Paranaguá	1.040.171,02	206.723,17	19,87%

Source: MDIC, (2019).

2.2. Analysis of Transportation Costs and CO2 Emissions

The transportation cost is understood, in this investigation, as the value in BRL (R$ – Brazilian currency) so that the entire load of soy and fertilizer in the ports studied is transported.

In this context, Equation 1 is presented, which provides the value of the ton of fertilizer freight according to the total cost of the quantity of fertilizers imported, the fraction of the fleet that participates in the collaborative logistics and the total load of fertilizers.

$$\boldsymbol{VTFF} = \frac{\mathbf{CTTF}}{\mathbf{f_p} \cdot \mathbf{CTF}} \tag{1}$$

Where:

VTFF: Value per ton of fertilizer freight (R $ / t)

CTTF: Total cost of transporting fertilizers (R $)

CTF: Total fertilizer load (t)

fp: Fraction of the fleet that participates in collaborative logistics {f_p ∈R | 0≤f_p≤1}

From Equation 1, it is possible to determine the freight value for each of the trucks, using Equation 2, presented below. It is noteworthy that Equation 3 is based on the concept of freight-weight, since the freight value of the truck is obtained as a function of the load.

$$\mathbf{VFF = VTFF \cdot CMC} \tag{2}$$

Where:

VFF: Fertilizer freight value (R $)

VTFF: Value per ton of fertilizer freight (R $ / t)

CMC: Average truck load (t)

From the presentation of Equations 1 and 2, it is possible to determine the total cost of fertilizer imports necessary for soy production.

$$\mathbf{CTTF = VTFF \cdot CTF} \tag{3}$$

Where:

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CTTF: Total cost of transporting fertilizer (R $)

VTFF: Value per ton of fertilizer freight (R $ / t)

CTF: Total fertilizer load (t)

The proposed analysis of this study starts from the idea of increasing the fraction of trips in which the truck returns loaded (in this case, fertilizers), thus reducing the transportation costs of the operation. Next, discussions on environmental analyzes begin.

The environmental analysis is based on the GHG Protocol methodology, in which, as already presented, it is the most used protocol for this type of analysis. In this study, we sought to relate the GHG Protocol methodology with the proposed objectives, mainly by focusing on the idea of building indicators that aim at eco-efficiency. Thus, some changes were necessary for the objectives to be achieved.

The methodology used by the GHG Protocol Program adopts the factors converted to kg/L, and the emission factor used was 2.603 kg CO_2/L, extracted from the last update of the calculation tool released in April 2019. Diesel consumption was identified through the application of the questionnaire, where the interviewed drivers informed the average consumption of their loaded and empty vehicles for the routes of the two ports studied.

The model of analysis for this research assumes as a premise the need to transport the respective fertilizer loads necessary for its production to the state of origin of the soybean. In the mathematical modeling developed to determine the amount of CO_2, the transport capacity of the trucks, the consumption of these empty and loaded vehicles, the fraction of the fleet that returns loaded, the emission factor proposed by the GHG Protocol, as well as the total load was considered of fertilizer imported annually. Equation 4, below, describes the context presented.

$$\boldsymbol{QCO2} = \left\{ f_p \cdot \left(\frac{CTF}{CMC}\right) \cdot \left(\frac{DMT}{CMCC}\right) + (1 - f_p) \cdot \left(\frac{CTF}{\mathrm{CMC}}\right) \cdot \left(\frac{DMT}{\mathrm{CMCV}}\right) \right\} \cdot \boldsymbol{fep} \quad (4)$$

Where:

QCO_2: Amount of CO_2 produced (kg CO_2)

fp: Fraction of the fleet that participates in collaborative logistics {f_p ∈R | 0≤f_p≤1}

CTF: Total fertilizer load (t)

CMC: Average truck load (t)

DMT: Average route distance (km)

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CMCC: Average consumption of the loaded truck (km / L)

CMCV: Average empty truck consumption (km / L)

fep: Emission factor (2.603 kg CO_2 / L)

2.3. Eco-Efficiency Indicators

Aiming at the analysis of collaborative logistics in the financial performance of the routes studied in this research, we proposed a model that takes into account the total value of soybeans transported, as well as the total value of fertilizers imported according to the fraction of the fleet that returns loaded and unloaded.

