

FREIGHT BEHAVIOR IMPACTS: AN APPLICATION OF COMPUTABLE GENERAL EQUILIBRIUM TO BRAZILIAN AGRICULTURAL PRODUCTS

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ABSTRACT

Objective: this study aimed to investigate the impact of the fluctuation in freight costs for Brazilian agricultural products.

Method: this is a descriptive research of a quantitative nature, focused on scenario analysis through modeling in computable general equilibrium for the five Brazilian macro-regions.

Main results: as a result of the research, it is indicated: (i) import and export suffered impact, caused by the fluctuation of the freight price, increasing in all Brazilian macro-regions; (ii) the increase in imports and exports is indicative that exist movement in trade flows and brings benefits to the country's economy, favoring the exchange and the regional economy and (iii) the regions with lower freight costs, gains of competitiveness for agricultural products.

Relevance/originality: this work contributes to a research agenda that involves important sectors of the Brazilian economy – agriculture and transport – and how they are related to each other, providing a view of how the freight cost influences in heating of the regional economy agricultural products trades in Brazil.

Theoretical/methodological contributions: the work presents a different approach than more traditional methods, by ECG, creating an alternative for analyzing how the cost of transport impacts on interregional trade.

1. Introduction

In the late 1990s and early 2000s, the globalized world and the internet age brought about amenities and made things easier for people. Access to information, mobility, products and other goods is facilitated by globalized commerce and the act of purchasing has been simplified. All physical products must be delivered to the buyer at a certain time and it must be done safely, if the product is virtual, such as software for example, delivery can be done via a computer network, but this is not possible for all products, most require a physical delivery.

The delivery of physical products is the attribution of logistics that Antón (2005) treats as a science in which it is studied how the goods exceed time and distance efficiently to maintain a productive activity. Thus, Rutner and Langley (2000), Bosona and Gebresenbet (2013) and Rushton *et al.* (2014) understood logistics as being the link between producers and consumers, or vice versa,

guaranteeing the flow of products and services from the point of origin to the point of consumption.

In a way, logistics can be confused or used as a synonym for transportation. Crainic and Laporte (1996) see transportation as being an activity that supports other economic and social activities and make exchanges possible. In turn, Cranic (2003) places transport as a key component of the supply chain, which includes the movement of raw materials for production to finished products.

Logistics, in general, is responsible for integrating business as defined by Cooper *et al.* (1997). Accordingly, Christopher (2016) highlights that logistics plans operations and structures following information that is then capable of generating efficiency gains for the business and thus obtaining competitive advantages.

One way to generate efficiency and competitiveness is through transport, that is, in the

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cost of freight. Businesses whose freight costs are differentiated, can become an attraction, making them more competitive than the others. In fact, the reduction of freight can guarantee a low cost of production or even a lower cost of delivery of the goods, which can in turn enable a lower price of the item in question. In a world with a narrow profit margin, such as agricultural commodities, reducing costs can imply the survival of a company in the market.

To determine the freight rate, some carriers rely on factors such as delivery speed, type of product and distance. All of these variables are important when the product is perishable, such as agricultural or food products. Piercy and Ballou (1978) studied attributes that impact the value of freight and had the most significant variables: speed and time (transit time), in addition to service availability. Therefore, the authors indicate that the best way to carry out cargo transportation is to combine these variables to provide a transportation alternative with lower freight costs.

In the case of Brazil, the means of transportation in which these two characteristics are combined is via road, especially in the case of agricultural products (BRANCO *et al.* 2012). Thus, Nascimento *et al.* (2010) and Perá *et al.* (2013) indicate freight as being the main cost of transporting cargo that is directly influenced, among other factors, by the infrastructure of transport routes. Going further, Perá *et al.* (2013) shows that fuel is an impact factor when the quality of the road implies a reduction in travel time as well as decreasing fuel consumption, contributing to lower freight costs.

Freight is a variable that depends on the location, the product, the periodicity, the perishability and the means of transport used, these directly impact the final cost of the product and this must be considered in the decision of whether or not to purchase a certain product from a specific producer and location. This directly influences the competitiveness of a product, that is, a competitive freight representing the entry of a business in to disputed markets.

There is a demand for transportation because there is a difference in geographical locations between producers (sellers) and consumers (buyers). However, freight calculation is not an exact science and it is difficult to predict its long-term behavior. For this reason, it is important to study the behavior of freight and the impacts that its volatility has on trade,

especially for being the most disputed and with a small profit margin.

In line with the behavior of freight, countries with high import and export economic activity, such as Brazil, may be affected by the increase and decrease in international freight. The fluctuation in the value of freight can impact the country's competitiveness in some economic sectors, making the product too expensive for other markets.

