Port Efficiency and Brazilian Exports: A quantitative assessment of the impact of port procedures time*

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Abstract

The purpose of this paper was to estimate the impacts of the port procedures time on Brazilian exports. The study uses an innovative database with municipal exports, with distinction over the port used and with aggregated products according to the harmonized system in 4 digits for the period from 2010 to 2012. To achieve the goal, we use an adapted difference gravity equation in order to explore the time variations of port procedures for 16 Brazilian ports. The estimation results indicate that, in general, each additional hour in the conduction of the port procedures represent costs to the Brazilian exporters, which may be reflected in loss of competitiveness of the domestic products abroad. According to the estimates made, each additional hour of the ship stay in the median port is equivalent to a reduction of the municipal exports in around 2%. Besides that, a reduction of 10% in time of stay for a ship in port can increase the number of exported product categories in 1%.

Keywords: 1. Trade Facilitation 2.Time. 3. Gravity Model.

Resumo

O objetivo deste artigo foi estimar os impactos do tempo dos procedimentos portuários sobre as exportações brasileiras. O trabalho parte de uma base de dados inovadora com dados de exportações municipais, com distinção do porto utilizado, e com produtos agregados de acordo com o sistema harmonizado em 4 dígitos para o período de 2010 a 2012. Para atingir o objetivo, este artigo faz uso de uma equação gravitacional em diferenças adaptada que explora variações do tempo dos procedimentos portuários para 16 portos brasileiros. Os resultados das estimações indicam que, de modo geral, cada hora adicional na condução dos procedimentos portuários representam custos para os exportadores brasileiros, que podem estar se refletindo em perda da competitividade dos produtos nacionais no exterior. Segundo as estimações realizadas, cada hora adicional de estadia no porto mediano é equivalente a uma redução do volume total das exportações municipais em cerca de 2%. Além disso, uma redução de 10% no tempo de estadia relativo do navio no porto pode aumentar o número de categorias de produtos exportados em torno de 1%.

Palavras-chave: 1. Facilitação de Comércio 2.Tempo. 3. Modelo Gravitacional.

JEL: F13, F14.

Anpec Classification: Área 7 – Economia Internacional.

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1 Introduction

Among the various elements that compose the level of trade facilitation of a country, the port infrastructure, as well as the efficiency of the customs procedures is among the most important in determining the final cost of an exported good. In fact, ports are the main gateway used by countries to access global trade. According to the International Chamber of Shipping, around 90% of world trade is carried by the international shipping industry. This importance is also highlighted on the academic literature. For instance, according to Clark et al. (2004), the activities required at port level are sometimes crucial for international trade transactions. Particularly in Brazil, this pattern is not different. According to data from the Brazilian Ministry of Development, Industry, and Foreign Trade - MDIC, between 2004 and 2013, around 82.6% of the total value and 95.8% of the weight from Brazilian exports were conducted through ports.

Despite this relative great importance of Brazilian ports in its trade flows, its infrastructure and organization are very far from the quality and efficiency practiced by countries with high levels of trade facilitation. Using the World Economic Forum indicator of "Quality of Port Infrastructure",[1] it is possible to delineate a *ranking* of countries according to their port quality and efficiency (Appendix A.1). Considering this information for 2013, Brazil was the 130^{th} country in a 148-countries ranking. Furthermore, according to data from the National Agency for Waterway Transportation, in 2012, 56.2% of the total time required for a ship to complete an average port procedure was wasted on either waiting to dock, or waiting to initiate the operations. These numbers suggest that Brazil present a high level of port procedures inefficiency. Thus, it is very important that the academic literature presents estimations of the impacts of policies that aim to improve the Brazilian ports, either by investing in infrastructure or stimulating port efficiency. This study aligns with this necessity, since we provide estimates of the impacts of port procedures time on Brazilian volume of exports and on the number of categories of products exported.[2]

Considering the significant growth of the volume of traded goods and services among the countries, along with the reductions of traditional barriers to trade, such as tariff rates, the relative importance of trade facilitation aspects as determinants of the costs associated to international trade is growing. While the traditional barriers dwindled, other trade obstacles, such as transportation costs, administrative hindrance and efficiency of port procedures grew rapidly in importance in determining the traded goods' final cost. As a result, trade facilitation has been highlighted, both in WTO[3] round of negotiations, and in the planning guidelines for policies that aim to promote international trade.

In this context, trade facilitation literature is relatively recent and the number of empirical studies that aims to estimate the impacts of trade cost reductions on trade flows is increasing. Considering this incipient literature, most of the empirical works use two different approaches to measure trade facilitation. On one hand, studies such as Wilson et al. (2005), Portugal-Perez and Wilson (2010) and Khan and Kalirajan (2011) use the construction of indexes or indicators that incorporate different dimensions of the trade facilitation in a small group of variables. On the other hand, there are works such as Limao and Venables (2001), Sadikov (2007), and Mesquita Moreira et al. (2008) that measure the trade facilitation through

[1]This indicator measures the country businessman's overall perception of their port installments. This information is available in the annual report "Global Competitiveness Report", and in the World Bank database.

[2]The choice of whether to use Brazil for this study is justified by the geographical feature of the country. In fact, Brazil is a country of continental dimensions and has a large number of ports with significant trade volumes. This ensures data variability in terms of products and trade partners which can not be found in many countries.