Equation 5 presents this relationship and defines the financial indicator (IF).

$$\boldsymbol{IF} = \begin{cases} \mathbf{0}\,,\ \boldsymbol{se}\ \boldsymbol{f_p} = \mathbf{0} \\ \frac{f(\bar{x})}{g(\bar{y})},\ \boldsymbol{se}\ \mathbf{0} < \boldsymbol{f_p} \leq \mathbf{1} \end{cases} \quad (5)$$

Where $\mathrm{f}(\bar{\mathrm{x}}) = \mathrm{CTS} \cdot \mathrm{VFS} + \mathrm{c} \cdot \left(\mathrm{f_p} \cdot \mathrm{CTF} - \left(1 - \mathrm{f_p}\right) \cdot \mathrm{CTF}\right) \cdot \mathrm{VFF}$

$$g(\bar{y}) = \mathrm{CTS} \cdot \mathrm{VFS} + \mathrm{c} \cdot (\mathrm{CTF} \cdot \mathrm{VMFF})$$

And IF: Financial Indicator

CTS: Total soybean load (t)

VTFS: Value of ton of soy freight (R $ / t)

fp: Fraction of the fleet that participates in collaborative logistics {f_p ∈R | 0≤f_p≤1}

CTF: Total fertilizer load (t)

VTFF: Value per ton of fertilizer freight (R $ / t)

VMFF: Minimum value of fertilizer freight (R $ / t)

c: Equation weight (0≤c≤71)

It should be noted that the weight given in the equation aims to highlight the importance of collaborative logistics in the composition of the financial indicator by route, as it is understood that the ton of soybeans exported has an order of magnitude much greater than that of fertilizer.

In order to study the influence of collaborative logistics in improving environmental indicators in each of the routes studied in this research, a model is proposed that considers the

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CO_2 emissions related to the transport of soybeans to be exported, as well as the emissions related to import of fertilizers.

Thus, the Environmental Indicator took into account the information that was collected from the application of the questionnaire and then a model was proposed in which for f_p = 0 you have IA = 0 and for values of f_p> 0 and f_p≤1, you have 0 <IA≤1. Mathematically, this model is described as:

$$\boldsymbol{IA} = \begin{cases} \boldsymbol{0}, & \boldsymbol{se\ f_p = 0} \\ \frac{f(\bar{x})}{g(\bar{y})}, & \boldsymbol{se\ f_p \neq 0} \end{cases} \quad (6)$$

Where $f(\bar{x}) = \left\{\left(\frac{CTS}{CMC}\right)\cdot\left(\frac{\mathrm{DMT}}{\mathrm{CMCC}}\right) + f_p\cdot\left(\frac{CTF}{CMC}\right)\cdot\left(\frac{\mathrm{DMT}}{\mathrm{CMCC}}\right) + (1-f_p)\cdot\left(\frac{CTF}{CMC}\right)\cdot\left(\frac{\mathrm{DMT}}{\mathrm{CMCC}}\right)\right\}\cdot fep$

$$g(\bar{y}) = \left\{\left(\frac{\mathrm{CTS}}{CMC}\right)\cdot\left(\frac{\mathrm{DMT}}{\mathrm{CMCC}}\right) + \left(\frac{CTF}{CMC}\right)\cdot\left(\frac{\mathrm{DMT}}{\mathrm{CMCC}}\right)\right\}\cdot fep$$

And IA: Environmental Indicator

CTS: Total soybean load (t)

CTF: Total fertilizer load (t)

CMC: Average truck load (t)

CMCC: Average consumption of the loaded truck (km/L)

CMCV: Average empty truck consumption (km/L)

DMT: Average route distance (km)

fp: Fraction of the fleet that participates in collaborative logistics {fp ∈R | 0≤f_p≤1}

fep: Emission factor (2.603 kg CO_2 / L)

3. RESULTS

After obtaining the flows, described in the Methodology, and also the definition of the determinants of the two scenarios analyzed, which are illustrated in Table 3, the transportation cost and fuel consumption of these scenarios are calculated, taking into account that, for the ideal scenario all trucks (100%) should be loaded.