Thus, this article aims to understand what happens to the consumption of goods (price, export and import) for agricultural products due to the variation in freight. Therefore, the main objective of this work is to propose a study for Brazil using a Computable General Equilibrium (CGE) Model that will investigate the impact of the fluctuation in freight costs for Brazilian agricultural products.

To investigate the impact of freight behavior on Brazilian agricultural products, the Project for the Analysis of General Equilibrium of the Brazilian Economy (PAEG) was chosen, which portrays the Brazilian economy in 19 sectors (7 related to agricultural products and food consumption) and 12 regions (five macro-regions of Brazil and seven other regions). The freight cost proxy will be based on the fluctuation of the fuel cost, since there is a predominance of cargo transportation by road.

The work is structured in five chapters, including this introduction one. The second chapter deals with a brief overview of cargo transportation in Brazil. The third part is dedicated to the methodology used in this work. The fourth part is dedicated to presenting the results and impacts caused by the cost of transportation. Finally, the fifth chapter is devoted to final considerations.

2. Transport of agricultural cargo in Brazil

The needs of logistics in finding ways to connect market agents fall on the actors - producers, shippers, carriers, governments and consumers - who depend on transport services to link them together. The connection between the aforementioned actors makes the service a fundamental role in a production chain (DASKIN, 1985).

In Brazil, there is a predominance and relative dependence on the transportation of cargo via roads (road mode), due to the lack of infrastructure and availability of other modes of transport. However, the

existence and use of rail and waterway modes can contribute to the decrease in transport costs and increase the efficiency of logistics in (CASTILLO, 2004;

LIMA, 2006; KATO, 2007; KAWANO *et al.*, 2012; BOZOKY *et al.*, 2014; BRANCO *et al.*, 2012).

The Brazilian transportation matrix is divided as shown in Figure 1.

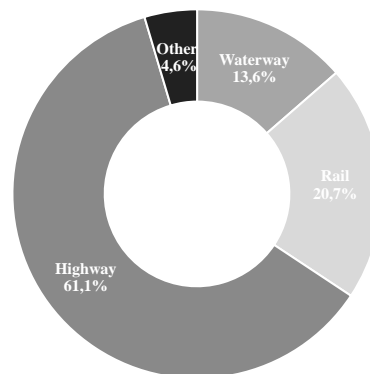


Figure 1. Brazilian transportation matrix for the year 2014.

Fonte: authors elaboration.

Note: data from Confederação Nacional do Transporte (CNT, 2014).

Shifting the transport of agricultural products, Caixeta Filho (2010) notes that the spatial organization of production makes transportation an important factor in the competitiveness of products, precisely because of the composition of production costs, where spatialization of the production zones, raw materials and consumer zone (even for export) increase the costs of agricultural and farming products.

The importance of transporting agricultural products becomes more critical when considering their time sensitivity. According to Behar and Venables (2011), Attavanich *et al.* (2013) and Redding and Turner (2014) the perishability of products of plant and animal origin increase transport costs, requiring greater care and quality in the contracted transport service, making this type of service more restrictive when compared to the transport of other products.

Likewise, the spatiality of production pointed out by Wilson and Dahl (2011), which gives grain transport greater transport volatility during the harvest and between harvests, making freight prices less predictable and increasing marketing costs. As a result, the demand for investments in adequate infrastructure is impaired.

Collaborating with the vision of Caixeta Filho (2010), Castro (2009) commented in his study that

the logistical cost is a relevant component in the composition of the final price of products for consumers and the increase in the road network since 1950 contributed to the geographical expansion of Brazilian agricultural production.

Considering that the road modal is the main means of cargo transportation in Brazil, the costs are directly connected to the elements involved in driving and the vehicle's load capacity. According to Lewczuk and Wasiak (2011), road transport costs are derived from distance (mileage traveled), product weight and loading and unloading time.

Oliveira *et al.* (2013) and Oliveira *et al.* (2016) points out that freight is directly influenced by the fuel price ratio. In the road modal, the authors recognize that the diesel price influences the question of the logistical cost for the transportation of cargo, impacting the final price of freight.

The dependence on the transport of farming and agricultural cargo by road and the increase in costs resulting from this type of transport ends up becoming a matter of concern and a target for study over the years. Studies such as those by Fujita *et al.* (2000), Gurgel (2014) and Oliveira *et al.* (2015) report the cost of transportation as being a concern in the logistics and distribution of farming and agricultural products.