[3]At WTO, the discussions over the trade facilitation are relatively recent. According to WTO (2013), trade facilitation has become an official discussion topic at the Ministerial Conference in Singapore, in December of 1996. At the occasion, analytical and exploratory studies on the simplification of trade procedures were recommended, in order to assess WTO role in the conduction of agreements in the area. Afterwards, the topic was included in the discussion agenda at Doha Round in November, 2001, when the ministers agreed to hold the negotiations on trade facilitation after the Ministerial Conference of Cancun in September, 2003. In August of 2004, WTO General Council unanimously decided to begin the negotiations on the modalities agreed by its members. Those modalities established the basis for the work plan adopted at the Negotiating Group first meeting, in November of 2004. Throughout the past recent years, detailed negotiations were often hold, and the negotiating text was improved and simplified until it was finally approved unanimously, during the Ministerial Conference of Bali in 2013.

specific variables, aiming for an analysis of isolated aspects.[4]

For each method of measurement of trade facilitation there are advantages and disadvantages. The main advantage of the construction of aggregated indexes refers to the synthesis of the facilitation characteristics in defined aspects. This technique reduces the problems caused by the strong correlation expected among some of the facilitation variables, leading to better estimates and facilitating the econometric analysis, when it is desired to identify and estimate the overall impact of the trade facilitation. Sometimes, the aggregation of variables in general indexes makes it impossible to analyze the impact of specific trade facilitation issues on trade. Therefore, the great advantage of using specific measures of trade facilitation is the direct interpretation of the estimated impacts of those variables on the trade flows. Indeed, for public policy directed to stimulate trade flows, the use of this approach enables the straight interpretation of the impact of specific actions aimed to reduce specific trading costs.

Within this second group of empirical studies, there is a growing literature specialized in estimating the impact of time on trade flows. The idea of time as a trade barrier is relatively new in the academic literature. Hummels (2001) is considered the first to highlight the importance of time to trade as a barrier to exports and imports, identifying the costs related to the slowness of shipping, compared to air transportation, and its implication on trade patterns and the global organization of production. Since Hummels (2001) findings, the required time to transport a product from a country to another has became an evident barrier to trade, and its importance could not be ignored anymore. Evans and Harrigan (2005) highlights the importance of time in determining trade patterns between the countries. For that, it is the first to build a solid and careful micro-foundation for the demand for timeliness and to present empirical evidences on its importance. Harrigan and Venables (2006) presents additional evidence of the importance of transportation time by analyzing its impacts through uncertainties on the delivery time. The results show that the demand for smaller uncertainties on the delivery time of final or intermediate goods is one of the reasons why the manufacturing plants present a spatial agglomeration.

After empirical evidence that the time to transport goods between two countries consists in a barrier to trade, other authors presented additional evidence that not only the transportation time may affect trade flows, but the time needed to perform all the administrative requirements, inspections, purchase of licenses, and transportation of goods from the industry gate to the port, has also an important role in determining the trade flows. Nordas (2006) contributes to the literature by bringing this wider notion of the impacts of the time on the trade flows. In a wider picture, the time of trade process may reflect other aspects of trade facilitation, such as the infrastructure as a whole, the port efficiency, the transparency in the custom, among others.

Djankov et al. (2010) also adopts this wider notion of time as a trade barrier. However, it contributes to the literature by using a new methodology to reduce econometric problems from endogeneity. The authors use a gravitational equation in difference, in order to reduce problems arising from endogeneity, as far as the effects of the trade volume on the time are probably similar between countries that are in the same geographic region. Therefore, assuming a specification in differences would eliminate all common factors in both localities, including endogenous effects that are equal between near regions. This methodology allows assessing the effect of the delays on the relative exports of countries with similar geographical characteristics, endowment, and that face the same tariff rates in the importer countries.

Therefore, the literature indicates that time is an important determinant of trade flows. Most of the studies aim to estimate the effect of the transportation time or total time to complete all the trade process on the trade flows. The literature present evidence that delays on the time to transport a product from the port to the importer country or on the time to complete the whole export/import procedure diminishes the volume of bilateral trade (intensive margin), and reduces the number of firms and production sectors that participate in international trade (extensive margin).

[4]Limao and Venables (2001) is concerned with the participation of the infrastructure in determining the costs of transportation and, therefore, highlights the importance of investments in infrastructure for the incentive of trade flows. Sadikov (2007) adopts variables related to the bureaucracy to measure the trade facilitation of the border and inside the border. While Mesquita Moreira et al. (2008) is concerned with transport costs impact on trade flows.

Nevertheless, no studies were found that perform an analysis of the effects of delays particularly in port procedures on international trade. So this study aligns with this group of studies, and contributes to the literature by giving new empirical evidence of the importance of the port procedures delays, specifically, on trade flows. Therefore, we use an innovative database, with exports from Brazilian cities, with products aggregated at four-digit Harmonized System (HS) over the period of 2010 to 2012, in order to estimate the impacts of the total stay time of a ship in the port on Brazilian exports, assessing which stages of the port procedures contributes more to this impact. We draw information on port procedures time from the Brazilian National Agency of Water Transportation (ANTAQ). These variables are measured in hours and present the mean time that a port takes to handle a complete procedure of importation or exportation of standard containers, since the arrival of the ship on the port anchoring area, until the moment it is undocked.

The database constructed for this study has several advantages over commonly used in the literature data. Most studies found in the literature are performed with *cross-section* data. The panel data allow the estimation of fixed effects, eliminating all costs invariant in time that could affect the export of a particular locality and that could bias the estimates due to its omission on the estimated equations.

Another advantage of the database refers to its high level of detail. The database built for this study is detailed by exporting municipality, product category, destination country and port used, allowing the use of a difference gravity model. The adoption of this strategy enables to control for several unobservable factors that can affect municipal exports. Moreover, such an approach may also reduce problems arising from the possible endogeneity between time measures and the exported volume.

The results indicate that, in general, each additional hour in the conduction of port procedures represents costs to Brazilian exporters, which may be reflected in a loss of competitiveness of domestic products abroad. According to the estimates made, each additional hour of the ship stay in the median port is equivalent to a reduction of the municipal exports in around 2%. Besides that, a reduction of 10% in time of stay for a ship in port can increase the number of exported product categories around 1%.

The rest of the paper is organized as follows: Section 2 describes the data and develops the empirical strategy used in this study. Section 3 presents the descriptive analysis, the empirical results and the sensibility tests followed by final remarks.

2 Methodology

2.1 Data

We use an innovative database built for this study of municipal exports, with distinction over the port used, country of destination, and with products aggregated at four-digit Harmonized System (HS) for the period from 2010 to 2012. The option for this period was due the availability of the data.

