BEHAVIOR OF BRAZILIAN COMMERCIAL RELATIONSHIP FOR HARDWOOD LUMBER EXPLAINED WITH GRAVITATIONAL EQUATION

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ABSTRACT

The aim of this study was to explain the dynamics of Brazil's hardwood lumber exports. The database containing information regarding the sales of hardwood lumber between 1997 and 2010, distance between Brazil and its hardwood lumber importers, a dummy variable indicating the contiguity, GDP and GDP per capita of the countries that bought hardwood lumber from Brazilian was analyzed. The fitted equation showed r^2=63.65% and all the variables were significant. This equation showed that countries with bigger economies import more Brazilian hardwood lumber than countries with small economies. Besides, the negative signal on the adjusted parameter associated with the distance shows that the imported quantity for the countries is inversely proportional to distance. The gravitation model explained Brazil's sawn hardwood exports.
KEYWORDS: Exports of sawn timber. International commerce. Brazil.

COMPORTAMENTO DAS RELAÇÕES COMERCIAIS BRASILEIRAS PARA MADEIRA DE ESPÉCIES FOLHOSAS EXPLICADAS COM EQUAÇÃO GRAVITACIONAL

RESUMO

O objetivo deste trabalho foi explicar a dinâmica das exportações brasileiras de madeira de espécies folhosas. A base de dados utilizada contém informações sobre

as vendas de madeira de espécies folhosas entre os anos de 1997 e 2010, distância entre o Brasil e os importadores de sua madeira serrada, uma variável binária indicando a contiguidade, PIB e PIB per capita dos países que compraram madeira de folhosas com origem brasileira. A equação ajustada teve um r^2=63.65% com todas as variáveis significativas. A mesma mostrou que países com maior economia importam mais madeira brasileira de folhosas do que países com economias menores. Além disso, o sinal negativo no parâmetro associado com a distância mostrou que a quantidade importada pelos países é inversamente proporcional à distância. Desta forma, o modelo gravitacional explicou as exportações brasileiras de madeira de espécies folhosas.
PALAVRAS-CHAVE: Exportações de madeira serrada. Comércio internacional. Brasil

INTRODUCTION

The forest sector has contributed significantly towards the Brazilian economy with 3.5% of the Brazilian GDP in 2011 (BRASIL, 2012). This number reveal that the sector is an alternative to Brazilian development. In 2012, the primary forest production achieved BRL 18.4 billions in silvicultural and logging of native forests (BRASIL, 2012). It represented almost 40% on the forest sector GDP that was approximately BRL 47 billions (CIFLORESTAS, 2016).

Sawnwood is an important means to add value to the wood, as it generates revenue and encourages economical activities like the sustainable management of the natural forests. This market has been passing through several transformations. Countries with long traditions of exporting sawnwood, such as Malaysia and Indonesia, have limited their production, opening up a space in the global market. Brazil has a great potential to occupy this market (SILVA et al., 2012), due to the low production costs and production systems (NOCE et al., 2003).

Gravitational equation has been used to explain the patterns of commercial relationships between different regions (CIPOLLINA & SALVATICI, 2010). It presents the commercial relationship between two countries as an analogy, similar to an attraction between two bodies. In physics, the bigger bodies are more attractive than the smaller bodies, and the distance between them can exert a negative effect on this attraction.

The gravitational models applied to the study of the international markets began to be used in the 1960s by TINBERGEN (1962). On the forest sector, Kangas & Niskanen (2003) analyzed the trade of forest products on the European Union and Eastern Europe, and KARIKALLIO et al. (2011) evaluated the price elasticities for export pulp and paper using gravitation models.

It is important to understand the relationship of the export of Brazilian sawnwood on the international trade flows. Thus, the aim of this study was to explain the export of Brazilian hardwood lumber by gravitational model.

MATERIAL AND METHODS

Theoretical model

The gravitational equation based on the universal law of gravitation, states that the attraction between two bodies is directly proportional to their mass and inversely proportional to their distance. It is expressed as:

$$\omega_{ij} = \varphi \frac{M_i M_j}{D_{ij}} \quad (1)$$

Where:

- ω_{ij} = attraction between the bodies *i* and *j*;
- φ = gravitational constant;
- M_i e M_j = masses of the bodies *i* and *j*;
- D_{ij} = distance between the bodies *i* and *j*.

This equation can be linearized and the effects of each independent variable can be analyzed individually. The linearized equation is given below:

$$ln\omega_{ij} = \beta_0 + \beta_1 lnM_i + \beta_2 lnM_j + \beta_3 lnD_{ij} + \varepsilon_{ij} \quad (2)$$

In the economy, the dependent variable on equation ω_{ij} represents the commercial relationship weight between the regions *I* and *j*, and can be expressed in monetary units or product units. The independent variable M_i is the GDP of the exported regions, M_j is the GDP of the imported regions, D_{ij} is the geographical distance between the exported and imported regions, ε_{ij} is the aleatory error, ε_{ij} is the napierian logarithm, β_0, β_1, β_2, β_3, β_4 and β_5 are the parameters of the model.

