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Costs of Soybean Transportation in Piaui State, Brazil: A Case Study

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Abstract. Soybean plays an important role in world agribusiness. Nowadays, Brazil is the largest global exporter and the main impact for the country is transportation costs. These costs are influenced by the mode of transport used, distance to the cargo ports and infrastructure. The Piauí state, for instance, is the new frontier of soybean production in Brazil with a low cost of land and excellent productivity rates. However, the logistics infrastructure affects the profitability of growers and transporters. In this sense, this article analysis the transportation costs of soybean movements among Piaui regions and cargo ports and explore different scenarios considering the future implementation of the railway service. The results showed that despite efforts to improve the movement of soybean exports from Piaui state, with the building a new railway and two new routes, the current route remains the best option for growers and transporters.
Keywords: Soybean, Piaui state, Transportation costs, Competitiveness, Growers profitability.

1. Introduction

Soybean is one of the leading world commodities, being consumed in nature, as bioproducts and as the main protein source of animal feed. The major producers of this grain are Argentina, Brazil, and the United States, with China as the world-leading importer [1]. Due to the need for large planting areas and adequate climate, soybean needs to be transported over large distances domestically and abroad to be processing and consumed. Therefore, the costs and investments in the supply chain and logistics play an essential role in the competitiveness of this product.

The transportation costs in Brazil, for example, are extremely high while the land cost is very low. Hyland [2] emphasizes that soybean production costs in the United States are higher compared to South American countries; however domestic transportation costs are significantly lower. Brazil, for example, has higher grain yields at lower production costs [3], but transportation costs may reach 146% higher during the harvest [4].

The primary consumer market for soybean is China. The Chinese government has been increasing grain imports in recent years due to the growing demand determined by improved population quality of life and changes in consumption structure [5]. The imports of Chinese grain increased from 84.64 Mt in 2013 to 130.62 Mt in 2017, an increase of 54% [6].

In this scenario, Brazil appears as one of the leading global soybean exporters but faces bottlenecks relate to the lack of transport infrastructure with limited rail availability and high dependence on roadway modal [3]. The problem is increasing due to the migration of production to regions with lower land costs but with a more deficient logistics infrastructure. One of these new production centers in the state of Piaui.

The main logistical problem of the state is the lack of a port of discharge. The closest port to the Piauiense Savanna vegetation is the Port of Itaqui which operates Mato Grosso grain production and handled 8.5 million tons in 2018. The route between Piaui Savanna and Itaqui only can be made by truck. Piaui production is accounting for 9% of total Brazilian soybean exports and almost 8% of exports to China,

Currently, the road transport alternative from production to the port is the most used in the Piauiense Savanna [7] and is ongoing a railway constructing linking the city of Eliseu Martins to the ports of Pecem and Suape, in Ceara and Pernambuco state respectively.

Based on this new future opportunity to move grains from the state to the ports that the present article analyzes whether the current characteristics of logistic flow such as cost, transport time and distance impact will be improved with these new routes. For this purpose, a cost comparison was made between the current route and the projected routes, considering the distances and costs per route between the soybean-producing municipalities and the destinations.

This article is structured as follows; After the Introduction, Methodology session 2 presents different scenarios considering origin and destinations, in addition to the use of available and designed modes. This method has been used in other countries with different results. In session 3 the results of the research are presented, and the discussion was held.

2. Methodology

This paper aims to analyze the routes available for the Soybean Transport from the Piauiense Savanna to the available cargo ports and to project future situations using other modes of transport for the soybean flow to the port. The railroad used in the analyzes it is still under construction. In the near future, this railway will enable producers to make strategic decisions involving time and cost. This study also seeks to offer guidelines for new projects and to improve the logistics infrastructure of Brazilian exports of soybean, as well as grain exports in general.

Based on the research developed by Ndembe [8] on transport logistics in Australia, with the analysis of different scenarios on rail sections from origin and destination to compose transport costs and time, and studies from Ghaderi [9] who verified the system of logistics transport Vietnamese, discussing the logistics infrastructure based on strategic dimensions that involve aspects of the infrastructure, we decided to verify the case of the state of Piaui.

In addition, this study also adopted the work of Banomyong [10] who explored the various transport route alternatives and methods available for exporters from Laos, Asian countries to make it easier to sell their products to the European Union. The authors used a multimodal transport model to verify route alternatives, using the following variables: cost, time, distance, mode of transport and transshipment.

