MANUFACTURED GOODS, MEATS AND GRAINS: ALTERNATIVES TO A BILATERAL AGREEMENT BETWEEN MERCOSUR AND CHINA

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Abstract:

This study aimed at identifying a possible bilateral agreement between Mercosur and China and its respective impacts on their economies. To this end, the General Equilibrium Analysis Project for the Brazilian Economy (PAEG) was used to conduct tariff reduction scenarios of 25, 50 and 75% of Mercosur agribusiness products such as soybean, corn and meat, together with the Chinese manufacturing sector, with household disaggregation. A tariff reduction scenario of 75% in the Brazilian meat industry and in the Chinese manufacturing sector led to the best results for the Brazilian economy, since the agreement (oap/man) would result in the highest gross domestic product growth rate and would reach industries more positively. However, the agreement (osd/man) involving Brazilian soybeans and the Chinese manufacturing sector was the best scenario for the Chinese economy, once it presented the best indices for the latter.

Keywords: Preferential Trade Agreement, GTAPinGAMS, PAEG.

1. INTRODUCTION

As reported by Perobelli et al. (2017) and Rorig and Feistel (2014), the Brazilian foreign trade, especially of products related to the agribusiness sector, has been an important alternative to obtain a greater international competitiveness, besides contributing to economic growth. Brazil and other Mercosur countries have searched for new trade partners, so that China has stood out as the main Brazilian trade partner (Silva; Figueiredo; Pereira, 2015).

According to data of the Atlas of Economic Complexity (AEC, 2017), regarding Brazilian export tariff, 19% correspond to mineral products, in addition to 18% for vegetable products, 12% for foodstuffs, and 7% for animals and animal products. Similarly, for Argentina, 31% correspond to vegetable products and 25% are related to foodstuffs. In Paraguayan exports, 36%, 24% and 15% correspond to vegetable, mineral and animal products, respectively. In Uruguay, 28% and 23% correspond to animal and vegetable products, respectively. Regarding destination countries, China stands out as to exports of such countries (20% for Brazil, 10% for Argentina and 27% for Uruguay), except for Paraguay (0.46%). In turn, China represents 21%, 17%, 16%, and 17% of Paraguayan, Brazilian, Argentinean, and Uruguayan imports, respectively (AEC, 2017).

In 2016, the People's Republic of China was the second largest economy in the world, with 11.3 trillion dollars based on gross national income (GNI, Atlas method), in current US$, code NY.GNP.ATLS.CD, from development indicators of The World Bank

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(2017). Its remarkable growth above the world average (The World Bank, 2017), high population (1.379 billion people) and an area of 9.6 million Km^2 makes it as one of the most world players.

The bilateral trade between Brazil and China has increased in recent years, since data of the Brazilian Ministry of Development, Industry and International Commerce (MDIC, 2015) indicate that Brazilian exports to China grew at an average rate of 34% per year from 2000 to 2014, while imports represented an average growth of 31.33% per year over the same period.

In this context, the economic impact on Brazilian macro-regions due to a bilateral agreement between Mercosur and China has been questioned. Tariff reduction scenarios on imports of Chinese manufactured products and exports of Mercosur agricultural ones such as soybean, corn and meat have been considered. Thus, the present study contributes to a regional analysis of the Brazilian economy, since it uses a general equilibrium model - General Equilibrium Analysis Project for the Brazilian Economy (PAEG) - that enables regional impacts of a preferential trade agreement between Brazil and China to be measured.

The hypothesis is that a bilateral agreement between Mercosur and China favors the Brazilian agroindustry and the Chinese manufacturing sector. However, such an agreement can also impair some sectors or regions of these economies. The general purpose of this work was to simulate a bilateral agreement between Mercosur and China and to analyze its impacts on Brazilian macro-regions.

Specifical purposes were: a) to identify a possible preferential trade agreement between Mercosur and China; and b) to analyze economic impacts based on GDP, household consumption, investments, public finances etc. due to the proposed trade agreement.

This work represents and advance in the academic literature in relation to similar studies such as those of Perrobelli et al. (2017) and Silva, Figueiredo and Pereira (2015) due to the use of basic data from the Global Trade Analysis Project (GTAP) version 9, and the programming GTAPinGAMS, which enables Brazilian macro-regions to be disaggregated according to Teixeira, Pereira and Gurgel (2013). Furthermore, since it represents a proposal of preferential agreement for specific sectors, it distinguishes from broader studies on free trade areas such as those of Gurgel (2002), Gurgel, Bitencourt and Teixeira (2002), and Figueiredo, Ferreira and Teixeira (2001). In this area of preferential agreements, the Mercosur-China relationship has been scarcely discussed. The study of Thorstensen and Ferraz (2016) might be mentioned, but the authors considered Brazil as a whole, not disaggregating its macro-regions. Thus, the present study contributes to the analysis of specific sectors like grains and meats in Brazilian macro-regions and Chinese manufactured products.

For this purpose, this study was divided into three parts in addition to this introduction. The first part refers to the methodology followed by the analysis of results and, then, concluding remarks.

2. COMPUTABLE GENERAL EQUILIBRIUM MODELS

This work was based on the general equilibrium model applied for the Brazilian economy (PAEG). According to Gurgel et al. (2013), such a model represents the economies of the five Brazilian macro-regions and other countries, their trade flows and scenarios of changes in trade policy. This section describes the adopted method and the structure of the PAEG model and its database.

Computable General Equilibrium Models (CGEMs) have become popular since the 1990s by making possible interdependence modeling between sectors and economic agents

(FOCHEZATTO, 2005). CGEMs are based on Walras's multi-equational system, with description of the allocation of economic resources in behavior blocks of consumers, producers and government. Each agent demands and supplies goods, services and production factors as a function of its prices. By assuming demand and supply equilibrium, the general equilibrium model computes prices of all markets and determines the allocation of resources and the distribution of income resulting from the equilibrium (BORGES, 1986).

The main aspects of CGEMs by which they are appropriate instruments for analyzing changes in economic policies consist of i) they are constructed on solid microeconomic bases, since economic agents should be defined through behavior equations; ii) they present internal consistency among all variables once they derive from a consistent and coherent database; iii) they provide numerical solutions for all endogenous variables, making possible the analysis of effects of changes in economic policies; iv) they consider all interrelationships among variables, enabling the detection of direct and indirect effects of changes in economic policy (FOCHEZATTO, 2005).