Table 3: Index of use of collaborative logistics by port and scenarios

Port	Base Scenario	Ideal Scenario
Paranaguá	76,4%	100%
Santos	61,5%	100%

Source: Authors, (2019).

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Table 4 is based on the questionnaire results and the use of descriptive statistics for the analysis of numerical variables.

Table 4: Characteristics of the fleet involved in the study obtained through the application of the questionnaire

Aspects	Port of Santos	Port of Paranaguá
Average consumption of loaded truck (km/L)	1,92	1,95
Standard Deviation	0,17	0,27
Average consumption of empty truck (km/L)	2,88	2,89
Standard Deviation	0,23	0,18
Average truck load (t)	36,00	39,00
Standard Deviation	3,00	5,00

Source: Authors, (2019).

Among the aspects that prevent the return freight from being practiced, 10 truck drivers pointed out that the main impediment is the low value of the freight and 8 truck drivers said that the most relevant reasons are the delay in loading and the lack of tipper. The other respondents did not provide answers to this question.

Next, the presentation of financial results begins, based on the analysis and comparisons of the base and ideal scenarios, for the two ports studied. All the information presented comes from the data collected from different sources and was built from the use of the equations proposed in the methodology.

Table 5 presents the calculation by port and type of product of the transportation cost, in which the average load of soybeans and fertilizers multiplied by the average freight of their respective routes, considering the 12 months of operation for the year 2018.

Table 5: Analysis of transportation cost of soybean and fertilizer in the ports of Santos and Paranaguá in 2018

Port	Product	Average load (t)	Average freight (R$/t)	Total cost of fertilizer transportation (R$)
Santos	Soy	745.955	279,82	2.504.838.796,42
Santos	Fertilizer	10.621	182,65	23.279.838,21
Paranaguá	Soy	86.681	253,44	291.065.519,14
Paranaguá	Fertilizer	17.227	197,31	37.757.792,13

Source: Adapted from MDIC, (2019); IMEA, (2019).

Fixing the port, we have the total cost of the transportation in 2018 (see Table 6). The transportation cost is calculated by multiplying the average freight and the average load per port, with the information collected in the different data sources used in this work.

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Table 6: Total transportation cost by port in 2018 identified in the databases

Port	Total transportation cost (R$)
Santos	2.528.118.634,63
Paranaguá	328.823.311,27

Source: Authors, (2019).

There is a difference in tonnage between the load of soybeans exported between the ports, as well as between the loads of imported fertilizer, in this way the rate of representativeness between the two products was calculated for each of the ports assessed. The value indicates that in the port of Santos the fertilizer load imported into the state of Mato Grosso represents about 1.4% of the total soy load exported by the state. On the other hand, at the port of Paranaguá, the imported fertilizer load destined for the state of Mato Grosso is equivalent to about 19.8% of the total exported soy load.

With the application of the questionnaire, it can be identified that in about 61% of the return trips made by the drivers interviewed in the Port of Santos, the fertilizer was the cargo transported. In the port of Paranaguá the rate was 76%. Based on these numbers, a model was applied that relates this fraction to the cost of transporting the operation, as can be seen in Table 7.

Table 7: Calculation of the transportation cost of the Base Scenario

Port	Fraction of the fleet that participates in collaborative logistics (-)	Total fertilizer load (t)	Total cost of fertilizer transportation (R $)
Santos	0,61	78.362,24	23.279.838,21
Paranaguá	0,76	157.995,567	40.789.065,875

Source: Authors, (2019).

In the column represented by Base Scenario, there is the fraction of trucks that return loaded (from the questionnaire application). If 61.5% of return trips are made with fertilizers, it means that only approximately 0.88% of the total fertilizer load is transported on trips back from the port of Santos. At the port of Paranaguá, the representativeness of the fertilizer load is greater, indicating that 15.19% of the total load is currently transported on return journeys.