For the delivery of products and goods, the Brazilian logistics sector favors roads, but other means of transport are receiving new investments and growing participation (MARCHETTI and FERREIRA, 2012; ASAI *et al.*, 2017; MACHADO *et al.*, 2018). However, to simulate scenarios with changes in freight prices, this work will use the fluctuation of fuel prices (diesel) as a proxy, which can be justified due to the high use of the road modal for transporting agricultural cargo.

With the outlined panorama of the farming and agricultural cargo transportation service in Brazil, it is possible to explore its limiting factors, those which cause the loss of efficiency and comparative advantage.

3. Methodology

The Computable General Equilibrium model has the ability to represent a country's economy and its trade relations with others within a set of algebraic equations. For Sadoulet and De Janvry (1995) and Partridge and Rickman (1998), the CGE models can capture the relationships between economic agents through the macroeconomic and microeconomic aspects present in the input-output matrix of each country.

Among the various uses of the CGE, logistics was the object of study by Tavasszy *et al.* (2003), Haddad (2004), Bröcker (2004), Barry (2013), Gurgel (2014), Kim *et al.* (2017) and Chen (2018). Such works evaluated the impacts of transport logistics on the economy, sometimes by investments in the sector, or sometimes by lowering costs. The studies point to the structuring of several CGE models to evaluate the efficiency of the sector or to evaluate the investments made in the improvement of logistics quality.

Haddad (2004) analyzes the returns obtained by reducing transport costs and how much these factors interfere with regional development. In this study, an own CGE model was created that allowed to verify the gains in transport efficiency for a certain state in Brazil.

Other works such as those by Mendes (2013), Fagundes *et al.* (2015), Waquil (2019) assess that the impact on trade in agricultural products is affected by

the cost of transportation. Analogous to the works with CGE, these authors used different methodologies such as a spatial analysis and an input-output matrix.

Therefore, this work contributes in promoting the theme and will be based on a descriptive research of a quantitative nature, focused on the analysis of scenarios through CGE modeling, being used to investigate the impacts of the behavior of freight in the trade of Brazilian agricultural products through the relations of interregional exchanges via import and export of agricultural products from the Brazilian macro-regions themselves and the other regions present in the model. In addition, the impact on the price factor of agricultural products will be analyzed.

3.1. General Equilibrium Analysis Project of the Brazilian Economy Model

PAEG is a static, multiregional and multisector model, structured to represent the Brazilian economy and its interactions with other economies worldwide. According to Gurgel *et al.* (2011) each region of the model is represented by a final demand structure, where the producer and consumer act to maximize their well-being while being subject to budget constraints, considering fixed investment, capital flow and public sector production.

The PAEG structure is based on *GTAPinGAMS* (Rutherford and Paltsev, 2000; Rutherford, 2005), adopting a problem of non-linear complementarity in the *General Algebraic Modeling System* (GAMS) developed by Brooke *et al.* (1998). For the programming language, PAEG uses the syntax based on *Modeling Programming System for General Equilibrium* (MPSGE) structured by Rutherford (1999).

PAEG is divided into a total of 12 regions and 19 sectors compatible with *GTAPinGAMS* in its seventh version, which refer to the world economy for the year 2011. In order to portray the Brazilian economy in its five macro-regions, the *Global Trade Analysis Project* (GTAP) database was disaggregated as described by Teixeira *et al.* (2013). The regions, sectors and production factors considered in the PAEG are described in Figure 2.

| Sectors | Acronym | Regiões | Acronym |
|--|---------|----------------------------|----------------|
| Rice | (pdr) | Northern Brazil | Nor |
| Corn and cereals | (gro) | Northeast of Brazil | Nde |
| Soy and other oils | (osd) | Midwestern Brazil | Coe |
| Sugarcane, sugar beet and sugar industry | (c_b) | Southeastern Brazil | Sde |
| Meat and cattle | (oap) | Southern Brazil | SUL |
| Milk and dairy products | (rmk) | Rest of Mercosur | Rms |
| Agribusiness products | (agr) | Venezuela | VEM |
| Food industry | (foo) | United States | Eua |
| Textile industry | (tex) | Rest of Nafta | RNF |
| Clothes and shoes | (wap) | Rest of America | Roa |
| Wood and furniture | (lum) | Europe | Euros |
| Pulp and printing industry | (ppp) | China | Chn |
| Chemical, plastic and rubber industry | (crp) | Rest of the world | Linha |
| Manufactured | (homem) | | |
| Distribution of gas, electricity and water | (siu) | Fatores de Produção | Acronym |
| Building | (cns) | Capital | cap |
| Sales | (trd) | Labor | lab |
| Transport | (otp) | | |
| Service and public administration | (adm) | | |

Figure 2. Regions and sectors present in the PAEG model.