Brazilian cities exports were obtained from the AliceWeb System, developed by the National Secretariat of Foreign Trade (SECEX) of the Ministry of Development, Industry and Foreign Trade (MDIC) in Brazil. Information was collected from 2010 to 2012 detailed to the product category (four-digit Harmonized System (HS) level) to the ports,[5] and in the goods origin cities. In total, export data were obtained from 1,876 Brazilian municipalities, destined for 204 countries that used 16 Brazilian ports. Note that the information used comprise only municipalities which exported products aggregated at four-digit Harmonized System (HS) level, and have done so using one of the selected sample ports. Furthermore, due to the empirical strategy, the estimations were realized with a subset of the main sample.

We selected 16 Brazilian ports to compose the analysis database: Belém – PA, Fortaleza – CE, Imbituba – SC, Itajaí – SC, Itaqui – MA, Paranaguá – PR, Rio de Janeiro – RJ, Rio Grande – RS, Salvador – BA, Santarém – PA, Santos – SP, São Francisco do Sul – SC, Itaguaí (Sepetiba) – RJ, Suape – PE, Vila do

[5]According to AliceWeb System, the port is defined as the last location in the country where the goods were dispatched to destination countries.

Conde – PA e Vitória – ES. The figure 1 presents these ports geographical location.

Figure 1: Ports examined - Geographical Location

These ports selection was made based on the availability of the data, and in its relative importance for the Brazilian trade. The ports selected to compose the sample are responsible for most part of the international trade in Brazil. According to data from the AliceWeb system, considering the period between 2010 and 2012, these ports were responsible for around 77.6% of the total Brazilian exports, and around 92.7% of the exports by shipping.

The Gross Domestic Product data of the Brazilian cities were obtained from the Brazilian Institute of Geography and Statistics (IBGE). Information about the average income of workers from the auxiliary activities of waterway transport sector in the cities were the ports are installed were collected from the Annual Information Relation (Relação Anual de Informações - RAIS) platform.

The distances between cities were calculated from the latitude and longitude of each location. The cities and ports latitude and longitude data were draw using the R software, with the *geocode* routine of the package *ggmap*.[6] For each pair of locations, the geographical distance was calculated in kilometers based on Great Circles distances using the Spherical Law of Cosine.[7]

We draw information on port procedures time from the Brazilian National Agency of Water Transportation (ANTAQ). These variables are measured in hours and present the average time that a port takes to handle a complete procedure of importation or exportation of a standard container, since the arrival of the ship on the port, until the moment it is undocked. The figure 2 illustrates the information collected.

The total time of stay on figure 2 refers to the total length of time that it is take to complete the trade procedure at the port, from the arrival of the ship to the area of anchoring to the moment the ship is undocked. This total time of stay, in turn, can be broken down into four steps: Waiting time for docking, waiting time for initiate the operations, operation time and time to undock. The docking time, reflects

[6]Kahle et al. (2013).

[7]To measure the distance more accurately we applied the Spherical Law of Cosine to calculate the great-circle distance d between two points, in the following manner:

$$d = R \;\; arcsen\left[sen(\iota_1)sen(\iota_2) + cos(\iota_1)cos(\iota_2)cos(\lambda_1 - \lambda_2)\right] \tag{1}$$

Where ι_1 and ι_2 are latitudes and λ_1 and λ_2 are longitudes of two points in a sphere with radius R. To the calculation of distance we used $R = 6.371$ km, that is accepted as the mean value of Earth's radius.

the average amount of hours that the ship has been docked at the port, and includes the waiting time for start the operations, operation and undocking times. The ineffectiveness time can be defined as the sum of hours a ship spend waiting.

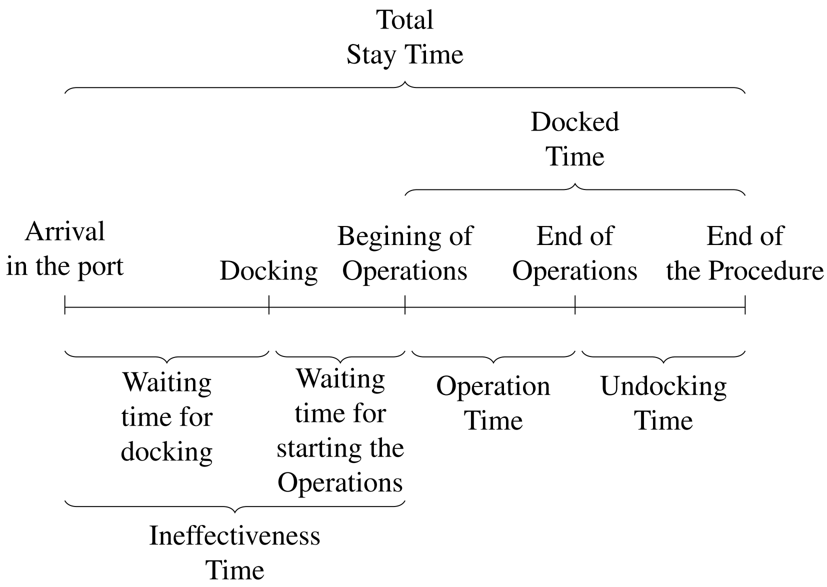


Figure 2: Port procedures time.

2.2 Analitical model and empirical strategy

In order to estimate the impact of time of port procedures on municipal exports, basically two different methodologies could be used: a model of Computable General Equilibrium (CGE) or a gravity model. According to Shepherd (2013), the CGE models are more indicated for analyzes that focus on estimate impacts on the economic welfare, labor and capital reallocation across sectors. In such cases, the gravity model would not be an appropriate methodology. According to the author, the comparative advantage in the use of the gravity model is to evaluate the sensitivity of trade flows in response to specific factors of trade costs, including policy effects.

Therefore, our approach derives from a traditional gravity equation. Gravity models have been widely used in the literature to estimate aggregate effects on trade of tariff and non-tariff measures and cost reductions associated with trade facilitation. Among these studies, are Wilson et al. (2005), Helble et al. (2007) and Shepherd and Wilson (2009). The standard gravitational model used in the literature can be represented by the following equation:

$$X_{j,i} = \frac{Y_i Y_j}{Y} \left(\frac{\phi_{j,i}}{Q_i Q_j} \right)^{1-\sigma} \tag{2}$$

Where $X_{j,i}$ represents the exportations from region j to region i; Y_i is the importer country income and represents the demand for goods from the importer country. Y_j is the exporting capacity of country j. Y represents the world production. $\phi_{j,i}$ is the factor that represents all trade costs between j and i. σ is the elasticity of substitution between products. Indexes Q_i and Q_j represent price indexes, also being identified in the literature as the multilateral resistance. These indexes express that the bilateral trade flows depend on the existing trade costs between the two countries, but also on trade costs associated with other trade partners.