Thus, as shown in Table 8, in the Ideal Scenario, the use of collaborative logistics always corresponds to 100% of the fertilizer load. Thus, the monthly cost of transportation in the port of Santos would be reduced in the Ideal Scenario to R$22,496,622.46 and the new cost in Paranaguá would be R$ 40,615,001.58.

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Table 8: Calculation of the monthly transportation cost of the Ideal Scenario

Port	Percentage of cost reduction	Estimated reduction (R $)	New transportation cost (R $)
Santos	40,59%	15.368.174,62	22.496.622,46
Paranaguá	23,89%	12.753.869,66	40.615.001,58

Source: Authors, (2019).

The total cost per trip was based on information collected about travel costs, in addition to freight. The fraction of trips in which the loaded return is given, in the base scenario, from the results observed in the application of the questionnaire. For the ideal scenario, the fraction is given by the total application of collaborative logistics in the transportation of imported fertilizers. Finally, we have the results of transportation costs for the two scenarios studied and the reduction factor, when comparing the ideal and base scenarios.

Table 9 presents a first application of the Equations presented in the methodology, covering the twelve months of the year 2018.

Table 9: Financial results obtained from the application of collaborative logistics - year 2018

Port	Base Scenario (R$)	Ideal Scenario (R$)	Estimated Reduction (R$)
Santos	2.528.118.634,63	2.514.447.781,28	13.670.853,35
Paranaguá	304.410.876,50	292.514.748,53	11.896.127,97

Source: Authors, (2019).

As we can see, there is a reduction of more than 0.5% in the costs of the port of Santos and of 4% in Paranaguá when applying the collaborative logistics between soy and fertilizers, being a joint savings of R $ 25.566.981,31 throughout 2018.

Table 10 below presents the environmental results we found from the analysis carried out in the two ports studied.

Table 10: Environmental results for the ports of Santos and Paranaguá - year 2018

Origin	Product	Amount of CO_2 produced (kg CO_2 / t)		Reduction
		Base Scenario	Ideal Scenario	
Santos	Fertilizer	94,85	65,37	31,08%
Paranaguá	Fertilizer	82,15	67,79	17,48%

Source: Authors, (2019).

In the case of the ideal scenario, in which it would be possible to apply collaborative logistics to the total load of fertilizers through the trucks that take soy to the ports of Santos and Paranaguá, there is a reduction in the year of the quotient kg in 2018 CO_2/t of approximately 31% in the port of Santos and more than 17% in the port of Paranaguá.

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3.1. Scenario Optimization - Eco-Efficiency

The analysis related to eco-efficiency proposed in this research aim to estimate the financial and environmental gains from the use of collaborative logistics. The presentation of these results begins with Table 11, indicating at the end the estimated value per ton of the financial reduction generated by the application of collaborative logistics.

Table 11: Financial result obtained with the application of collaborative logistics in the fertilizer import operation in the Port of Santos in 2018

Fraction of the fleet that participates in collaborative logistics (-)	Value of the ton of fertilizer freight (R $ / t)	Fertilizer freight value (R $)	Total cost of fertilizer transportation (R $)
0,61	297,08	10.991,95	37.864.797,09
0,65	278,93	10.320,50	35.551.789,12
0,70	255,52	9.454,22	32.567.649,31
0,75	245,23	9.073,42	31.255.874,27
0,80	226,95	8.396,98	28.925.707,85
0,85	218,79	8.095,23	27.886.230,33
0,90	191,29	7.077,83	24.381.521,78
0,95	185,47	6.862,22	23.638.797,73
1,00	181,77	6.725,63	23.168.287,20

Source: Authors, (2019).