The model utilized

The gravitational model was expressed as:

$$ln\omega_{ij} = \beta_0 + \beta_1 lnM_i + \beta_2 lnM_j + \beta_3 lnD_{ij} + \beta_4 \ln m_j + \beta_5 Y_{ij} + \varepsilon_{ij} \quad (3)$$

Where:

- ω_{ij}, ε_{ij}, ln, M_i, M_j, β_0, β_1, β_2, β_3, β_4 and β_5 as explained earlier;
- m_j = GDP per capita of the importing region; and
- Y_{ij} = dummy variable of contiguity; when Brazil borders with the importer country, this variable assumes value 1.

The model was fitted by Ordinary Least Squares (OLS) method from 1997 and 1998, with 112 countries.

Database

Secondary database was used in this study, with the annual data collected between 1997 and 2010, related to the volume of Brazil's sales (*USD*) for each importing country. During this period, Brazil sold sawnwood to 112 countries. Only those countries, that experienced a commercial relationship with Brazil during the entire analyzed period, were considered to fit the gravitational equation.

The values of the sawnwood exported to each country, in American dollars, were drawn from the Food and Agriculture Organization database (FAO, 2015). The GDP and GDP per capita of the countries involved in this study were taken from the United States Department of Agriculture (USDA, 2015). The distance between the importing countries and Brazil were derived from The Center for the Studies and Prospects of International Information (CEPII, 2013).

Statistical tests

Some statistics were calculated to evaluate the quality of the fitted equation.
a) Coefficient of Determination: explains the perception of the variance of the independent variable that was explained for the fitted equation. The formula is expressed as:

$$R^2(\%) = \left[1 - \frac{\sum(y-\hat{y})^2}{\sum(y-\bar{y})^2}\right] x\ 100 \quad (4)$$

b) Adjusted Coefficient of Determination: it was calculated to compare the fitted equation with the others that were fitted with different number of observations. The formula is expressed as:

$$\bar{R}^2(\%) = \left[1 - \left(\frac{n-1}{n-p-1}\right) x\ (1-R^2)\right] x\ 100 \quad (5)$$

Where

- $R^2(\%)$ = coefficient of determination;
- $\bar{R}^2(\%)$ = adjusted coefficient of determination;
- y, $\hat{y}$ and $\bar{y}$ = observed and estimated values, and average of the observed values of the sawnwood sales;
- n = number of observations; and
- p = number of independent variables.

These results were compared with the literature to evaluate the quality of the equation, and the significance of the fitted parameters was analyzed using the student's t-test.

RESULTS AND DISCUSSION

The coefficient of determination and adjusted coefficient of determination were 64.20% and 63.65%, respectively. These values were considered acceptable in the studies with gravitational equations (CHENG & WALL, 1999; BAIER & BERGSTRAND, 2009; SALLES et al., 2011).

Only the parameter $\widehat{\beta_0}$ was non-significant (Table 1). The parameter corresponded to Brazil's GDP and was significant at 5%, whereas the others were significant at the 1% level. All the results can be observed in Table 1.

TABLE 1: Estimated parameters of the Brazilian sawnwood export model, 1997-2010

Variable	Parameter	Estimative	Test t	Level of Significance
	$\widehat{\beta_0}$	-9.1710	-0.5431	0.5875
Exporter Market GDP	$\widehat{\beta_1}$	1.2144	2.0011	0.0463
Importer Market GDP	$\widehat{\beta_2}$	0.9349	21.0243	0.0000
Distance	$\widehat{\beta_3}$	-2.4908	-7.9867	0.0000
GDP per capita of the importing	$\widehat{\beta_4}$	-1.1810	-12.0710	0.0000
Dummy of country contiguity	$\widehat{\beta_5}$	-3.9254	-5.34633	0.0000
$R^2(\%)$ = 64.20%	$\bar{R}^2(\%)$ = 63.65%			

Some authors found better adjusted coefficient of determination, varying to 70% for 90% (DOUMBE; BELINGA, 2015; BITTENCOURT; CAMPOS, 2014). Although the gravitational equations can be used to estimate the future cash flows (NASCIMENTO; PREGARDIER JUNIOR, 2013), the main objective on this analysis is understand the relationship between the studied variables on Brazilian exportation of hardwood lumber. Thus, the most important is find an equation with significant parameters, what occurred in this work.

However, there are authors that found adjusted coefficient of determination values similar to this study, like LEUSIN JR. & AZEVEDO (2009), with between 51 and 71%. Still, SALLES et. al. (2011) and PEREIRA & ALMEIDA (2014), in studies about export of forest products, such as paper and pulp, found values of coefficient of determination approximately equal to 61% and lower than this study.