CGEMs describe the functioning of the economy through mathematical relationships of the behavior of economic agents in several markets of goods, services and production factors. Various studies on analysis of economic policies including tax policies, development plans, agricultural programs, international trade, energy policies, and environmental policies have used such a theoretical framework (SADOULET and DE JANVRY, 1995; BRAGA et al., 2004).

It must be emphasized that one of the main applications of CGEMs refers to issues related to international trade as observed in the present study, which aimed at identifying economic impacts on the central-west region of Brazil due to a trade agreement.

2.1 THE STRUCTURE OF PAEG[4]

The General Equilibrium Analysis Project for the Brazilian Economy (PAEG) consists of a model that represents economies of north, northeast, southeast, south and central-west regions of Brazil and partner countries. Furthermore, it also evaluates trade flows and projections, in addition to the application of changes in trade policy variables. The interrelationships between several market sectors and economic agents have also been considered to enable complementarity among several sectors to be observed and aggregated effects on welfare and factor markets to be calculated (GURGEL et al., 2013).

According to Gurgel et al. (2013), the reference model for PAEG is known as Global Trade Analysis Project – GTAP. This model arose in 1992 aimed at reducing the cost of entry for researchers worldwide interested in performing a quantitative analysis of international economic issues. The project consisted in providing a global database properly documented and available to researchers, besides constructing a standard modeling in addition to a software for manipulation and implementation of general equilibrium models. This allowed forming an international network of researchers interested in analyzing multi-regional trade issues (HERTEL, 1997).

The basic structure of PAEG is the GTAPinGAMS model, which was developed from the GTAP model (GURGEL et al., 2013). It uses the GTAP database and was elaborated as a non-linear complementarity problem, in the programming language GAMS (General Algebraic Modeling System). The model PAEG was elaborated from the GTAPinGAMS model version 9.0, which in turn was constructed from the GTAP 9.0 database.

[4] The PAEG model was developed in Teixeira et al. (2013).

The use of the GTAPinGAMS model structure by PAEG is due to the disaggregation of Brazil into macro-regions, representing each region individually instead of the country as a whole (GURGEL et al., 2013). This occurs because the GTAPinGAMS model enables the original model structure to be changed, in the programming language GAMS.

PAEG is a static, multi-regional and multisectoral model. In this sense, it represents the production and the distribution of goods and services in the world economy. Each region is represented by a structure of final demand, composed of public and private expenditure with goods and services. The model is based on optimizer behavior, in which consumers seek to maximize their welfare, being subjected to budget constraint, considering fixed investment levels and public sector production. Productive sectors combine intermediate inputs and primary production factors - capital, skilled and unskilled work, land and natural resources - in order to minimize costs, given the technology. Database includes bilateral trade flows between countries and regions, in addition to transport costs, import tariffs and taxes (or subsidies) on exports. Table 1 describes set indices represented in the model.

Table 1. Database set indices.

Indice	Description
i, j	Sectors and goods
r, s	Countries and regions
$f \in m$	Free-mobility production factors within each region: skilled and unskilled work, capital
$f \in s$	Fixed production factors: land and other natural resources

Source: Gurgel et al. (2013, p. 16).

Gurgel et al. (2013) presented in Figure 1 the general structure of the PAEG model, in which symbols represent economic model variables as Y_{ir}, the production of the good i, in the region r; C_r, I_r and G_r - private consumption, investment and public consumption, respectively; M_{jr} - imports of the good j by the region r; HH_{jr} - representative consumer (or household); and $GOVT_r$ - public sector or government; FT_{sr} - activity by which production factors are allocated to private sectors.

In Figure 1, flows in markets of factors and goods are represented by solid lines or irregularly dashed ones, while tax payments are shown by a regular dashed line. Markets of household and imported goods are in vertical lines, on the right. The household production (vom_{ir}) is distributed among exports ($vxmd_{irs}$), international transport services (vst_{ir}), intermediate demand ($vdfm_{ijr}$), private consumption ($vdpm_{ir}$), investment ($vdim_{ir}$), and government consumption ($vdgm_{ir}$). Accounting identity in the database, represented by social accounting matrices regarding household production, is shown by equation (1).

$$\mathbf{vom_{ir}} = \sum_{\mathbf{s}} \mathbf{vxmd_{irs}} + \mathbf{vst_{ir}} + \sum_{\mathbf{j}} \mathbf{vdfm_{ijr}} + \mathbf{vdpm_{ir}} + \mathbf{vdgm_{ir}} + \mathbf{vdim_{i}} \quad (1)$$