Table 11 begins with the presentation of the collaboration fraction identified in the port of Santos from the application of the questionnaire. As previously mentioned, in this port, approximately 61% of the trucks participate in return freight. It is observed that, in this scenario, the total cost of importing fertilizers is R $ 37,864,797.09. When increasing the percentage of collaboration, the costs are gradually decreasing, as can be seen when reaching the 100% level of collaboration, in which the total import costs can reach R $ 23,168,287.20, that is, there is a reduction in costs of R $ 14,696,509.89, that is, a reduction of approximately 36% in costs in relation to the initial value.

Regarding the port of Paranaguá, it was responsible for exporting 1,040,171.02 tons of soybeans and importing 206,723.17 tons of fertilizers in 2018, at an average transportation cost of R $ 37,757 .792.00. As shown for the port of Santos, there is Table 12, in which the collaboration indexes and their respective results are present.

Table 12 begins with the presentation of the fraction of the fleet that participates in collaboration and that was identified at the port of Paranaguá from the application of the questionnaire. As previously mentioned, in this port, there is 0.76 of the fraction of the truck fleet participating in the return freight. It is observed that, in this scenario, the total cost of importing fertilizers is R$ 49,402,718.67. When increasing the percentage of collaboration, the

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costs are gradually decreasing, as can be seen when reaching the totality of collaboration, in which the total import costs can reach R$ 37,596,663.57, that is, a reduction in costs of R$ 11,806,055.10.

Table 12: Financial efficiency obtained with the application of collaborative logistics in the fertilizer import operation in the Port of Paranaguá in 2018

Fraction of the fleet that participates in collaborative logistics (-)	Value of the ton of fertilizer freight (R$/t)	Fertilizer freight value (R$)	Total cost of fertilizer transportation (R$)
0,76	238,98	9.320,22	49.402.718,67
0,80	224,31	8.747,93	46.369.218,40
0,85	213,80	8.338,33	40.198.084,43
0,90	202,60	7.901,44	39.882.316,56
0,95	191,40	7.464,55	39.566.548,64
1,00	181,87	7.092,91	37.596.663,57

Source**:** Authors, (2019).

In the analysis related to environmental efficiency, the results obtained are shown in Table 13, for the port of Santos. When considering the base scenario, with approximately 0.61 of the fleet returning loaded, there is the production of 94.852 Kg CO_2 per ton of fertilizer transported, as a larger fraction of the fleet participating in collaborative logistics, this relationship improves significantly, for example, when considering 0.84 of the fleet, there is 75.08 Kg CO_2 produced per ton transported.

Table 13: Environmental Indicator in the fertilizer import operation in the Port of Santos in 2018

Fraction of the fleet participating in collaborative logistics	Total CO_2 emission (kg CO_2)	Environmental Indicator	CO_2 emission (kg CO_2 / t)
0,61	7.432.783	-	94,85
0,65	7.546.078	0,92	90,42
0,75	7.829.316	0,95	81,38
0,85	8.112.554	0,97	74,46
0,90	8.324.982	0,98	70,56
0,95	8.431.196	0,99	68,61
1,00	8.537.410	1,00	66,66

Source**:** Authors, (2019).

As we can see, the introduction of collaborative logistics significantly improves this relationship, as emissions go from 94.85 kg CO_2/t to 66.66 kg CO_2/t when presenting the entire fleet participating in collaborative logistics.

With regard to the port of Paranaguá, Table 14 is shown, which shows that, initially, with 0.76 of the fraction of the fleet participating in collaborative logistics, there is a proportion

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of 82.25 kg of CO_2 produced per ton of fertilizer transported, whereas when 0.95 of the fleet fraction is reached, it participates in collaborative logistics, there is 70.27 kg of CO_2 produced for each ton transported.

Table 14: Result obtained with the application of collaborative logistics in the fertilizer import operation in the Port of Paranaguá in 2018

Fraction of the fleet participating in collaborative logistics (-)	Total load of fertilizers (t)	Amount of CO_2 produced (kg CO_2)	CO_2 emission (kg CO_2 / t)
0,76	157.995,567	12.994.348	82,25
0,80	166.264,494	13.176.945	79,25
0,85	176.600,653	13.405.191	75,91
0,90	186.936,811	13.633.438	72,93
0,95	197.272,970	13.861.684	70,27
1,00	207.609,128	14.089.931	67,87

Source: Authors, (2019).