Specifically, the present study adopted the following procedures:

- First, the values of road freight were established using the values of freight provided by the Brazilian National Land Transportation Agency - ANTT [11]. The value of road freight was considered according to Resolution No. 5820/2018 of the entity defining the minimum road freight. The road distances were consulted on Google Maps®. The routes envisaged considered road displacements from municipalities to the Ports. The size of the trucks considered in the analysis for bulk cargo was 7-axle, two-axle profile, carrying 38 tons of soybean per trip [12]. The Freight cost is considered per kilometer.
- Second, the rail freight was performed regarding the spreadsheet of the West SA stretch concessionaire Latin America logistics - ALL controlled by ANTT Resolution No. 3730/2011 [13] corresponding to the transportation of soybeans that operates in the Midwest region of Brazil, as a reference, once Transnordestina railway mentioned is not running yet.
- Third, a formation of the routes and the determination of the values follow steps presented in Figure 1. Eleven cities were chosen, which represent [14] 96% of the soybean production of the state.

To calculate the cost of the routes we used equations 1, 2 and 3.

$$FRA = DItq \times Cfr \quad (1)$$

Where:

FRA = Current Freight Cost in Dollar / Ton
DItq = Road distance from the municipality to Porto Itaqui-MA in KM
* Cfr = Freight cost Dollar / ton / KM:

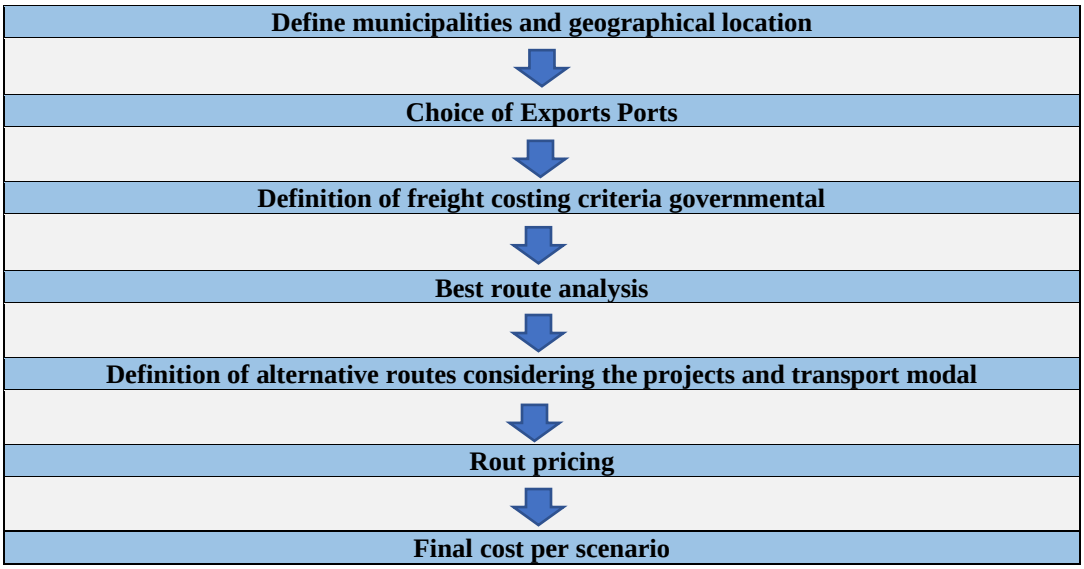

Figure 1: Data preparation steps for method application

$$TFR = (DistEM \times CRdFr) + Tcost + (DistFP \times RlFr) \quad (2)$$

Where:

TRF = Total freight cost Dollar / ton
DistEM = Road distance from the municipality to the city of Elizeu Martins, intermodal point for the KM rail
CRdFr = Road Freight Cost Dollar / ton / KM[1]
Tcost = Transfer cost Dollars / ton
DistFP = Railway Distance to destination cargo port KM
CRlFr = Rail Freight Cost Dollar / ton / KM[2]

$$CFR = Dist \times CkamE \times NA \quad (3)$$

Where:

CFR = Freight Cot road
Dist = Distance
CkmE = kilometer cost per axle
NA = number of axes

3. Results

3.1 Soybean Logistics in Piauí State

Piauí is in the third position at the soybean exporter ranking in northeastern Brazil according to the United States Department of Agriculture - USDA [3]. It has a great potential for expansion due to the availability of areas. According to Gibbs [15] the area of MATOPIBA - Soybean production area that encompasses

[1] Road Freight = Distance Distance by Track x Standard cost per kilometer related to the number of axles of the truck according to the stretch.