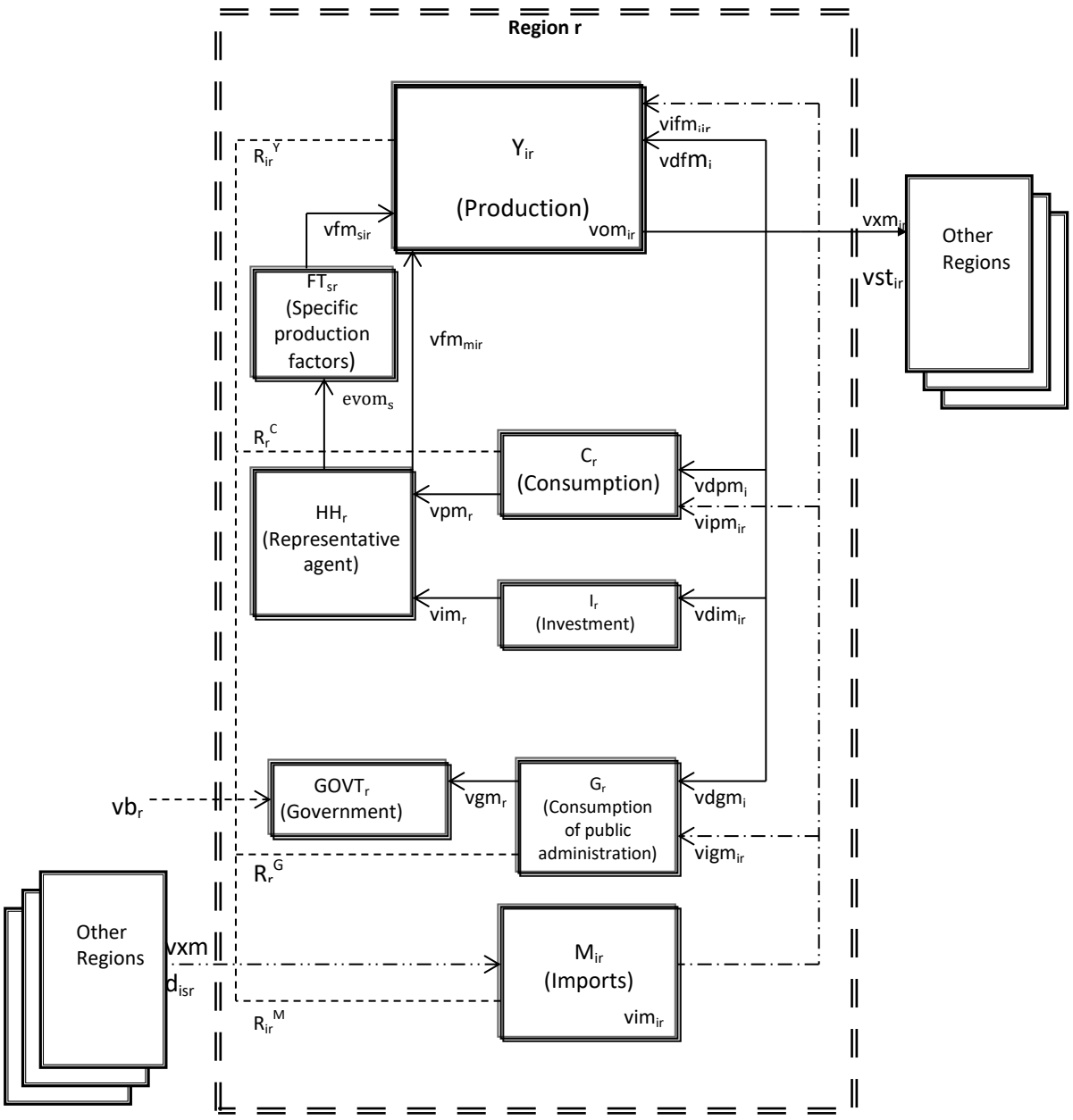
Imported goods (vim_{ir}) are used in intermediate, private and government consumptions. Equation (2) shows the accounting identity of such flows.

$$\mathbf{vim_{ir}} = \sum_{\mathbf{j}} \mathbf{vifm_{ijr}} + \mathbf{vipm_{ir}} + \mathbf{vigm_{ir}} \quad (2)$$

The production of Y_{ir} includes intermediate inputs (household and imported), free-mobility production factors (vfm_{fir}, $f \in m$), within each region, belonging to the set m = {skilled work, unskilled work and capital}, and consumption by the public agent ($vigm_{ir}$). The income of production factors is distributed to the representative agent. The equilibrium in factor markets is given by an identity that relates the payment amount of factors to their income. Equation (3) shows such a relationship.

$$\sum_{\mathbf{i}} \mathbf{vfm_{fir}} = \mathbf{evom_{fr}} \tag{3}$$

Figure 1. Flows in the PAEG model.



Source: Gurgel et al. (2013, p. 17).

For international markets, demand and supply equilibrium conditions require that exports of the good i by the region r (vxm_{ir}) are equal to its imports by all trade partners ($vxmd_{irs}$), as shown in equation (4).

$$\mathbf{vxm_{ir}} = \sum_{\mathbf{s}} \mathbf{vxmd_{irs}} \tag{4}$$

Likewise, equilibrium conditions are also applied to international transport services. The aggregate supply of the transport service j, vt_j, is equal to the amount of transport services in exports as shown in expression (5).

$$\mathbf{vt_j} = \sum_{\mathbf{r}} \mathbf{vst_{jr}} \tag{5}$$

For the market of transport services, demand and supply equilibrium equals the supply of such services to the sum of bilateral flows of transport services acquired in imports of goods ($vtwr_{jisr}$) expressed in equation (6).

$$\mathbf{vt_j} = \sum_{\mathbf{r}} \mathbf{vtwr_{jisr}} \tag{6}$$

Tax and transfer revenues (dashed line) are indicated by the letter R. Tax flows consist of indirect taxes on production and export (R_{ir}^{Y}), consumption (R_{r}^{C}), government demand (R_{r}^{G}), and imports (R_{ir}^{M}). Government income also includes direct taxes on the representative agent (R_{r}^{HH}), in addition to overseas transfers (vb_r). The government budget constraint can be represented by expression (7).

$$\mathbf{vgm_r} = \sum_{\mathbf{i}} \mathbf{R_{ir}^{Y}} + \mathbf{R_r^{C}} + \mathbf{R_r^{G}} + \sum_{\mathbf{i}} \mathbf{R_{ir}^{M}} + \mathbf{R_r^{HH}} + \mathbf{vb_r} \tag{7}$$

The constraint for the representative agent relates the income of production factors, deducted from tax payments, to consumption expenditure and private investment, as shown in equation (8).

$$\sum_{\mathbf{f}} \mathbf{evom_{fr}} - \mathbf{R_r^{HH}} = \mathbf{vpm_r} + \mathbf{vim_r} \tag{8}$$

It must be emphasized that, based on equations above, two types of conditions are observed for the consistency of the database contained in input-output and social accounting matrices - market equilibrium, in which supply equals demand for all goods and production factors, and income balance, in which net income equals net expenditure (GURGEL et al., 2013).