The profile of the reduction of CO_2 emissions per ton of fertilizer transported at the Port of Paranaguá, when using collaborative logistics is shown in Figure 62, showing that, if the entire fleet participates in collaborative logistics, CO_2 emissions would decrease by 14, 38 kg of CO_2 produced for each ton transported.

3.2. Eco-Efficiency Indicators

About the presentation of eco-efficiency indicators, Table 15 is presented, showing the financial indicator for the year 2018 in the port of Santos.

Table 15: Transport cost indicator for 2018 at the port of Santos

Fraction of the fleet participating in collaborative logistics (-)	Total cost of fertilizer transportation (R $)	Percentage of reduction (%)	Financial Indicator
0,61	37.864.797,09	-	0,62
0,70	33.029.723,15	12,77%	0,71
0,75	30.841.787,62	18,55%	0,76
0,80	28.925.707,85	23,61%	0,81
0,85	27.233.779,53	28,08%	0,86
0,90	25.728.842,88	32,05%	0,91
0,95	24.381.521,78	35,61%	0,96
1,00	23.168.287,20	38,81%	1,00

Source: Authors, (2019).

As shown in Table 15, the load of fertilizer imported into the state of Mato Grosso represents only 1.4% of the total volume of soybeans exported by the state, a characteristic that makes it difficult to implement collaborative logistics between commodities.

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Table 16 presents the financial indicator for the year 2018 in the port of Paranaguá, following the same analysis proposal for the port of Santos.

Table 16: Behavior of the financial indicator for the year 2018 in the port of Paranaguá

Fraction of the fleet participating in collaborative logistics (-)	Total cost of fertilizer transportation (R $)	Percentage of reduction (%)	Financial Indicator
0,76	49.402.718,67	-	0,69
0,80	46.945.745,10	4,97%	0,76
0,85	44.198.084,43	10,54%	0,83
0,90	41.754.272,49	15,48%	0,90
0,95	39.566.548,64	19,91%	0,96
1,00	37.596.663,57	23,90%	1,00

Source: Authors, (2019).

As noted in Table 16, the cost reduction reaches 23.90% when all trucks in the fleet participate in the collaboration.

Regarding the presentation of environmental indicators, Table 17 shows the environmental indicator for the year 2018, in the port of Santos, where it is possible to observe that, the closer the total fleet participating the collaboration, the greater the environmental efficiency presented (reduction in CO_2 emissions per ton transported).

Table 17: Environmental Indicator for the Port of Santos in 2018

Fraction of the fleet participating in collaborative logistics (-)	Fraction of CO_2 Fertilizer (kg CO_2) - Truck loaded	Fraction of CO_2 Fertilizer (kg CO_2) - Empty truck	Environmental Indicator
0,61	5.086.211,62	3.186.542,22	0,73
0,65	5.417.121,78	2.855.632,07	0,79
0,70	5.830.759,47	2.441.994,37	0,82
0,75	6.244.397,16	2.028.356,68	0,85
0,80	6.658.034,85	1.614.718,99	0,88
0,85	7.071.672,54	1.201.081,30	0,91
0,90	7.485.310,24	787.443,61	0,94
0,95	7.898.947,93	373.805,91	0,97
1,00	8.312.585,62	39.831,78	1,00

Source: Authors, (2019).

For each ton in which collaborative logistics is used to transport fertilizer back, the percentage of reduction in the emission of greenhouse gases is improved. It is understood that, when a route that presents a large cargo movement (of soy or fertilizers), more trucks are needed and, consequently, the higher GHG emission rates. More collaboration opportunities are likely to occur if the physical movement of products is discussed as part of the commercial negotiation between companies. Many purchasing managers have traditionally held the view that responsibility for delivery is best left to the supplier, transferring responsibility for

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transportation to the selling company, resulting in better coordination of inbound and outbound deliveries.