Source: Pinto, et al., 2016.

Gurgel *et al.* (2011) and Teixeira *et al.* (2013) define the PAEG model as a way to represent the goods and services produced in the Brazilian and world economies. The regions are represented by a structure of final demand and the behavior of agents is an optimizer in the sense of maximizing well-being. These authors indicated that the productive sectors

minimize their costs with a combination of intermediate inputs and primary factors, given the use of a certain technology. Bilateral trade, transportation costs, taxes and subsidies are also part of the model. A set of PAEG databases is shown in Figure 3.

| Índice | Descrição |
|-----------|---|
| l, j | Sectors and goods |
| r, s | Countries and regions |
| $f \in m$ | Free mobility production factors between a given region: labor; capital |
| $f \in s$ | Fixed production factors: natural resources |

Figure 3. Data set present in PAEG.

Source: Gurgel *et al.* 2011.

To structure the model in regional economies, some variables are created, starting from an economic model. The model's variables are: (i) Y_{ir} , as production of good i in region r ; (ii) C_r , I_r and G_r are private consumption, investment and public consumption in region r , respectively; (iii) M_{jr} represents the import of goods j by region r ; (iv) HH_r

is the variable for the representative consumer; (v) public sector or government in region r is the variable $GOVT_r$; and (vi) FT_{sr} represents the activity through which specific inputs are allocated to private sectors. To illustrate how the regional economy is structured in the PAEG model, Figure 4 illustrates the structure and economic flows.

In order to fulfill the proposed objective, to analyze the impact of the fluctuation in freight costs for Brazilian agricultural products, the PAEG model was adapted to reflect the cost of transportation.

To understand the proposed scenarios, it was necessary to structure some of the accounting identities in order to portray the cost of freight. Since, vt_j , the cost of transporting goods and services in a region, this variable was explored for scenario projections. Therefore, the identity related to the freight is the one described by number 7 and has two main parts represented in Equations 8 and 9.

$$vt_j = \sum_r vst_{jr} \quad \text{(Equation 8)}$$

$$vt_j = \sum_r vtwr_{jisr} \quad \text{(Equation 9)}$$

Equation 8 represents the balance of the transport services, provided by the equality of the aggregated offer of transport services and the value of transport services. While Equation 9 describes an equal supply and demand for transport services.

These two equations are directly correlated with the production function described in Equation 1. The relationship between transport services and the production function is based on the accounting identity in Equation 1 which can also be described according to Equation 10.

$$vom_{ir} = \sum_r vxmd_{irs} + \sum_j vdfm_{ijr} + vst_{ir} + vdp_{ir} + vdgm_{ir} + vdim_{ir} \quad \text{(Equation 10)}$$

Through Equation 10, production is made up of exports ($vxmd_{irs}$), intermediate demand ($vdfm_{ijr}$), private consumption (vdp_{ir}), government consumption ($vdgm_{ir}$), investments ($vdim_{ir}$) and also transportation services (vst_{ir}). Therefore, goods and services are directly affected by the transportation cost in the model.

The logic of the PAEG model and its accounting identities are related to the MPSGE as production blocks. Figure 5 shows the technological decision tree representing the production block and describes the technologies used by the companies, vom_{ir} , in PAEG.

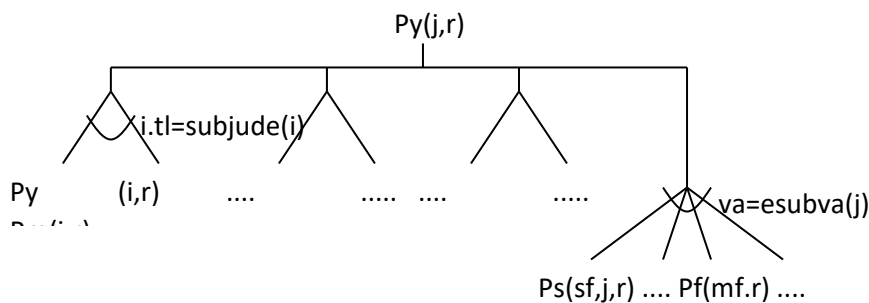


Figure 5. Technological decision tree of the production function of the PAEG model. Source: Gurgel et al., 2011.

Da mesma lógica para a função de produção, os serviços de transporte possuem uma árvore de decisão tecnológica representando a Figura 6.

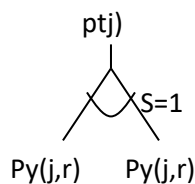


Figure 6. The technological decision tree of the PAEG model transport services function. Source: Gurgel et al., 2011.