A third set of identities refers to net operating profits in sectors of the economy. PAEG and GTAP models consider the perfect competition market structure and constant returns to scale, so that costs with intermediate inputs and production factors equal production value, and economic profits equal zero. This condition is applied to each productive sector and activity, as shown in equations (9) to (15) as follows.

$$\mathbf{Y_{ir}}: \quad \sum_{\mathbf{f}} \mathbf{vfm_{fir}} + \sum_{\mathbf{j}} (\mathbf{vifm_{jir}} + \mathbf{vifm_{jir}}) + \mathbf{R_{IR}^{Y}} = \mathbf{vom_{ir}}; \tag{9}$$

$$\mathbf{M_{ir}}: \quad \sum_{\mathbf{s}} \left(\mathbf{vxmd_{isr}} + \sum_{\mathbf{j}} \mathbf{vtwr_{jisr}} \right) + \mathbf{R_{IR}^{M}} = \mathbf{vim_{ir}}; \tag{10}$$

$$\mathbf{C_r}: \quad \sum_{\mathbf{i}} (\mathbf{vdpm_{ir}} + \mathbf{vipm_{ir}}) + \mathbf{R_{ir}^{C}} = \mathbf{vpm_r}; \tag{11}$$

$$\mathbf{G_r}: \quad \sum_{\mathbf{i}} (\mathbf{vdgm_{ir}} + \mathbf{vigm_{ir}}) + \mathbf{R_{ir}^{G}} = \mathbf{vgm_r}; \tag{12}$$

$$\mathbf{I_r}: \quad \sum_{\mathbf{i}} \mathbf{vdim_{ir}} = \mathbf{vim_r}; \tag{13}$$

$$\mathbf{FT_{fr}}: \quad \mathbf{evom_{fr}} = \sum_{\mathbf{i}} \mathbf{vfm_{fir}} \quad f \in s; e \tag{14}$$

$$\mathbf{YT_j}: \quad \sum_{\mathbf{i}} \mathbf{vst_{jr}} = \mathbf{vt_j} = \sum_{\mathbf{irs}} \mathbf{vtwr_{jirs}} \tag{15}$$

All mentioned equations present the economic identities of the model, but they do not describe the behavior of economic agents. According to Gurgel et al. (2013), the behavior of agents and sectors should be pointed out in order to understand the functioning of the model.

Table 2 shows variables representing the levels of activities that define an equilibrium and variables of relative prices of goods and factors. The model determines values for all variables, except for international capital flows, which can be endogenously determined in an intertemporal model. Model equilibrium conditions define relative prices instead of nominal ones. Each equilibrium price is associated with a market equilibrium condition.

Table 2. Endogenous variables representing activity levels and prices of goods and factors.

Variable	Description
C_r	Aggregate demand of private agents
G_r	Aggregate demand of the public sector
Y_{ir}	Production
M_{ir}	Aggregate imports
FT_{fr}	Transformation of factors
YT_J	International transport services
PC_r	Private consumption price index
PG_r	Government provision price index
PY_{ir}	Household supply price, gross price of indirect taxes on production
PM_{ir}	Import price, gross price of taxes on exports and tariffs on imports
PFF_{fr}	Price of factors for labor, land and natural resources
PFS_{fir}	Primary factor price in the sector
PT_J	Marginal cost of transport services

Source: Gurgel et al. (2013, p. 20).

The productive sectors of an economy seek to minimize their costs subjected to their technological constraints. The production of Y consists in choosing inputs from the minimization of unit costs, represented by the conditioned optimization problem presented below (16). In these equations, decision variables correspond to initial data (also known as benchmarks), represented by the initial letter "d" instead of "v". Thus, $vdfm_{jir}$ represents initial data of the intermediate demand of the good j in the production of the good i in the region r, while $ddfm_{jir}$ represents intermediate demand variables, which corresponds to the equilibrium of the production-decision problem (GURGEL et al., 2013).

$$\min_{\mathbf{difm,ddfm,dfm}} \quad \mathbf{C_{id}^{D} + C_{ir}^{M} + C_{ir}^{F}}, \tag{16}$$

$$\textbf{Subjected to:} \quad \mathbf{C_{id}^{D} = \sum_j py_{jr}\left(1 + t_{jir}^{fd}\right)ddfm_{jir}};$$

$$\mathbf{C_{ir}^{M} = \sum_j pm_{jr}\left(1 + t_{jir}^{fi}\right)difm_{jir}};$$

$$\mathbf{C_{ir}^{F} = \sum_j \left(pf_{fr\, f \in m} + ps_{fir\, f \in m}\left(1 + t_{fir}^{f}\right)\right)dfm_{fir}};$$

$$\mathbf{F_{ir}\,(ddfm, difm, dfm) = Y_{ir}}.$$

As shown by the optimization problem above, production function is described in the model through the Constant Elasticity of Substitution (CES) function, in which added-value components - primary production factors - can be replaced. This replacement is determined from the elasticity of substitution represented in the model by the parameter $esubva_j$. In turn, intermediate inputs and added value are combined from a Leontief production function and cannot be replaced each other. Each intermediate input j in the Leontief production function is

a combination between household and imported portions of the same good j, in which the portion is determined by the CES function, represented by the parameter $esubd_i$.

According to Gurgel et al. (2013), each imported good demanded by a region is an aggregate of goods imported from different world regions. The choice among imports from different countries is based on the Armington assumption, in which a good imported from a country is an imperfect substitute of the same good from other countries. Thus, bilateral imports are described in the model as the optimization problem below (17).

$$\mathbf{min}_{\mathbf{dxmd,\ dtwr}} \quad \sum_{\mathbf{s}}(\mathbf{1}+\mathbf{t}^{\mathbf{ms}}_{\mathbf{isr}})\left(\mathbf{py_{is}}(\mathbf{1}-\mathbf{t}^{\mathbf{xs}}_{\mathbf{isr}})\mathbf{dxmd_{isr}}+\sum_{\mathbf{j}}\mathbf{pt_j dtwr_{jisr}}\right), \tag{17}$$

$$\textbf{Subjected to:} \quad \mathbf{A_{ir}}\,(\mathbf{dxmd},\mathbf{dtwr})=\mathbf{M_{ir}}.$$

In which A_{ir} represents import aggregation function, where transport services are proportionally added to the value of imports from different model regions, resulting in differences among countries as to transport percentage per transported unit. The replacement among imports from different locations is managed by the elasticity of substitution $esubm_i$. It may occur in trade flows, subsidies (or taxes) on exports, paid by the exporting country, and tariffs on imports, in which income is sent to governments of importing regions (GURGEL et al, 2013).

The optimization problem (18) represents the cost minimization of an aggregate consumption level by the private agent.

$$\mathbf{min}_{\mathbf{ddpm,\ dipm}} \quad \sum_{\mathbf{s}}\mathbf{py_{is}}\left(\mathbf{1}-\mathbf{t}^{\mathbf{pd}}_{\mathbf{ir}}\right)\mathbf{ddpm_{ir}}+\mathbf{pm_{ir}}\,(\mathbf{1}+\mathbf{t}^{\mathbf{pi}}_{\mathbf{ir}})\mathbf{dipm_{ir}}\,; \tag{18}$$

$$\textbf{Subjected to:} \quad \mathbf{H_r}\,(\mathbf{ddpm},\mathbf{dipm})=\mathbf{C_{ir}}.$$

The final demand of the model is described through the Cobb–Douglas production function among nested goods, constituted by aggregation between household and imported goods.