This standard specification of the gravity model considers data at the country level. Considering the database collected for analysis, and the objective of estimating the time impacts of port procedures on exports from Brazil, the model can be directly adapted to disaggregated data for exporter municipalities, for the sector of goods and panel data:

$$X_{m,i,t}^{k} = \frac{Y_{i,t}^{k} Y_{m,t}^{k}}{Y_{t}^{k}} \left(\frac{\phi_{m,i,t}^{k}}{Q_{i}^{k} Q_{m}^{k}} \right)^{1-\sigma_k} \tag{3}$$

In this case, $X_{m,i,t}^{k}$ represents the exports from the municipality m to the country i in product sector k, in the year t, $Y_{i,t}^{k}$ is the country i production in sector k in year t and $Y_{m,t}^{k}$ is the export capacity of the municipality m in the sector k, in the year t. Y_{t}^{k} is the global production of industry k. $\phi_{m,i}^{k}$ is the factor that represents all trade costs between the municipality m and the country i for a particular category of products k in the year t . σ_k is the elasticity of substitution between products of a same category k. Indexes Q_{i}^{k} and Q_{m}^{k}, represent the multilateral resistance, which are by hypothesis, time invariant. Applying the logarithm in this model,[8] the *log-linear* gravity equation is obtained:

$$\begin{aligned} ln(X_{m,i,t}^{k}) =& ln(Y_{i,t}^{k}) + ln(Y_{m,t}^{k}) - ln(Y_{t}^{k}) + (1-\sigma_k) ln(\phi_{m,i,t}^{k}) \\ & - (1-\sigma_k) ln(Q_{i}^{k}) - (1-\sigma_k) ln(Q_{m}^{k}) \end{aligned} \tag{4}$$

From this equation, considering the purpose of the study, it is necessary to establish a specification for the cost term $\phi_{m,i,t}^{k}$ affecting the trade flow of Brazilian municipalities and to consider all factors affecting the export procedure, including the time of port procedures. To better meet this need, it was held one decomposition of the cost term $\phi_{m,i,t}^{k}$. Therefore, a feature of the study data was essential to allow such decomposition. Export data of Brazilian municipalities were obtained with distinction of the port used to make the transport of the traded goods. From this, trade costs can be represented by the new term $\phi_{m,p,i,t}^{k}$, where p denotes the port used to export, and by the following decomposition in three components that incorporate all trade facilitation elements:

$$ln(\phi_{m,p,i,t}^{k}) = ln(\mu_{m,p,t}^{k}) + ln(\omega_{p,t}) + ln(\psi_{p,i}^{k}) \tag{5}$$

Where $\mu_{m,p,t}^{k}$ represents the set of variables that reflect any cost factor between the exporter city m and the port p, such as the distance between the city and the port, the quality and availability of transport infrastructure (roads and railways, for example), and comparative advantages on the production of some goods. $\omega_{p,t}$ is a set of variables that reflect the characteristics of the port used for export, such as the quality and efficiency of customs procedures, including the time required to perform each step of the procedure. Finally, $\psi_{p,i,t}^{k}$ is the set of variables representing costs during the trading process between the port p and destination country i in the year t, such as the distance between the port and the country, and other characteristics of the importer country. The next figure illustrates this decomposition:

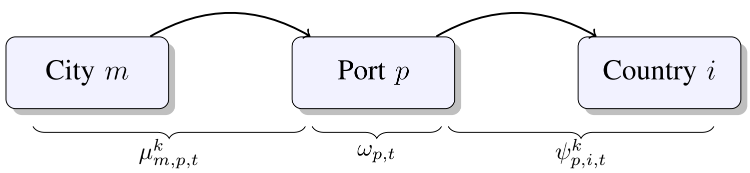


Figure 3: Decomposition of trade costs

Similarly to Khan and Kalirajan (2011) definitions, the variables represented by $\mu_{m,p,t}^{k}$ consist primarily of elements from "behind the border" trade facilitation, while $\psi_{p,i,t}^{k}$ refers to the elements "beyond the border". However, $\omega_{p,t}$ reflects specifically all the aspects of the "frontier" because it captures trade facilitation characteristics inherent to ports. In this case, the empirical specification takes the following form:

$$\begin{aligned} ln(X_{m,p,i,t}^{k}) =& ln(Y_{i,t}^{k}) + ln(Y_{m,t}^{k}) - ln(Y_{t}^{k}) + (1-\sigma_k) ln(\mu_{m,p,t}^{k}) + (1-\sigma_k) ln(\omega_{p,t}) + \\ & (1-\sigma_k) ln(\psi_{p,i}^{k}) - (1-\sigma_k) ln(Q_{i}^{k}) - (1-\sigma_k) ln(Q_{m}^{k}) \end{aligned} \tag{6}$$

[8]The specification *log-log* is widely used in the literature related to the gravity model, as in the works of Wilson et al. (2005), Helble et al. (2007) and Shepherd and Wilson (2009).

The study hypothesis to be tested is that time delays in performing the export procedure on each Brazilian port imply in additional costs to exporters. According to the theoretical model, the possibly higher cost is reflected in lower trade flows. However, in order to test this hypothesis, it is necessary to consider the problems arising from the omitted variables of the aspects of trade facilitation "behind" and "beyond" the border.

According to the constructed model, it is necessary to include in the equation to be estimated costs that represent various factors throughout the international trade process. However, some of these factors, especially those related to the facilitation term "behind the border", $\mu^k_{m,p,t}$, and "beyond the border", $\psi^k_{p,i}$, are unobservable or difficult to measure accurately for different cities and countries in the sample. The omission of these factors could lead to biased estimates of the coefficients of the port procedures time variables. Given these potential problems, the study builds an identification strategy based on the development of hypotheses about the trade facilitation elements and on the construction of a difference gravity model.