In the same logic for the production function, transport services have a technological decision tree represented in Figure 6.

The production block for transportation services is a combination of the inputs $py(j, r)$ to produce $opt(j)$. An interpretation that can be given to this production block is that to produce $pt(j)$ there is a need for a number of intermediate inputs (i) that must be transported (q) to obtain the final product (O). The model logic represents the matrix in Equation 11.

$$\begin{aligned} & \text{prod: } yt(j) \text{ } vt_w(j) \text{ } s: 1 \\ & \text{o: } pt(j) \text{ } q: vt_w(j) \\ & \text{i: } py(j, r) \text{ } q: vst(j, r) \end{aligned} \quad \text{(Equation 11)}$$

In this case, the price of transport services for certain regions are in balance and no surplus or absence is observed due to the elasticity imposed by the Leontief function, $s: 1$. To adapt the PAEG in order to capture changes in freight behavior, the vst will be broken down into two other variables: price and quantity of transport services. Equation 12 introduces these two variables into the model.

$$S_j = D_{jr} = P_{ir} \times Q_{ir} \quad \text{(Equation 12)}$$

In balance.

$$vst_{ir} = P_{ir} \times Q_r \quad \text{(Equation 13)}$$

Thus, the price of an input in the region P_{jir} and demand for the quantity of this input in another

region (Q_{jir}) of the transport services is given according to the law of supply and demand. Therefore, freight volatility will be simulated in the changes of this price, which creates scenarios to investigate the impact of the freight rate on Brazilian trade flows, restricting it to agricultural products.

For this work, the agricultural and food sectors are: rice (pdr); corn and cereals (gro); soy and other oils (osd); sugar cane, beetroot and sugar industry (c_b); meat and livestock (oap); milk and dairy products (rmk); other agricultural products (agr); and food (foo).

In this case, the entire projected scenario will be based on changes in the freight rate, which leads to different quantities required for each product and sector (i and j) divided by each region present in the model and an increase in transportation cost. The change will take advantage of the fluctuation of the fuel price for each macro-region, since the impact of the diesel price is relevant to the value of freight. Thus, the average value of fuel from 2013 to 2019 was taken into account.

To project the scenario that reflects the impact of the cost of transport in the trade of Brazilian agricultural products, the variation of freight was used to effect shocks in the CGE model and thereby project the impacts of freight on imports and exports and the price, whose variables represent the impact on interregional trade.

That said, diesel prices for use in trucks for each Brazilian macro-region were raised between January 2013 and February 2019, in order to determine the magnitude of the shock in the CGE model. Average consumer prices were used, that is, the final prices with all taxes included. The results of the fuel prices are shown in Table 1.

| Year | Midwest | Northeast | North | Southeast | South |
|--------------------------------|---------|-----------|-------|-----------|-------|
| 2013 | 2.605 | 2.348 | 2.478 | 2.427 | 2.420 |
| 2014 | 2.818 | 2.567 | 2.716 | 2.636 | 2.629 |
| 2015 | 3.137 | 2.953 | 3.117 | 2.935 | 2.915 |
| 2016 | 3.336 | 3.145 | 3.361 | 3.107 | 3.038 |
| 2017 | 3.457 | 3.164 | 3.463 | 3.232 | 3.103 |
| 2018 | 3.771 | 3.560 | 3.743 | 3.568 | 3.438 |
| 2019 | 3.710 | 3.569 | 3.757 | 3.507 | 3.386 |
| Average growth rate (%) | 6.155 | 7.373 | 7.284 | 5.863 | 6.614 |

Table 1. Diesel S10 prices by region in R \$ per liter.

With the shock value in the CGE model calculated, each macro-region will have its own multiplier for the price rate P_{ir} , described in Equation 13, representing an oscillation in freight prices. From this point, it is noted that the price of fuel has risen in all regions, increasing the value of vst_{ir} .

Therefore, in the shock for the projection of the scenario there is an increase in the price of transport services, the magnitude of which is different in each macro-region. The level of shock that each region represents is described in Equations 14 to 19.

$$\text{MIDWEST: } vst_{ir} = (1,0615 \times P_{ir}) \times Q_r \text{ (Equation 14)}$$

$$\text{NORTH: } vst_{ir} = (1,0724 \times P_{ir}) \times Q_r \text{ (Equation 15)}$$

$$\text{NORTHEAST: } vst_{ir} = (1,0737 \times P_{ir}) \times Q_r \text{ (Equation 16)}$$

$$\text{SOUTH: } vst_{ir} = (1,0661 \times P_{ir}) \times Q_r \text{ (Equation 17)}$$

$$\text{SOUTHEAST: } vst_{ir} = (1,0586 \times P_{ir}) \times Q_r \text{ (Equation 18)}$$

With the increase in transportation and, with the only impact factor being the fluctuation in the value of fuel, it is expected to analyze the impacts on imports, exports and the price of agricultural products produced in the Brazilian macro-regions.