4. CONCLUSIONS

From a sample analysis perspective, the results found are reflected in the agribusiness sector and allow discussions about elements related to transport costs and environmental benefits related to collaborative logistics, thus contributing to the greater use of this practice in Brazilian agribusiness and to research focused on this theme.

Thus, the main conclusions of this paper are:

- With the application of the questionnaire, it can be identified that in about 61.5% of the return trips made by the drivers interviewed in the port of Santos, the fertilizer was the cargo transported. At the port of Paranaguá, this index was 76.4%. The potential impact regarding the costs of transporting fertilizers by road would be around R$ 14,696,509.89 in the port of Santos and R$ 11,806,055.10 in Paranaguá, totaling R$ 26,502,564.99. In the ideal scenario, there was a reduction in CO_2 emission during 2018 in the order of 29.48 kg CO_2 per ton transported in the port of Santos, with the reduction obtained in Paranaguá was 14.38 kg CO_2 per ton.
- With the application of collaborative logistics, a reduction in the order of 379,842.89 kilometers was generated with empty trucks, 227,705.18 kilometers for the port of Santos and 152,137.71 kilometers for Paranaguá, which consequently contributes to the reduction of pollution environmental impact, as well as reducing traffic jam.

From the study carried out, it was identified that the need for greater investment in storage infrastructure, both for the final product (soy) and for the fertilizer input, thus reducing the effects of seasonality of import and export, making the flows cadenced throughout the year; creation of an information system that is easy and quick to access, so that the carrier, when loading grain inside the country, can already schedule the return cargo at the destination port; need for adequacy of the receiving infrastructures, so that conventional bulk vehicles can unload easily in the fertilizer factories.

In addition to the notes on financial costs, in which the application of collaborative logistics demonstrates significant financial savings, it is also necessary to turn to the advantages that the practice presents to the environment. Sustainable management in logistics requires an understanding aimed at companies to be able to compete and grow in highly competitive and

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constantly evolving environments. More importantly, green logistics requires an understanding of the interactions between companies' eco-efficiency, their results and financial considerations. The proposed analysis is intended to facilitate the development and application of grounded theories that explain complex causal relationships between strategic positioning, cargo transport logistics and the environment.

REFERENCES

ABBASI M.; NILSSON, F. (2012) Themes and challenges in making supply chains environmentally sustainable. **Supply Chain Management: An International Journal**. Available: https://www.emerald.com/insight/content/doi/10.1108/13598541211258582/full/html

ALMEIDA, A. M. D. P.; VIEIRA, J. G. V. (2013) Logística colaborativa: um estudo com fornecedores de supermercados de pequeno e médio porte**. Revista Gestão Industrial**. DOI: 10.3895/S1808-04482013000300011

ANDA. Associação Nacional para Difusão de Adubos. **Relatório Anual de 2018**. Available: http://anda.org.br/estatisticas/.

BARTHOLOMEU, D. B.; PÉRA, T. G.; CAIXETA-FILHO, J. V. (2016) Logística sustentável: avaliação de estratégias de redução das emissões de CO2 no transporte rodoviário de cargas. **Journal of Transport Literature**. DOI: https://doi.org/10.1590/2238-1031.jtl.v10n3a3

BOWERSOX, D.; CLOSS, D.; COOPER, M.; BOWERSOX, J. (2013) **Supply chain logistics management**. 3rd ed. New York: McGraw-Hill.

BRASIL (2018) Ministério da Agricultura, Pecuária e Abastecimento. **Balança comercial do agronegócio fica positiva em US$ 7,3 bi em outubro**. Brasília, DF, 2018. Available: http://www.agricultura.gov.br/noticias/balanca-comercial-do-agronegocio-fica-positiva-em-us-7-3-bi-em-outubro

CARVALHO, M. S.; MAGALHÃES, D.; VARELA, M. L. (2016) Definition of a collaborative working model to the logistics area using design for Six Sigma. **International Journal of Quality & Reliability Management**. DOI: 10.1108/IJQRM-11-2014-0190

COÊLHO, J. D. (2018) Produção de grãos – feijão, milho e soja. **Caderno Setorial ETENE**. Available: https://www.bnb.gov.br/documents/80223/4141162/51_graos.pdf/42dd9e02-f9fe-10fc-69ff-314f3c89faf8

CONAB (2015) Companhia nacional de abastecimento. **Observatório Agrícola: Confederação Nacional do Transporte - CNT. Sondagem CNT de eficiência energética no transporte rodoviário de cargas**. Available: http://www.cnt.org.br/Estudo/sondagem-eficiencia-energetica.