Considering the "behind the border" facilitation elements, $\mu^k_{m,p,t}$, the study uses a similar approach to Djankov et al. (2010), in which a gravity equation in differences is estimated. The study estimates a gravity equation in which the variables are calculated as the ratio of two observations regarding the exports of two countries located in a same geographic region. However, differently from what was done by the authors, in this study, the ratios are built considering municipalities instead of countries. The aim of the adoption of this strategy is to eliminate the need to control for regional factors that could affect the volume of exports of a given municipality.

In this case, the difference in the gravitational model is held between observations regarding municipalities located geographically close. The construction of these groups should be conducted so that the facilitation features "behind the border" observed for the municipalities of a same group are similar. For the construction of these groups of municipalities we used the hierarchical *cluster* analysis, using the geographical distance as the dissimilarity variable between municipalities.[9]

By using the approach of construction of ratios from municipalities located sufficiently close, so that the trade facilitation characteristics "behind the border" may be considered the same, we eliminate the need to control for these factors that could affect the exports of municipalities. Therefore, the first identifying hypothesis of the model is that municipalities belonging to the same *cluster* share the same characteristics in terms of regional trade facilitation, such as the business environment, infrastructure in general, and any other local factor.

However, just this strategy is not sufficient to eliminate all unobservable components of the term $\mu^k_{m,p,t}$. Therefore, this strategy should be complemented by a second identifying hypothesis, according to which, given two cities belonging to the same *cluster*, the components of $\mu^k_{m,p,t}$ that differ for two distinct ports are invariant in the short term.[10]

Therefore, controlling for the factors specific to the municipalities by *clustering* them, and adding the hypothesis that aspects between the port and the municipalities of the same *cluster* do not vary from year to year, so if a fixed effects model is estimated, the term of trade facilitation "behind the border", $\mu^k_{m,p,t}$, can be eliminated from the equation.

In order to control for the elements of trade facilitation "beyond the border", we made an additional restriction to the ratios. In fact, we restrict the ratios to be calculated only with observations which the country of destination is the same. This approach was also used by Djankov et al. (2010) and eliminate the need to include trade facilitation terms "beyond the border", $\psi^k_{p,i}$. Therefore, incorporating to the model the assumptions about the facilitation elements "behind the border" and "beyond the border", and making

[9]The Cluster analysis is a multivariate statistical procedure whose primary purpose is to look for patterns in the data to identify relatively homogeneous subgroups between observations called *clusters*. In this case, we used the hierarchical *cluster*, with the Average Linkage agglomeration method. We also considered a limit of 40 kilometers as the criterion for the realization of the cluster.

[10]Here it is assumed that from one year to the other trade facilitation "behind the border" involving the exporter municipality and the port used does not change. This assumption is reasonable towards regional infrastructure. For instance, investments in construction of a new railway, linking a particular region and a specific port usually takes several years to be accomplished.

the construction of ratios of municipal observations belonging to the same region, and using the fixed effects model, we obtain the following equation:

$$ln\left(\frac{X^k_{m_1,p_1,i,t}}{X^k_{m_2,p_2,i,t}}\right) = \beta_1 ln\left(\frac{Y^k_{m_1,t}}{Y^k_{m_2,t}}\right) + \beta_2 ln\left(\frac{\omega_{p_1,t}}{\omega_{p_2,t}}\right) \tag{7}$$

Where $X^k_{m_1,p_1,i_1,t}$ are the exports of city m_1, product k, using the port p_1, to country i in the year t and $X^k_{m_2,p_2,i,t}$ are the exports of city m_2 belonging to the same *cluster* of m_1, of product k, which were shipped through the port p_2, to country i in the year t. The other variables are defined as before.

We also opted for the creation of the ratios between municipal observations that export the same product, but which have made their exports through different ports. This option allows the control of intrinsic characteristics to each category of products that are not observed, such as the elasticity of substitution, eliminating bias arising from the omission of these variables.[11]

The strategy of building groups of municipal observations although it may limit the examination of time delays effects only for the municipalities that already export, has several advantages of the econometric point of view. In addition to eliminate non-observable components, the approach also allows the reduction of endogeneity problems between the characteristics of trade facilitation and Brazilian exports. Under the assumption that investments in trade facilitation "behind the border" occur on a regional scale, so that geographically close cities equally benefit from it, then the use of ratios calculated for municipal observations belonging to a same *cluster* eliminates the presence of endogeneity between the volume of municipal and trade aspects "behind the border". Additionally, as the ratio is performed with data ports and cities of a same country, in this case Brazil, any endogenous channel between time costs and volume of trade that may affect the results on a national scale, is also eliminated.

From this model, the econometric specification adopted to estimate the impact of time of port procedures on Brazilian exports involves the collected variables described in section 2.1. Usually empirical studies use GDP as a measure of the income of the countries involved in bilateral trade. However, in the case of a disaggregated model for municipal data, GDP would possibly not be the best variable to be used to capture the term of export capacity of the city.[12] In order to better capture this term, we used the export coefficient of municipalities, calculated as the ratio of the total exported by each municipality in a given sector and the municipal GDP in a given year t.

Finally, the trade facilitation term of "border" elements should include the characteristics of Brazilian ports. Therefore, we include in the equation the number of dockings, the cost of port usage[13] and variables of time of port procedures. Therefore, the empirical equation can be written as follows:

$$\begin{aligned} ln\left(\frac{X^k_{m_1,p_1,i,t}}{X^k_{m_2,p_2,i,t}}\right) =&\alpha_t + \beta_1 ln\left(\frac{Coef.Exp^k_{m_1,t}}{Coef.Exp^k_{m_2,t}}\right) + \beta_2 ln\left(\frac{Cost_{p_1,t}}{Cost_{p_2,t}}\right) + \beta_3 ln\left(\frac{Time_{p_1,t}}{Time_{p_2,t}}\right) + \\ &\beta_4 ln\left(\frac{Nr.Docking_{p_1,t}}{Nr.Docking_{p_2,t}}\right) + \varepsilon^k_{m_1,m_2,p_1,p_2,i_1,i_2,t} \end{aligned} \tag{8}$$

The term α_t represent a set of *dummy* variables for year, used to capture intrinsic effects of each year. $Coef.Exp_{m,t}$ is the export coefficient of the municipality m for product sector k, at time t. $Cost_{p,t}$ is the

[11] We restricted the ratios to be calculated only between observations referred to different cities (belonging to a same cluster) and different ports, but to a same importer country and related to a same product category.