It is worth mentioning that the change in the freight price will only be applied to cases of transport services originating from Brazil.

4. Impacts of freight behavior on the trade of agricultural products

To analyze the impact of freight on the interregional trade of agricultural products, this work will focus on imports, exports and prices. In the model, exports and imports portray the exchanges between Brazilian macro-regions in order to represent the level of trade activity for each of the agricultural products in a given macro-region. Prices, on the other hand, indicate the amount paid for products in their respective regions. All the projected results are shown in Tables 2, 3 and 4.

| | North | Northeast | Midwest | Southeast | South |
|------------|--------|-----------|---------|-----------|--------|
| Pdr | -0.743 | 0.065 | 0.565 | 0.719 | -0.214 |
| Gro | -0.122 | 0.070 | 0.134 | 0.560 | 0.058 |
| Osd | -0.177 | 0.079 | 0.392 | 0.662 | -0.220 |
| c_b | -0.526 | 0.008 | 0.212 | 0.506 | 0.015 |
| Oap | -0.186 | 0.066 | 0.302 | 0.690 | -0.044 |
| rmk | -0.790 | -0.633 | -0.014 | 0.979 | -0.324 |
| Agr | 1.167 | 0.389 | 0.409 | 1.124 | 0.406 |
| Foo | -0.175 | 0.121 | 1.057 | 1.103 | 2.490 |

Table 2. Variation of total imports (%).

For the projected scenario, starting with the imports, all regions show similar behavior, as well as for the exports. However, in some sectors, the imports are not close to the exports, which may represent an imbalance in the region's trade balance. The greater increase in imports compared to exports indicates that the region needs additional local production to supply consumption, while the increase in exports represents self-sufficiency.

In the agricultural sectors, represented by the commodities of rice, corn and cereals, soy, sugar, milk and meat, as far as imports are concerned, in some sectors such as milk and dairy products, there is a greater increase than the exports, which reveals the need to complement local consumption with products from other regions. When imports exceed exports, it can be said that there is already a loss of self-sufficiency in that sector in the region.

| | North | Northeast | Midwest | Southeast | South |
|------------|-------|-----------|---------|-----------|-------|
| Pdr | 3.401 | 3.144 | 0.278 | 3.246 | 1.337 |
| Gro | 1.060 | 0.780 | 0.633 | 0.549 | 0.683 |
| Osd | 1.784 | 1.622 | 0.689 | 0.825 | 1.444 |
| c_b | 1.547 | 0.234 | 0.424 | -0.427 | 0.485 |
| Oap | 1.057 | 0.529 | 0.447 | 0.200 | 0.872 |
| rmk | 2.064 | 1.764 | 0.390 | -0.732 | 1.209 |
| Agr | 1.703 | 2.598 | 0.837 | 2.649 | 0.991 |
| Foo | 6.341 | 6.150 | 1.866 | 6.799 | 0.794 |

Table 3. Variation in total exports (%).

In general terms, when exports exceed imports, it is indicative of a comparative advantage for the macro-region with more exports. This comparative advantage was caused only by the shock in the freight cost, thus, the impact will be on the lower production cost for the region with the greatest comparative advantage, given that freight or transport becomes a component in the production cost for agriculture.

For Almeida and Guilhoto. (2007) and Branco *et al.* (2012), the cost of transportation directly impacts the cost of agricultural production, sometimes making local production unfeasible. Transport becomes a limiting factor for trade between regions due to its cost, as pointed out by Inklaar and Timmer (2014). By raising transport costs from one point to another, some products and services become economically unfeasible for a region, preventing trade between them.

Thus, the region with the lowest production cost and, consequently, the greatest comparative advantage, will have an increase in the export of products compared to the regions with the least comparative advantage. This fact is observed for all Brazilian macro-regions. By correlating the comparative advantage and the imbalance of the affected sectors, freight can influence the final prices, since the region with the lowest production costs will

perform better, unlike those with higher production costs.

Such a situation causes a loss of comparative advantage that the region with the lowest production cost, including freight, would have when compared to the one with the higher cost. Thus, the concerns raised by Fujita *et al.* (2000) and Oliveira *et al.* (2015), where the loss of a comparative advantage due to the cost of transportation becomes real, as the cost of transportation creates an inefficiency for a given sector, making the production or supply of raw materials and productive inputs in the chain unfeasible and so soon after, as a result, there is a loss of competitiveness.