DALL'AGNOL, A. (2016) **A Embrapa Soja no contexto do desenvolvimento da soja no Brasil: histórico e contribuições**. Embrapa.

FERREIRA, R. F.; FERREIRA, K. A.; PALHARES, M. A. (2015) Logística Colaborativa na Distribuição de Autopeças e Jornais: Um Estudo de Caso. **XXXV Encontro Nacional De Engenharia de Produção**. Fortaleza. Available: http://www.abepro.org.br/biblioteca/TN_STP_206_222_26857.pdf

http://www.ijmp.jor.br v. 11, n. 5, Special Edition IFLOG 2019 - September 2020
ISSN: 2236-269X
DOI: 10.14807/ijmp.v11i5.1303

HOFFMANN, R. (1991) **Estatística para economistas**. Pioneira.

IRMA (2017) **Information Resources Management Association. Natural Resources Management: Concepts, Methodologies, Tools, and Applications**. IGI Global, 2017.

MCKINNON, A.C.; BROWNE, M.; WHITEING, A. (2012) **Green Logistics: Improving the Environmental Sustainability of Logistics**. Kogan Page Publishers, London.

MDIC (2019) Ministério do Desenvolvimento, Indústria e Comércio Exterior**. Balança Comercial – Exportações**. Available: http://www.mdic.gov.br/index.php/comercio-exterior

NASCIMENTO, E. P. (2012) Trajetória da sustentabilidade: do ambiente ao social, do social ao econômico. **Estudos Avançados**. DOI: https://doi.org/10.1590/S0103-40142012000100005

PALAK, G.; EKŞIOĞLU, S. D.; GEUNES, J. (2014) Analyzing the impacts of carbon regulatory mechanisms on supplier and mode selection: an application to a biofuel supply chain. **International Journal of Production Economics**. DOI: https://doi.org/10.1016/j.ijpe.2014.04.019

RINCÓN, E.; WELLENS, A. (2011) Cálculo de indicadores de ecoeficiencia para dos empresas ladrilleras mexicanas. **Revista internacional de contaminación ambienta**. Available: http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0188-49992011000400006

SNA (2015) Sociedade Nacional de Agricultura. **Brasil está mais dependente da importação de fertilizantes**. Rio de Janeiro. Available: https://www.sna.agr.br/brasil-esta-mais-dependente-da-importacao-de-fertilizantes

TEIXEIRA, P. P. C. (2010) **Mapeamento das unidades misturadoras de fertilizantes no estado no estado de Minas Gerais**. Escola Superior de Agricultura “Luiz de Queiroz” Universidade de São Paulo. Available: https://esalqlog.esalq.usp.br/teixeira-p-p-c-mapeamento-das-unidades-misturadoras-de-fertilizantes-no-estado-no-estado-de-minas-gerais-2010

UBEDA, S.; ARCELUS, F. J.; FAULIN. J. (2011) Green logistics at Eroski: A case study**. International Journal of Production Economics**, v. 131, n. 1. DOI: https://doi.org/10.1016/j.ijpe.2010.04.041

WBCSD (2000) World Business Council of Sustainable Development. **Measuring Eco-Efficiency. A Guide to Reporting Company Performance**. World Business Council for Sustainable Development.

ZHOU, G.; HUI, Y. V.; LIANG, L. (2011) Strategic alliance in freight consolidation. **Transportation Research Part E: Logistics and Transportation Review**. DOI: https://doi.org/10.1016/j.tre.2010.07.002