Land and natural resources are considered specific production factors, supplied through the Constant Elasticity of Transformation (CET) function, which allocates factors in sectoral markets. The supply of specific production factors can be observed from the optimization problem (19), in which Γ_{ir} represents the CET function and the elasticity of transformation is represented in the model by the parameter $etrae_f$.

$$\mathbf{max}_{\mathbf{dfm}} \quad \sum_{\mathbf{j}}\mathbf{dfm_{sjr}ps_{sjr}}, \tag{19}$$

$$\textbf{Subjected to:} \quad \Gamma_{\mathbf{ir}}\,(\mathbf{dfm})=\mathbf{evom_{sr}}.$$

International transport services are supplied as an aggregation of transport services exported by several countries and regions of the model. The aggregation of transport services is represented by the minimization problem (20), in which the unit substitution elasticity (Cobb-Douglas production function) is used for replacement among transport from different origins.

$$\mathbf{min}_{\mathbf{dst}} \quad \sum_{\mathbf{j}}\mathbf{py_{ir}dst_{ir}}, \tag{20}$$

$$\textbf{Subjected to:} \quad \mathrm{T_i}\,(\mathbf{dst})=\mathbf{YT_i}.$$

The consumption of public administration is represented in the model by a Leontief aggregation between composite goods of household and imported portions. The different composite goods are not interchangeable. However, household and imported items of each good respond to prices and can be interchangeable, as previously observed in the elasticity of substitution $esubd_i$.

Above-mentioned optimization problems present mathematical relationships found in the PAEG model. In addition to them, the model also considers demand and supply

equilibrium conditions in markets, zero profit and the income-expenditure equilibrium of agents to complete the process of computable general equilibrium.

The model closure considers that the total supply of each production factor does not change, but they are mobile among sectors within a region. The factor land is specific to agricultural sectors, while natural resources are specific to some sectors (extraction of mineral resources and energy). Furthermore, the model does not consider unemployment and the prices of factors are flexible. In turn, regarding demand, investments and capital flows are fixed, as well as payment balance. Thus, changes in real exchange rate should occur to accommodate alterations in export and import flows after shocks. Government consumption can change due to alterations in prices of goods, as well as the revenue from taxes will be subjected to changes in activity level and consumption (GURGEL et al., 2013).

The model proposed by Gurgel et al. (2013) uses the syntax of the algorithm MPSGE (Mathematical Programming System for General Equilibrium), developed by Rutherford (1999). The MPSGE model represents a general equilibrium model through blocks of equations of production function, demand function and specific constraints. After description of blocks, the model converts such information into algebraic equations, which are processed by the software GAMS. Equations generate zero profit conditions for production, demand and supply equilibrium in markets and the definition of income for consumers in the model as a mixed complementarity problem.

2.2 PAEG DATABASE

In the PAEG model, Brazil is represented by five macro-regions, differing from GTAP, which considers the country aggregately. Data from Brazilian regions and GTAP reflect the economic scenario in 2011 for the GTAP 9.0 database. This version covers 140 regions, 57 sectors and 5 primary factors, containing information on international and domestic trade.

According to Gurgel et al. (2013), Brazil needs to be replaced in GTAP by data of input-output matrices developed for Brazilian regions to represent the five regions in the model. In this process, GTAP data for other regions in the model and data of trade flows between Brazil and the rest of the world remain intact to consolidate statistics from several sources elaborated by the GTAP team.

In this replacement process, the first step consists in aggregating regions and sectors of study interest in GTAP and Brazilian regional matrices. After, both data are read in a same file, thus rescheduling data of Brazilian regional matrices, so that the GDP of the Brazilian economy, formed by the sum of GDPs from regional matrices, is compatible (in magnitude) with Brazilian GDP obtained through the GTAP database.

GTAP data on Brazilian imports are distributed among the five regions using data of Brazilian regional matrices to define the relative participation of imports from each region in the total of Brazilian imports. This same procedure is used to define the relative participation of Brazilian regions in the exports of the country as a whole in the GTAP database.

From these procedures, original data of exports and imports of Brazilian regional matrices are replaced for data of trade flows obtained through GTAP. This assures the consistency of trade relationships between Brazilian regions and other regions and countries in the GTAP database. However, supply and demand accounts of Brazilian regional matrices become unbalanced, since their original data of exports and imports were replaced for GTAP data. To recover the equilibrium, the values of sectoral investments and capital flows are adjusted in Brazilian regions. Once the closing rule of the general equilibrium model

maintains fixed such aggregates, adjustments in their values to equilibrate sectoral supply and demand and payment balance do not interfere with results of simulations with the model. This adjustment method also prevents problems regarding changes in input-output coefficients of unbalanced sectors.

After such adjustments, elasticity parameters for Brazil contained in the GTAP database are attributed to Brazilian regions and then Brazilian matrix data of GTAP are removed, only remaining adjusted data of Brazilian regional matrices and other regions covered by GTAP (Gurgel et al., 2013).

The basic aggregation of PAEG consists of 19 sectors and 12 regions, as shown in Table 3, which emphasis on agribusiness sectors, given their importance for income generation and Brazilian export tariff.

Table 3. Aggregation among regions and sectors for the PAEG model.

Regions	Activities
1- Northern Brazil (NOR)	1- Paddy rice (pdr)
2- Northeastern Brazil (NDE)	2- Corn and other cereal grains (gro)
3- Central-western Brazil (COE)	3- Soybean and other oilseeds (osd)
4- Southeastern Brazil (SDE)	4- Sugarcane, sugar beet (c_b)
5- Southern Brazil (SUL)	5- Meat and animal products (oap)
6- Rest of Mercosur (MER)	6- Raw milk (rmk)
7- United States (USA)	7- Other agricultural products – wheat, fibers, fruits, plants etc. (agr)
8- Rest of Nafta (NAF)	8- Food products (foo)
9- Rest of America (ROA)	9- Textiles (tex)
10- European Union (EUR)	10- Wearing apparel and leather products (wap)
11- China (CHN)	11- Wood and furniture (lum)
12 - Rest of the World (ROW)	12- Paper, cellulose and publishing products (ppp)
	13- Chemicals, rubber and plastics (crp)
	14- Manufactured products: non-metallic minerals, metalworking, mining, several industries (man)
	15- Electricity, gas, manufacture distribution and water (siu)
	16- Construction (cns)
	17- Trade (trd)
	18- Transport (otp)
	19- Services (ser)

Source: Pereira et al. (2013, p. 34).