[12] This can be explained by the fact that municipalities usually have a much more limited range of production sectors than a country. In addition, growth in local GDP will be associated with greater trade flows only if the growth occurs in the export sector. If the growth of municipal income is strongly linked to the service sector, for example, the municipal income may not affect the municipal exports.

[13] We included in the equation the average income of workers from the auxiliary activities of waterway transport sector in the cities were the ports are installed. This variable was used to control for the cost of port usage. In fact, the price a port charges the exporter can be an important determinant of which port will be used for the exportation procedure. However, this type of information is dispersed and difficult to obtain with precision for all the sample ports. Therefore, we used the average income as a rough measure of this cost. Implicitly we are assuming that the ports which have higher port charges, are located in municipalities whose salaries paid to employees in water transport auxiliary activities are also higher.

cost of port p usage in year t. $Time_{p,t}$, refers to the port procedures time variables in the port p and in the year t. $Nr.Docking_{p,t}$ is the number of dockings for the port p and year t. $\varepsilon^{k}_{m_1,m_2,p_1,p_2,i,t}$ is a random error term. The estimates made were based on four basic specifications, in which different measures of time were inserted into the equation in order to better estimate the impact of the various steps of the port procedure.

According to Nordas (2006), the time to transport goods, or to complete the trade procedure may have effects on exports at the extensive and intensive margins of trade. Therefore, time represent costs to exporters, which can affect both the volume of exported products (intensive margin) and the number of sectors and firms participating in the international trade (extensive margin). In this sense, two measures of exports were used as dependent variables in the equations presented before.

The first was the volume exported in dollars. Equations with this dependent variable result in estimates of the impact of port procedures time variables on the intensive margin of trade. In this case, we estimate the effect of reductions in port procedures time on the intensity of trade volumes. These estimations consider only those cities that are already exporters and the products that are already exported.

We do not intended to perform a rigorous analysis of the effects of time of port procedures on the extensive margin of trade. Accordingly, no probability model was estimated, as this type of analysis usually is performed in the literature. Instead, we adopts a similar approach to Moreira et al. (2013), where the number of exported products is used as the dependent variable in place of the exported value.

In this sense, the second measure used as the dependent variable was the number of categories of exported products. At this stage, the goal is to analyze to what extent the time of port procedures can affect the diversification of exports. This variable was measured as the total number of different product categories aggregated by the Common Nomenclature of MERCOSUR - NCM in 8 digits.[14] In this case, the ratios were calculated as the number of products categories NCM-8 digits in a given HS-2 digits for two cities in a same *cluster*, for a same country, and using two different ports.

3 Results

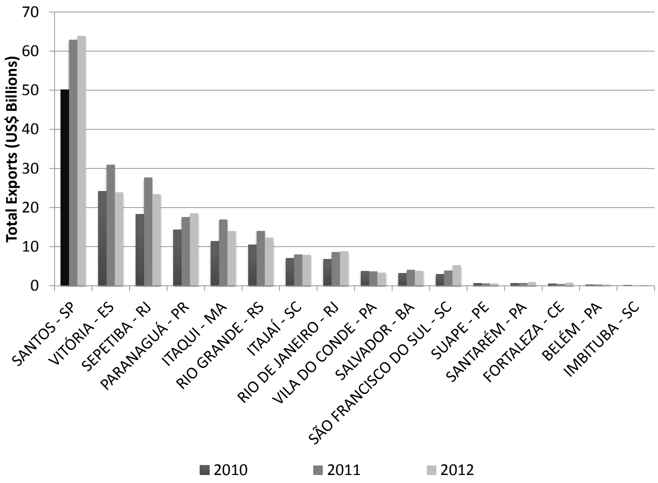
3.1 Port procedures and time

In order to better delineate the profile of each port of the sample, we present their relative importance to Brazilian trade. Figure 4 present the total volume of exports of each port of the sample during the period from 2010 to 2012.

According to the figure, Santos is the Brazilian port with higher exports volume (around US$ 64 billion in 2012). All the other ports can be divided into three groups. Vitória, Sepetiba, Paranaguá, Itaqui and Rio Grande can be considered as ports with high volume of exports, ranging from 10 to 30 billion dollars. Itajaí, Rio de Janeiro, Vila do Conde, Salvador and São Francisco do Sul can be considered ports with moderate volume of exports ranging from 3 to 9 billion dollar. Finally, Suape, Santarém, Fortaleza, Belém and Imbituba are ports of low volume of exports, with less than 1 billion dollar. Despite this low volume compared to the other ports of the sample, these ports are considered in the analysis due to their regional importance or to the products they usually export.

Considering the time variables of port procedures, it is possible to characterize each port of the sample according to its efficiency in the conduction of trade procedures. The time that each port takes to complete each stage of the trade process may reflect the trade facilitation characteristics of the port, such as the port infrastructure quality, or the ports bureaucracy and other features that may affect the time to complete a standard procedure.

[14] Although we do not estimate an effect of time on port on the likelihood of new companies and productive sectors enter the international market as exporters, the results present the effects of time on the diversification of exports. In this sense, the results can be interpreted as evidence of the effects of time in port on the extensive margin of trade.

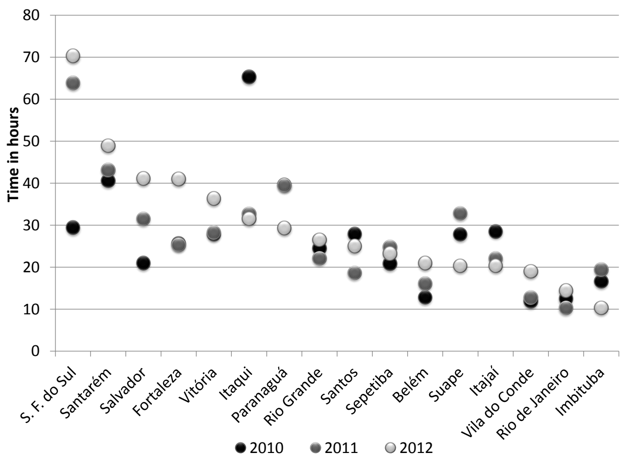


Source: AliceWeb (2015).