Considering freight as a component of the cost of production, it is normal for sectors to try to minimize costs, especially those sectors that involve very competitive agricultural commodities with low profit margins. The increase in transportation costs, both for final products and for productive inputs, can affect and even render products unfeasible in certain regions. For commodities, freight and prices must be analyzed together, in order to see if the increase in the cost of transportation will be reflected in the final prices, in order to verify whether the increase in the cost of transportation is transferred to the consumer.

| | North | Northeast | Midwest | Southeast | South |
|------------|--------|-----------|---------|-----------|--------|
| Pdr | 0.172 | 0.039 | -0.174 | -0.084 | -0.006 |
| Gro | 0.146 | 0.034 | -0.175 | -0.152 | -0.046 |
| Osd | 0.200 | 0.063 | -0.194 | -0.043 | 0.019 |
| c_b | 0.141 | 0.024 | -0.194 | -0.138 | -0.067 |
| Oap | 0.175 | 0.060 | -0.186 | -0.069 | -0.019 |
| rmk | 0.213 | 0.096 | -0.137 | -0.131 | 0.022 |
| Agr | -0.437 | -0.195 | -0.330 | -0.276 | -0.268 |
| Foo | 0.079 | -0.114 | -0.657 | -0.530 | -1.295 |

Table 4. Price variation (%).

When it comes to prices, all changes are less than 1% causing a difference between the behavior of freight prices (based on fuel prices) and the final prices of the goods. This can indicate two types of situations: (i) freight is not an important cost and does not directly affect the final consumer prices; or (ii) Brazil has no impact to lead the price changes in the agricultural products market and is an international price taker.

In the first situation, there are various components of cost production and freight is just one of them. However, the second situation becomes more appropriate, which means that the Brazilian economy is not strong enough to change the prices of the goods individually, especially if the sector is conditioned by the international prices of commodities, even though it is considered to be one

of the leading producers and exporters of agricultural commodities in the world.

As they are agricultural commodities, there is a narrow profit margin and many international commodities such as soybeans and corn, are linked to and traded on commodities and futures exchanges (with long term or future contracts), indicating a fixed price for the medium and long term so its final price is not only impacted by the one variable of its production cost.

The explanation for the variation in imports, exports and prices is explained by the microeconomic theory present in the CGE model and is based on the shift of the agricultural product supply curve to the right which is due to the increase in exports and imports in the macro-regions, as shown in Figure 7.

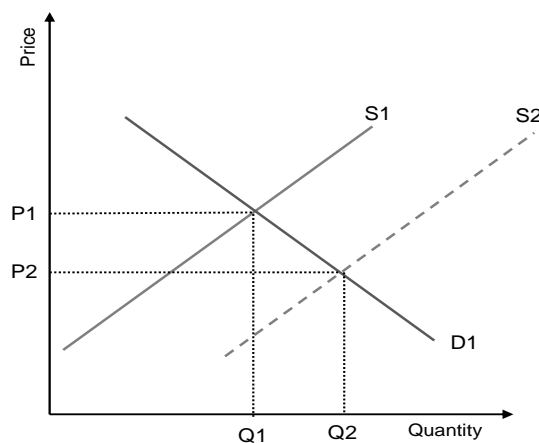


Figure 7. Displacement of supply and demand curves when imports and exports increase with a decrease in price.

In the south, southeast and center-west, the decrease in the prices of agricultural products was caused by the shift of the import and export curve to the right, increasing the quantity of imported and exported products ($Q1 < Q2$) and the decrease in prices ($P1 > P2$). This represents a direct effect of the decrease in transport costs, since the logistics cost is a relevant component in the final price of the products according to Castro (2009) and Caixeta Filho (2010).

Contrary to what happens when prices decrease, the increase is caused by the shift of the agricultural supply curve for both export and import to the left, decreasing the quantity offered and increasing the

prices. This increase in prices can be seen in the North and Northeast regions.

In the case of price decreases, the Brazilian macro-regions gain in competitiveness, since when there is an increase in prices, there is a loss of competitiveness in the agricultural sectors. This fact is driven by the competitive advantage generated by the oscillation of the production cost. Thus, the lower production cost would create a greater comparative advantage in the production of agricultural products.

In short, the behavior of freight directly impacts Brazilian interregional trade flows, causing a shift in trade to those regions where there is a greater comparative advantage.