Agribusiness is disaggregated into sectors – paddy rice (pdr);, corn and other cereal grains (gro); soybean and other oilseeds (osd); sugarcane and sugar industry (sgr); meats and live animals (oap),; milk and dairy (rmk); other agricultural products (agr);and food products (foo). Sectors of manufactured products are disaggregated into: textiles (tex); Wearing apparel and leather products (wap); paper, cellulose and publishing products (ppp); chemicals, rubber industry and plastics (crp); and other manufactured products (man). Lastly, service sectors is disaggregated into: Electricity, gas, manufacture distribution and water (siu); construction industry (cns); trade (trd); transport (otn); and other services (ser).

In addition to the five Brazilian regions, aggregation includes the Mercosur (MER) countries Argentina, Uruguay and Paraguay, while other Latin American countries are grouped into one region named Rest of America (ROA). Due to their role in the international scenario, USA were treated in a disaggregated manner from the rest of Nafta (NAF)[5].

[5] Canada and Mexico.

Regarding European Union, the 25 member countries (EUR) were considered[6]. China was also treated in a disaggregated manner in the present study (CHN), and other countries covered by the database were grouped as Rest of the World (ROW).

Household income brackets of Brazilian regions were disaggregated as follows: F1 = Bracket 1 -- up to R$ 400.00; F2 = Bracket 2 -- more than R$ 400.00 up to R$ 600.00; F3 = Bracket 3 -- more than R$ 600.00 up to R$ 1000.00; F4 = Bracket 4 -- more than R$ 1000.00 up to R$ 1200.00; F5 = Bracket 5 -- more than R$ 1200.00 up to R$ 1600.00; F6 = Bracket 6 -- more than R$ 1600.00 up to R$ 2000.00; F7 = Bracket 7 -- more than R$ 2000.00 up to R$ 3000.00; F8 = Bracket 8 -- more than R$ 3000.00 up to R$ 4000.00; F9 = Bracket 9 -- more than R$ 4000.00 up to R$ 6000.00; F10 = Bracket 10 -- more than R$ 6000.00. Disaggregation into income brackets was described by Wolf (2016).

2.3 SCENARIO ANALYSIS

The bilateral trade between Mercosur and China has a range of possibilities for export tariff diversification between the two countries, with emphasis on a possible agreement involving Mercosur agroindustry and the Chinese manufacturing sector. In the present study, analyzed scenarios consisted of a tariff reduction at three possibilities (25, 50 and 75%) in Brazilian exports of the sectors corn and other cereal grains (gro); soybean and other oilseeds (osd); meats and live animals (oap); and in imports of the sector of manufactured products - non-metallic minerals, metalworking, mining, several industries (man) - from China.

Ferraz (2013) and Thorstensen and Ferraz (2016) stated that a preferential agreement with China would result in a greater incentive for the Brazilian trade chain (exports and imports), with significant gains in the allocation efficiency of household factors, as well as in a positive performance regarding GDP growth rate.

Analysis consists in highlighting the best scenario for Brazil considering its regions, in addition to China. For this purpose, impacts of scenarios on the economy were analyzed through percentage variations (%) in the following variables: Gross Domestic Product; Gross Value Added in sectors of the economy based on the model; Household Consumption (Welfare); Government Expenditure; Investments; Exports and Imports.

Scenarios were analyzed from data of the GDP's percentage variation for Brazilian regions, Brazil and China. Then, a summarized table is addressed to game theory in order to compare these scenarios and determine the best ones for studied regions. After table analysis and the evidence of the main scenarios, they were compared in the other variables.

3. ANALYSIS OF RESULTS

This work aimed at analyzing the impact of a possible agreement between Brazil and China on the economy of the central-west region of Brazil. For this purpose, tariff reduction scenarios of 25, 50 and 75% were considered in Brazilian sectors - corn and other cereal grains (gro); soybean and other oilseeds (osd); meats (oap) and in the Chinese manufacturing sector (man). The first results refer to the percentage variation of GDP at the five Brazilian regions and in China due to implemented scenarios. Such results are summarized in Table 4 similarly to a payoff matrix in order to obtain the best scenario for Brazilian regions, Brazil and China. Table 4 shows that a reduction of 75% is preferable to those of 25 and 50% for

[6] Germany, Austria, Belgium, Denmark, Spain, Finland, France, Greece, Netherlands, Ireland, Italy, Luxembourg, Portugal, United Kingdom, Sweeden, Cyprus, Slovakia, Slovenia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, and Czech Republic.

Brazil and China, since the higher tariff reduction, the higher percentage variation of GDP in both countries. However, considering Brazilian regions, a reduction of 75% in the northeast region was not a dominant strategy for GDP variation.

Furthermore, a reduction of 75% was preferable for China regarding soybean and the scenario "all", i.e. corn and other cereal grains (gro); soybean and other oilseeds (osd); and meats (oap), simultaneously. Considering Brazilian regions, southeast and south ones presented gro and oap as preferable scenarios, while scenarios were indifferent for the central-west region. In turn, osd and "all" were the preferable scenarios for north and northeast regions.

Table 4. Percentage variation (%) of GDP.