[2] Rail Freight = freight cost per ton / km between 810 and 1,600 km for soybean.

the states of Maranhão, Tocantins, Piaui and Bahia, that also includes Piauí, is one of the most recent areas of expansion of soy production.

The state current logistics are operationalized as shown in Figure 2.

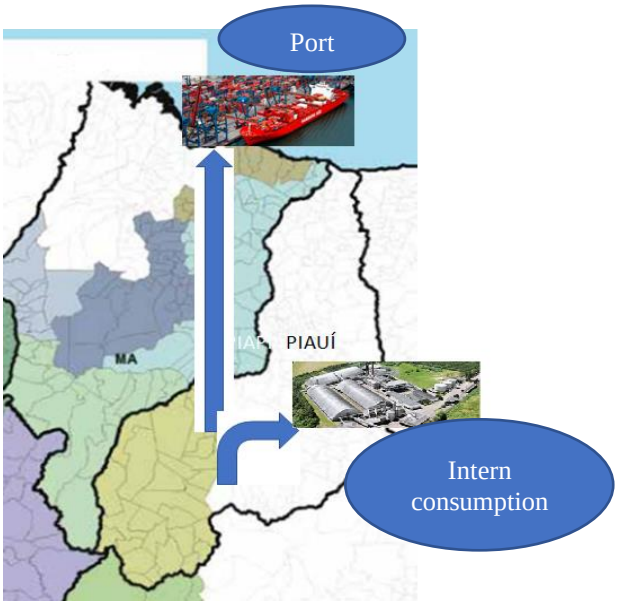

Figure 2: Current soybean runoff situation

The smallest portion of the soybean production of the Piaui is destined for domestic consumption and the majority (around 90%) is exported [16]. Currently, the production is all transported to Ports by trucks. Soybeans destined for domestic consumption are usually purchased by trades such as the company Bunge Food Company, headquartered in the municipality of Uruçuí / PI. The company crushes to produce bran and oil to supply nearby markets mainly for animal feed, as well as other human consumption products. Regarding the external market, Brazilian Federal Government are building a new railway among the city of Eliseu Martins in Piaui connecting the Ports of Pecem, Ceara state and Suape, Pernambuco state [17], Figure 3.

Figure 3: Transnordestina Railway Project Map. Retrieved from [17]

3.2 Cost Statement of Freight and Rout Projections

The soybean outflow to the foreign market should consider the distances traveled from farms to ports or farms to rail terminals. This article used the distance between the downtown of the municipalities and cargo

ports. In addition to the mentioned aspects, the value of freight did not consider the period of high demand or harvest, as freight usually gets higher due to the increased demand for transportation.

As mentioned early, three situations are compared. First, the production areas to Port of Itaqui, Table 1. Second, production areas to Port of Pecem using intermodal system (road + rail), Table 2. Third, production areas to Port of Suape using intermodal system (road + rail), Table 3. Soybean reference values were surveyed on 6/18/2019 from $ 312.82 [18] a ton and the exchange rate in one dollar to $ 4,1734 [19] quote at the Brazilian central bank in 09/23/2019.

Regarding Tables 1, 2 and 3, the representation of the reference values of soybean transportation costs considered acceptable in the literature represents 30% of the total value [20]. Tables 2 and 3 consider the cost of transhipment between the modes. When comparing the hypothesis of road freight, theoretically, the highest result of flow I cause a percentage of 14.05%, shown in the current scenario.

A study from USDA [3] presented a table with the freight costs of the municipality of Bom Jesus-PI to Porto worth U$ 0.0358, however, two years ago, when compared to the survey data, represents an increase of 28,49%, in addition to the rising cost of fuel in recent years. It is believed that the new pricing policy established by the Brazilian government following the strike movements in 2018, among other things, influenced this variation.