Figure 4: Brazilian Ports - Total exported in US$ billions from 2010 to 2012

The first relevant information to characterize the ports is the total time of stay (also called turnaround time), which consists in the time spent from the moment in which the ship arrives in the port until it is undocking. The figure 5 presents the time of stay of each port throughout the years of the sample.[15]

According to the information from figure 5, Imbituba and Rio de Janeiro may be considered the most agile ports, or those with the lowest time of stay. On the other hand, São Francisco do Sul stands out as the most time consuming, and can take more than 70 hours to complete the entire port procedure. It is also worth noting that, during the analyzed period, only Itaqui, Paranaguá, Suape, Itajaí, and Imbituba reduced their total time of stay. This result points out to a latent need of investment on the Brazilian ports that are, at each year, taking more time to execute the exportation and importation of goods.



Source: ANTAQ (2015).

Figure 5: Brazilian Ports - Time of stay

Table 1 presents additional information related to the time variable in the sample ports. According to the information, the Brazilian ports from the sample present an average stay time of 28 hours and 12

[15]Three adjustments were made in the time database for the presence of *outliers*. Verifying the monthly data, ports from Salvador, in April 2011, Paranaguá, in March 2011, and Fortaleza, in August 2012, presented stay time data excessively above their monthly averages, affecting the annual value of this measure. Thus, it was made a substitution of the monthly observations affected by the monthly average of each port, for the calculation of the annual time measure of these ports.

minutes. From this total, an average of 15 hours and 42 minutes is spend with the ship docked, and the rest of the time is wasted in waiting steps.

Table 1: Time measures

Variable	Obs	Mean	Median	Std. Dev.	Min	Max
Time of Stay	48	28.2	25.5	13.6	10.3	70.3
Docked Time	48	15.7	12.7	9.7	5.7	48.9
Ineffectiveness Time	48	13.6	11.8	11.8	0	60.2
Waiting time for docking	48	12.5	11.4	11.9	0	57.6
Waiting time for Starting the Operations	48	1.1	0.8	1.6	0	10.6
Operation time	48	12.5	9.6	8.2	4.4	44.1
Undocking time	48	2.1	1.3	3.5	0	24.4

Source: ANTAQ (2015)

Table 1 also provides information related to the variation in sample ports times. While there are ports with no ineffectiveness time, there are other ports in which the maximum waiting time is 60 hours and 12 minutes, with the ship waiting to dock or to start the operation. Regarding the operation time, the results also vary a lot between ports. While the most agile port spends 4 hours and 24 minutes to perform the operations, the slowest one takes around 44 hours to perform the same stage of the procedure.

For a better understanding of the composition of the stay time, figure 6 presents the information of each stage of the sample ports trading process over the analyzed period. Each graph bar represents a year of the sample in the sequence from 2010 to 2012, and each stage of the procedure is added equally to the stay time.

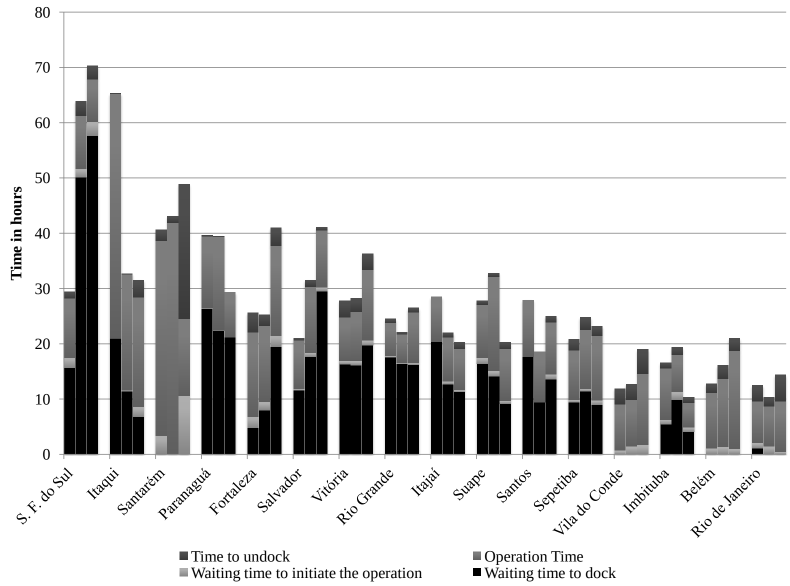


Figure 6: Brazilian ports - Average time of each step of the port procedure

Each stage varies a lot between the sample port, and over the sample years as well. Indeed, the operation time captures the efficiency in carrying out the goods loading and unloading at each port. Santarém and Itaqui are examples of ports which operation time is higher than the others sample ports. On the other hand, Rio Grande and Imbituba are examples of port with relatively more agile operation. According to figure 6, undocking time represents the smaller portion of the procedure total time. Santarém in 2012 presented the greater average time to undocking a ship. Nevertheless, in the average for the sample, the ports take around 2 hours to undock a ship.

According to the information, it is noted that in most of the ports analyzed, the waiting time for docking is the stage that contributes the most for the total stay time. São Francisco do Sul, for example, has the highest waiting time for docking of the sample. And throughout the sample years, this stage has considerable increased. Salvador, Fortaleza and Vitória also presented growth of the waiting time for docking. Other ports such as Itaqui, Paranaguá, Itajaí, and Suape presented a reduction of the waiting time for docking, although this stage still consists in a relevant part of the port procedure. Ports such as Santarém, Vila do Conde, and Belém stand out for not having waiting time for docking. However, these ports present important shares of waiting time to initiate the operations (red color). Indeed, the sum of both waiting times is called ineffectiveness time and represents the time in which the ship is prepared to perform the goods loading and unloading procedure, but stay waiting, or to dock in the port, or to initiate the operation. Table 2 presents the participation of the waiting time in the total time of stay of each port over the sample years.