		MAN China		
Sector	**Region**	**25%**	**50%**	**75%**
GRO	North	(0.018;0.001)	(0.036;0.001)	(0.052;0.002)
	Northeast	(0.001;0.001)	(0.001;0.001)	(-0.001;0.002)
	Central-west	(0.004;0.001)	(0.008;0.001)	(0.012;0.002)
	Southeast	(0.015;0.001)	(0.029;0.001)	(0.040;0.002)
	South	(0.012;0.001)	(0.025;0.001)	(0.039;0.002)
	Brazil*	(0.012;0.001)	(0.023;0.001)	(0.033;0.002)
OSD	North	(0.019;0.001)	(0.037;0.003)	(0.053;0.005)
	Northeast	(0.001;0.001)	(0.001;0.003)	(0.000;0.005)
	Central-west	(0.004;0.001)	(0.008;0.003)	(0.012;0.005)
	Southeast	(0.015;0.001)	(0.028;0.003)	(0.039;0.005)
	South	(0.012;0.001)	(0.024;0.003)	(0.038;0.005)
	Brazil	(0.012;0.001)	(0.023;0.003)	(0.033;0.005)
OAP	North	(0.018;0.001)	(0.036;0.001)	(0.052;0.002)
	Northeast	(0.001;0.001)	(0.001;0.001)	(-0.001;0.002)
	Central-west	(0.004;0.001)	(0.008;0.001)	(0.012;0.002)
	Southeast	(0.015;0.001)	(0.029;0.001)	(0.040;0.002)
	South	(0.012;0.001)	(0.025;0.001)	(0.039;0.002)
	Brazil	(0.012;0.001)	(0.023;0.001)	(0.033;0.002)
GRO; OSD; OAP "all"	North	(0.019;0.001)	(0.037;0.003)	(0.053;0.005)
	Northeast	(0.001;0.001)	(0.001;0.003)	(0.000;0.005)
	Central-west	(0.004;0.001)	(0.008;0.003)	(0.012;0.005)
	Southeast	(0.015;0.001)	(0.028;0.003)	(0.039;0.005)
	South	(0.012;0.001)	(0.024;0.003)	(0.038;0.005)
	Brazil	(0.012;0.001)	(0.023;0.003)	(0.032;0.005)

Note: sectors are corn and other cereal grains (gro); soybean and other oilseeds (osd); meats (oap), and manufactured products (man). (see Table 3). *Brazil stands for the whole country.
Source: Research results.

Considering the magnitude of results, the strategy of adopting a scenario "all" within 75% reduction seems to be preferable for Brazilian regions and China. Thus, sectoral results should be presented in details for the scenario of 75%. Table 5 shows the main sectoral results.

Table 5. Percentage variation (%) in the gross value of production in Brazilian regions and China due to a tariff reduction of 75% in Brazilian sectors (gro, osd and oap) and in the Chinese sector (man).

Regions	pdr	gro	osd	c_b	oap	rmk	agr	foo	tex	wap	lum	ppp	crp	man	siu	cns	trd	otp	ser
Northern Brazil	0.433	0.435	2.244	0.144	0.555	0.021	0.752	0.619	0.474	0.788	0.846	0.674	0.585	-0.349	-0.012	-0.003	0.320	0.025	0.301
Northeastern Brazil	0.116	0.173	2.014	0.047	0.049	-0.219	0.116	0.071	0.233	0.098	0.046	-0.066	0.178	-0.945	-0.058	-0.011	-0.025	0.023	-0.004
Central-western Brazil	-0.082	0.034	1.365	0.006	0.038	-0.015	-0.008	-0.034	0.060	0.071	0.088	0.050	0.052	-1.047	-0.085	-0.013	0.017	0.049	-0.007
Southeastern Brazil	0.069	0.174	2.154	0.162	0.077	0.068	0.128	0.111	0.216	0.187	0.187	0.171	0.256	-0.132	0.011	-0.049	-0.020	0.043	-0.020
Southern Brazil	0.192	0.217	0.902	0.176	0.178	0.156	0.219	0.124	0.197	0.049	0.097	0.119	0.212	-0.583	0.017	-0.029	0.009	0.058	0.004
Rest of Mercosur	0.035	0.075	-0.434	0.050	0.050	0.050	0.030	0.054	0.082	0.069	0.039	0.016	0.028		-0.011		0.007	0.037	-0.005
United States	0.001		-0.374		0.002		0.002		0.039	0.046	0.012	0.003	0.008	-0.004	-0.001		-0.001	0.003	
Rest of Nafta	-0.013	-0.004	-0.204	-0.002	-0.001	-0.002	-0.017	-0.003	0.049	0.050	0.030		-0.001		-0.001			0.002	
Rest of America	0.014	0.005	-0.024	0.006	0.005	0.006	0.023	0.007	0.103	0.060	0.039	0.012	0.017	-0.040	-0.004	0.001	0.003	0.018	0.004
European Union	-0.010	-0.017	-0.047	-0.002	-0.002	-0.003	-0.008	-0.004	0.051	0.050	0.015	-0.001	0.005	-0.004	-0.001		0.001	0.005	
China	-0.029	-0.049	-0.553		-0.009	0.003	-0.044	-0.001	-0.215	-0.172	-0.151	-0.063	-0.118	0.060	0.003	-0.001	-0.008	-0.014	0.016
Rest of the World	-0.003	-0.003	-0.021	-0.004	-0.002	-0.001	-0.002	-0.005	0.051	0.044	0.013	0.001	0.006	-0.002	-0.001		0.001	0.004	-0.001

Note: sectors are 1- Paddy rice (pdr); 2- Corn and other cereal grains (gro); 3- Soybean and other oilseeds (osd); 4- Sugarcane, sugar beet (c_b); 5- Meat and animal products (oap); 6- Raw milk (rmk); 7- Other agricultural products – wheat, fibers, fruits, plants etc. (agr); 8- Food products (foo); 9- Textiles (tex); 10- Wearing apparel and leather products (wap); 11- Wood and furniture (lum); 12- Paper, cellulose and publishing products (ppp); 13- Chemicals, rubber and plastics (crp); 14- Manufactured products: non-metallic minerals, metalworking, mining, several industries (man); 15- Electricity, gas, manufacture distribution and water (siu); 16- Construction (cns); 17- Trade (trd); 18- Transport (otp); 19- Services (ser) (See Table 3). Source: Research results.

For the central-west region of Brazil, eleven (11) out of nineteen (19) sectors had an increase in their gross value of production. Southeast and south regions had fifteen (15) and seventeen (17) sectors with gains from the trade agreement, respectively. Northeast and north regions had gains in twelve (12) and sixteen (16) sectors, respectively. The Rest of Mercosur showed fourteen (14) sectors with gains from the proposal. Namely, the proposal is quite favorable for Mercosur and Brazilian regions. China would have advantages in its sectors of manufactured products and services.

A decline in the sector of manufactured products in Brazilian regions was expected due to increased competition with those produced by China. In turn, sectoral data indicated that the Brazilian soybean sector has a greater advantage than other sectors considering grouped results, while the sector of meats has a greater chain since it leverages the growth of other economy sectors.