The elasticity of Brazil's GDP was 1.214, what implies that every $10 increase on the GDP will give $12.14 on the value of the sawnwood exported. The parameter correlated with the importers' GDP was significant (Table 1). Moreover, this positive signal implies that rich countries import more sawnwood than poor countries. The same occurs in physical law of gravitation, where the bigger bodies are more attractive than the small ones, agreeing with the theory of gravity models. Corroborating the study, ZANCHI et al. (2013) found positive parameter for the variables GDP of the origin and consumers' countries of fresh fruits.

The parameter linked with distance was negative (Table 1) indicates that distance affects negatively the export, as stated by the gravitational theory. A similar trend was observed for Brazil's pulp and paper exports (SALLES et al., 2011; PEREIRA; ALMEIDA, 2014), for export of Brazil's agricultural products, such as fresh grapes (FONSECA et al., 2010), fresh fruits (ZANCHI et al., 2013) and agrifood products (ALMEIDA et al., 2014). Indicating that exports are affected by resistance factors to the flow of trade with the outside as transport costs and time, information costs, differences in tastes between regions and others (FONSECA et al., 2010).

In a study, ROMANATTO (2011) found positive parameter for the variable GDP and negative for the distance variable. For this, the great distance between the States and the trading partner countries, the trade flow will be low between them.

The parameter related to the GDP per capita of the importing was significant and negative (Table 1). Since this parameter is an indicator of development (MADDISON, 1983), we conclude that developing countries have tendency to import more Brazilian sawnwood than the developed countries, when the GPD of these countries had similar dimensions. For example, during the study period, Spain and Canada had an identical average GDP. However, the GDP per capita of Spain was much lower than the average. On comparing these two countries, Spain imported more because of its lower GDP per capita. As this study, SALLES et. al. (2011) found negative and significant parameter for country's GDP importer of both products analyzed, but using an 8% level of significance.

The contiguity produces a very interesting result, because its negative signal implies that the Brazilian neighbors import less Brazilian sawnwood. In the beginning, we assumed that the contiguity would decrease the shipping and thus facilitate the trade. However, that did not happen. In fact, the Brazilian neighbors experienced identical environmental conditions, including the possibility of sawnwood production. It must be remembered that the Amazon forest extends to other countries as well, such as Bolivia, Venezuela and Colombia. In this case, we can view these countries as Brazil's competitors on the market.

In Figure 1, we can see the representation of each country to which Brazil exports sawnwood. As evident, big economies, such as China, France and the United States, are more largely represented than the smaller economies, confirming the results found in the equation. Furthermore, when comparing the economies of two countries with similar distances, regarding the GDP, such as France and United Kingdom, the country with the lower per capita GDP tends to import more, in this case France. Although very far away, China imported plenty of Brazilian hardwood lumber due to its high growth rate. Besides, countries with similar GDP and GDP per capita, like Spain and Italy, had their differences in imports explained by distance. In this case, Spain imported more because it was nearer.

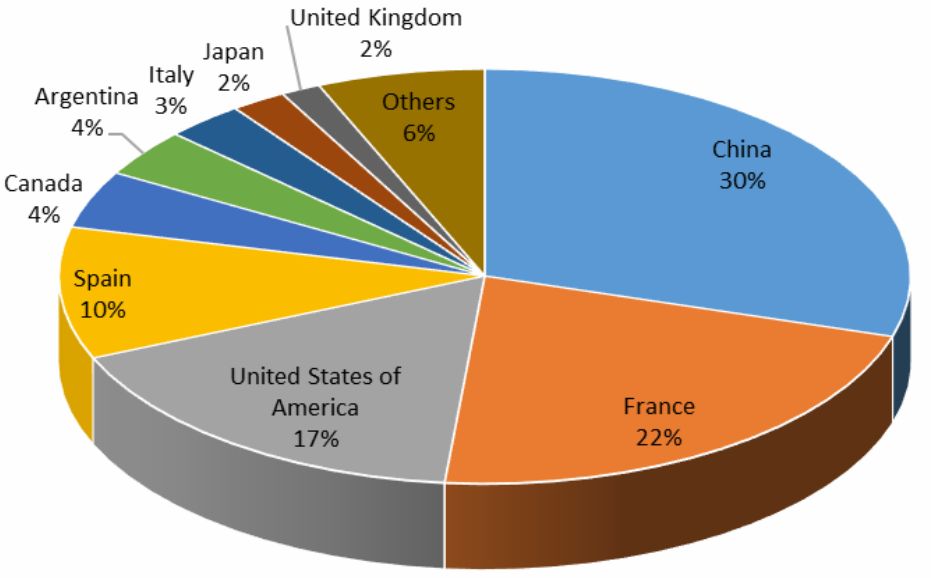

FIGURE 1: Representation of each country, showing Brazil's sawnwood export to them on the analyzed period.

CONCLUSION

The gravity model proposed can explain Brazil's trade relationship between 1997 and 2010. Thus, there is evidence that the great distance between Brazil and importers of the hardwood lumber causes decrease of the volume traded in monetary units.

Export of hardwood lumber are more sensitive to the GDP of the exporting region (in this case Brazil), compared with the GDP and GDP per capita of the importing region.

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