5. Final remarks

The objective of the work was to carry out a study on the impacts of the fluctuation of freight costs for Brazilian agricultural products using General Computable Equilibrium modelling, taking a look at price, import and export behavior.

Through CGE modeling the work contributes with a different approach than the more traditional methods, creating an alternative for analyzing how the cost of transport impacts the interregional trade.

As a result of the projection, import and export were impacted by the variations in the freight prices. In cases, especially those with intensive labor such as agriculture, exports and imports increase in all Brazilian macro-regions in regards to agricultural products. This type of variation is indicative of the movement of trade flows and brings benefits to the country's economy, since there is commercial activity inside and outside the country, favoring exchanges and heating up the regional economy.

The shift in the supply curves for Brazilian agricultural products indicates an increase in imports

and exports across the macro-regions, directly impacting prices. When the supply curve is shifted to the right, the price tends to suffer a negative impact, that is, there is a decrease, cases were observed in the South, Southeast and Center-west regions. In the North and Northeast regions, where prices rose, the supply curve shifted to the left.

This movement of the supply curve is a direct indicator of the sector's competitiveness in the micro-region. When there is an increase in supply, it provokes a decrease in prices and an increase in exports, indicative of an increase in the competitiveness of the sector which, even with the increase in the value of transportation (freight), increases its competitiveness by better managing production costs compared to the other regions.

Thus, freight can interfere with interregional trade flows. The freight behavior scenario, over time, may determine a point where the freight rate is important for the national economy, having an impact on the competitiveness of the agricultural sectors in the micro-regions of Brazil.

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IMPACTOS NO COMPORTAMENTO DO FRETE: UMA APLICAÇÃO DE EQUILÍBRIO GERAL COMPUTÁVEL PARA OS PRODUTOS AGROPECUÁRIOS DO BRASIL

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RESUMO

Objetivo: este trabalho teve como objetivo investigar o impacto da oscilação do custo do frete para os produtos agropecuários brasileiros.

Método: trata-se de uma pesquisa descritiva de natureza quantitativa, focado na análise de cenário por meio da modelagem em equilíbrio geral computável para as cinco macrorregiões brasileiras.

Principais resultados: como resultado da pesquisa indica-se: (i) a importação e a exportação sofreram impacto causado pela variação do preço do frete, aumentando em todas as macrorregiões brasileiras; (ii) o aumento das importações e exportações é um indicativo no movimento dos fluxos comerciais e traz benefícios para a economia do país, favorecendo a troca e a economia regional e (iii) as regiões com menor custo de frete, apresentam ganhos de competitividade para produtos agropecuários.

Relevância/originalidade: trabalho contribui com uma agenda de pesquisa que envolve setores importantes da economia brasileira – agropecuária e transportes – e como estão relacionados entre si, fornecendo uma visão de como o custo de frete influencia no comércio dos produtos agropecuários no Brasil.

Contribuições teóricas/metodológicas: o trabalho apresenta uma abordagem diferente de métodos mais tradicionais, por ECG, criando uma alternativa para análise de como o custo de transporte impacta no comércio inter-regional.

IMPACTOS EN EL COMPORTAMIENTO DEL CARGA: UNA APLICACIÓN DEL EQUILIBRIO GENERAL COMPUTABLE A LOS PRODUCTOS AGRÍCOLAS BRASILEÑOS

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RESUMEN

Objetivo: este estudio tuvo como objetivo investigar el impacto de la fluctuación en los costos de flete de los productos agrícolas brasileños.

Método: esta es una investigación descriptiva de naturaleza cuantitativa, centrada en el análisis de escenarios a través del modelado en equilibrio general computable para las cinco macrorregiones brasileñas.

Resultados principales: como resultado de la investigación, se indica: (i) la importación y exportación sufrieron el impacto causado por la variación del precio del flete, que aumentó en todas las macro regiones brasileñas; (ii) el aumento de las importaciones y exportaciones es indicativo del movimiento de los flujos comerciales y aporta beneficios a la economía del país, favoreciendo el comercio y la economía regional y (iii) las regiones con menores costos de flete, ganancias actuales en competitividad para productos agrícolas.

Relevancia/originalidad: el trabajo contribuye a una agenda de investigación que involucra a importantes sectores de la economía brasileña, agricultura y transporte, y cómo se relacionan entre sí, proporcionando una visión de cómo el costo del flete influye en el comercio de productos agrícolas en Brasil.

Contribuciones teóricas/metodológicas: en el trabajo presenta un enfoque diferente a los métodos más tradicionales, por ECG, creando una alternativa para analizar cómo el costo del transporte impacta en el comercio interregional.

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