The percentage variation of welfare (Table 6) measures changes in household consumption. The north region of Brazil showed a decline in welfare of -0.009%, while the Rest of Mercosur showed a decline of -0.003%. However, for other Brazilian regions, welfare results had a positive variation of 0.034% for Central West, 0.067% for Southeast, 0.032% for South, and 0.025% for Northeast, in addition to 0.063% for China.

Table 6. Percentage variation (%) of welfare in Brazilian regions and China due to a tariff reduction of 75% in Brazilian sectors (gro, osd and oap) and in the Chinese sector (man).

Regions	Welfare
Northern Brazil	-0.009
Northeastern Brazil	0.025
Central-western Brazil	0.034
Southeastern Brazil	0.067
Southern Brazil	0.032
Rest of Mercosur	-0.003
China	0.063

Note: sectors are corn and other cereal grains (gro); soybean and other oilseeds (osd); meats (oap); manufactured products (man). (See Table 3).
Source: Research results.

Table 7 shows the results of aggregate demand components such as consumption (welfare measurement); government expenditure; investments; exports and imports, in addition to GDP in all model regions. In general, for Brazilian regions, except for North, the results of the agreement would be favorable, with a growth in components and a decline in government expenditure, which can be considered a desirable policy in the Brazilian context. The other model regions also indicate a decline in government expenditure, except for China, which had a growth by 0.058%.

Regarding welfare in Northern Brazil (NOR); the Rest of Mercosur (RMS); the United States (USA); the Rest of America (ROA); Europe (EUR), and the Rest of the World (ROW), they showed a decline in consumption, while other regions had an increase, except for the Rest of Nafta (RNF), which remained stable. A decline in investment was observed in the Rest of Mercosur (RMS); the Rest of America (ROA) and in China (CHN), while an increase was observed in the north (NOR), southeast (SDE) and south (SUL) regions of Brazil and in the United States (USA), remaining stable in other regions. Exports and imports increased in all Brazilian regions, in the Rest of Mercosur, in China, and in the Rest of America (ROA).

Table 7. Percentage variation (%) of GDP and aggregate demand components due to a tariff reduction of 75% in Brazilian sectors (gro, osd and oap) and in the Chinese sector (man).

Region	Consumption	Government Expenditure	Investiment	Export	Import	GDP
Northern Brazil	-0.009	-0.719	0.017	0.662	0.300	0.053
Northeastern Brazil	0.025	-0.108		0.227	0.192	
Central-western Brazil	0.034	-0.067	0.002	0.160	0.189	0.012
Southeastern Brazil	0.067	-0.550	0.026	0.830	0.681	0.039
Southern Brazil	0.032	-0.431	0.004	0.309	0.228	0.038
Rest of Mercosur	-0.003	-0.057	-0.003	0.079	0.050	0.001
United States	-0.002		0.001	-0.024	-0.018	-0.001
Rest of Nafta		-0.001				
Rest of America	-0.002	-0.003	-0.001	0.008	0.005	-0.001
European Union	-0.001	-0.001		-0.005	-0.004	-0.001
China	0.063	0.058	-0.008	0.031	0.129	0.005
Rest of the World	-0.002	-0.001		-0.009	-0.010	-0.001

Source: Research results.

Regarding household welfare, the model considered ten income brackets for Brazilian regions. Table 8 shows the percentage variation of welfare. Only families of the income brackets 8, 9 and 10 from the north region would have welfare losses.

Table 8. Percentage variation (%) of Brazilian regional household welfare per income bracket due to a tariff reduction of 75% in Brazilian sectors (gro, osd and oap) and in the Chinese sector (man).

Bracket	Northern Brazil	Northeastern Brazil	Central-western Brazil	Southeastern Brazil	Southern Brazil
F1	0.013	0.005	0.005	0.029	0.026
F2	0.017	0.006	0.007	0.028	0.018
F3	0.017	0.006	0.013	0.041	0.021
F4	0.014	0.008	0.015	0.044	0.014
F5	0.010	0.007	0.020	0.051	0.026
F6	0.001	0.015	0.020	0.057	0.025
F7	0.003	0.017	0.036	0.049	0.030
F8	-0.008	0.033	0.052	0.069	0.038
F9	-0.033	0.039	0.036	0.065	0.035
F10	-0.052	0.045	0.041	0.084	0.037

Note: F1 = Bracket 1 -- up to R$ 400.00; F2 = Bracket 2 -- more than R$ 400.00 up to R$ 600.00; F3 = Bracket 3 -- more than R$ 600.00 up to R$ 1000.00; F4 = Bracket 4 -- more than R$ 1000.00 up to R$ 1200.00; F5 = Bracket 5 -- more than R$ 1200.00 up to R$ 1600.00; F6 = Bracket 6 -- more than R$ 1600.00 up to R$ 2000.00; F7 = Bracket 7 -- more than R$ 2000.00 up to R$ 3000.00; F8 = Bracket 8 -- more than R$ 3000.00 up to R$ 4000.00; F9 = Bracket 9 -- more than R$4000.00 up to R$ 6000.00; F10 = Bracket 10 -- more than R$ 6000.00.
Source: Research results.

4. CONCLUDING REMARKS

Regarding export destinations, China highlights in exports from Brazil, Argentina and Uruguay. In turn, China represents 21, 17, 16, and 17% Paraguay, Brazil, Argentina, and Uruguay imports, respectively. What would be the effects of a preferential trade agreement between Mercosur and China?

The present study simulated and analyzed preferential trade agreements between Mercosur and China, in addition to their impacts on the economies of Brazilian macro-regions and China. The General Equilibrium Model for the Brazilian Economy - PAEG - was used for analysis. Scenarios consisted in reducing tariffs of the Brazilian sectors of soybean; corn and meat and the Chinese manufacturing sector by 25, 50 and 75%, since they are sectors involved in trade relationships between the two countries.

The main results obtained in this work refer to the identification of a possible agreement between Mercosur and China - a 75% reduction in taxes on exports of the sectors Corn and other cereal grains; Soybean and other oilseeds; Meats and live animals; and in Chinese manufactured products.

Welfare gains, increases in Gross Domestic Products, in sectors of Brazilian regions and in macroeconomic aggregates of regions involved in the trade agreement were detected. The results indicated a desirable trade agreement between Mercosur and China.

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