Table 1: Current flow to Itaqui Port

Municipalities Origin - Soybean producers	Road distance (KM)	freight cost / ton U$	Total Freight Cost U$	Transit time day
Baixa Grande do Ribeiro	970	0,042	40,674	1
Uruçuí	749	0,051	38,387	1
Ribeiro Gonçalves	796	0,047	37,087	1
Bom Jesus	941	0,046	43,404	1
Santa Filomena	1045	0,046	47,714	1
Currais	954	0,046	44,004	1
Gilbués	1106	0,046	50,499	1
Sebastião Leal	760	0,047	35,764	1
Monte Alegre do Piauí	1096	0,046	50,043	1
Corrente	1183	0,046	54,015	1
Palmeira do Piauí	914	0,046	42,159	1

[a] Lowest value [b] Highest value

Table 2: Flow from Eliseu Martins to PECÉM / CE Port via Transnordestina Railway

Municipalities Origin - Soybean producers	Road distance (km)	Road freight cost / ton (U$)	Railway distance (km)	Cost freight/ ton Railway (U$)	Transshipment cost (U$)	Total Freight Cost (U$)	Transit time (days)
Baixa Grande do Ribeiro	291	0,055	1112	0,037	0,4	57,182	3
Uruçuí	174	0,062	1112	0,037	0,4	52,101	3
Ribeiro Gonçalves	280	0,055	1112	0,037	0,4	56,582	3
Bom Jesus	142	0,062	1112	0,037	0,4	50,118	3
Santa Filomena	412	0,075	1112	0,037	0,4	72,032	3
Currais	153	0,062	1112	0,037	0,4	50,800	3
Gilbués	305	0,051	1112	0,037	0,4	56,950	3
Sebastião Leal	100	0,010	1112	0,037	0,4	51,290	3
Monte Alegre do Piauí	295	0,055	1112	0,037	0,4	57,400	3
Corrente	382	0,051	1112	0,037	0,4	60,897	3
Palmeira do Piauí	113	0,062	1112	0,037	0,4	48,321	2

[a] Lowest value [b] Highest value

Table 3: Flow from Eliseu Martins to SUAPE / PE Port via Transnordestina Railway

Municipalities Origin - Soybean producers	Road distance (km)	Road freight cost / ton (U$)	Railway distance (km)	Cost freight/ ton Railway (U$)	Transshipment cost (U$)	Total Freight Cost (U$)	Transit time (days)
Baixa Grande do Ribeiro	291	0,055	1130	0,037	0,4	57,633	3
Uruçuí	174	0,062	1130	0,037	0,4	52,552	3
Ribeiro Gonçalves	280	0,055	1130	0,037	0,4	57,031	3
Bom Jesus	142	0,062	1130	0,037	0,4	50,570	3
Santa Filomena	412	0,075	1130	0,037	0,4	72,485	3
Currais	153	0,062	1130	0,037	0,4	51,250	3
Gilbués	305	0,051	1130	0,037	0,4	57,405	3
Sebastião Leal	100	0,010	1130	0,037	0,4	51,742	3
Monte Alegre do Piauí	295	0,055	1130	0,037	0,4	57,857	3
Corrente	382	0,051	1130	0,037	0,4	61,354	3
Palmeira do Piauí	113	0,062	1130	0,037	0,4	48,777	3

[a] Lowest value [b] Highest value

3.3 Freight costs and routes remakes

Table 4 shows the cost of freight in the current stretches and hypotheses of the Transnordestina railway to the ports of Pecém and Suape.

Tabela 4: Scenario Comparison

Scenario	Highest reight costs found (US$)	Lowest freight costs found (US$)	Average freight costs (US$)	Soybean Ton (US$)	Percentage
Current scenario	$43,97	$38,387	$54,015	$312,82	14,05%
Scenario Simulation I Pecém Transnordestina	$55,78	$48,321	$72,032	$312,82	17,83%
Scenario Simulation II Suape Transnordestina	$56,24	$48,777	$72,485	$312,82	17,97%

Table 4 presents the percentage of cargo freight on soybean prices. The value differences between flows are relatively small. In the two scenarios projected with the railway, costs are bigger compared to the current situation. One of the factors that increase intermodal freight costs is the long road distance from producing cities to the rail terminal, south as the case of Santa Filomena- PI whose distance is 512 km from the terminal.

The transit times when using rail is higher in both simulations involving the scenarios II and III. The differences found presented a percentage of approximately 3% higher than in the current scenario. The use of rail transport was expected to reduce the value of freight.

4. Conclusions

The study identified the unfeasibility of investment in Transnordestina railway considering the soybean movement of Piaui. Comparing the higher freight of the simulations with the current section, a cost growth of 33.35% is expected. Moreover, the port of São Luis has been more competitive, taking third place in 2017, with 8% of soybean exports to China [21]. Therefore, it comes the advantage of continuing to distributing soybeans through the port in ITAQUI-Northeast Brazil is the largest soybean exporter to China. The results allow concluding that railway projected need to be modified or improved to better meet the logistic needs for soybean production in Piauí.

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