Table 2: Waiting time as a percentage of total time of stay

Port	2010	2011	2012
Rio de Janeiro	16.80%	14.56%	3.47%
Belém	8.59%	8.70%	4.76%
Vila do Conde	5.88%	11.81%	8.95%
Santarém	8.37%	0.00%	21.68%
Itaqui	32.31%	35.47%	27.30%
Itaguaí (Sepetiba)	47.60%	47.98%	42.24%
Imbituba	37.95%	58.25%	47.57%
Suape	62.95%	46.04%	47.78%
Fortaleza	26.56%	37.55%	52.45%
Vitória	60.79%	59.93%	56.75%
Itajaí	71.58%	60.00%	57.64%
Santos	63.44%	50.54%	58.00%
Rio Grande	72.65%	75.11%	62.64%
Paranaguá	66.67%	56.90%	72.35%
Salvador	56.67%	58.44%	73.48%
São Francisco do Sul	59.52%	80.91%	85.63%
Mean	43.65%	43.89%	45.17%

Source: ANTAQ (2015)

According to the table 2, the less ineffectiveness ports are the ones from Rio de Janeiro, Belém, and Vila do Conde, in which the waiting time is below 10% of the procedure total time. On the other hand, from the 16 sample ports, 11 of them present waiting time superior to 40% of total time. Among them, Fortaleza, Vitória, Itajaí, Santos, Rio Grande, Paranaguá, Salvador, and São Francisco do Sul present percentage values superior to 50%. In these ports, in most part of the total time of stay, the ship is inoperative. Moreover, in many cases, this participation of the waiting time has increased over the sample years. In fact, the average of this participation of the waiting time has increased for the sample ports. These results indicate the presence of a bottleneck in the flow of the Brazilian production to the international market. Because of the growth in Brazilian trade flows over the last decade, those limitations have become even more evident, and they point out to a need of investments in order to increase the port capacity, reducing inefficiencies that generate those elevated percentages of ineffectiveness time in Brazilian ports.

3.2 Estimated Results

From the discussed empirical strategy, this section presents the estimates of the proposed models using four basic specifications to obtain a more precise analysis of the time effects on Brazilian exports. In this sense, the models were estimated by fixed effects for the pair of municipalities, destination country, product category and pair of ports used. In order to evaluate the time of port procedure effects over trade, the fixed effects model is presented as the most appropriate. In fact, the fixed effects model consists in an appropriate treatment for estimating the gravity equation, since it allows control of the heterogeneity of countries, and the effect of other unobservable omitted or difficult to measure variables, that are time invariant (such as the multilateral resistance indexes, Q_i^k and Q_m^k) in order to eliminate bias resulting from its omission. In addition to eliminating the need for inclusion of many unobservable characteristics, the choice of using fixed effects models were confirmed by running Hausman statistics, that corroborate this option instead of the random effects model. Table 3 presents these estimations.

Table 3: Impacts of port procedures time on volume of exports from Brazilian cities

Dependent variable: ln(Ratio Exported Value FOB)				
	Fixed Effect Models			
	(1)	(2)	(3)	(4)
ln(Ratio Export Coefficient)$_{t-1}$	0.170***	0.174***	0.171***	0.176***
	(0.054)	(0.054)	(0.054)	(0.054)
ln(Ratio Number of Dockings)	1.170***	1.167***	0.757***	0.904***
	(0.209)	(0.210)	(0.199)	(0.195)
ln(Ratio Port Cost)	-1.098***	-1.202***	-1.229***	-1.335***
	(0.233)	(0.267)	(0.241)	(0.227)
ln(Ratio Time of Stay)	-0.514***			
	(0.136)			
ln(Ratio Operation Time)		-0.050		
		(0.147)		
ln(Ratio Waiting Time + Undock)		-0.353***		
		(0.086)		
ln(Ratio Waiting Time for Docking)			-0.100***	
			(0.020)	
ln(Ratio Docked Time)			-0.029	
			(0.167)	
ln(Ratio Waiting Time Rate)				-0.266***
				(0.070)
Constant	-0.554***	-0.563***	-0.426***	-0.470***
	(0.106)	(0.109)	(0.104)	(0.101)
Observations	11,377	11,377	11,377	11,365
Year Dummies	Yes	Yes	Yes	Yes
R^2	0.040	0.040	0.041	0.038

Source: Authors' calculations.
Note: Standard errors robust to heterocedasticity are in parentheses.
*, **, and *** denote statistical significance of 10%, 5% e 1%, respectively.

According to the estimated coefficients, the municipal export coefficient has a positive and statistically significant effect on the exported volume in all estimated specifications. These results show the importance of the export capacity in determine the Brazilian exports at the municipal level, which supports the theory of the gravity model and are similar to results found in the literature of the traditional gravity model.

The average number of dockings variable present a positive and statistically significant coefficient in all equations estimated. This result is intuitive and supports the idea that ports that have a higher number of dockings also have higher volume of trade. On the other hand, the variable that measures the cost of the port, present negative and statistically significant coefficients in all equations. This result indicates that the cost of the port is an important determinant of the trade volumes. Moreover, the results highlight the importance of the inclusion of these two variables in all equations to control for port characteristics that may affect the trade volume.

The first specification shows the effect of the total time of stay on exports for the Brazilian municipalities. In fact, assuming that a reduction in the time of stay affects only the exports of municipalities that use that port, a reduction of 10% of the total length of stay, or at any stage of the procedure, would generate an increase of around 5.14% in relative local exports. For a more detailed analysis, the specifications (2) and (3) estimate the effects of the time of the port procedure disaggregated by the steps of the port procedure.

In specification (2), the operation time and the remaining time of the procedure, that is the total time of stay excluding the operating time were included on the equation. According to the estimated coefficients, keeping the time of the other steps constant, a reduction in the relative operation time do not affect the relative exports, while a reduction of 10% on the time of the remaining process would generate an increase in exports of 3.53%. These results suggest that the operation step do not matter for the exported volume, while at least one of the other steps (waiting to dock, waiting to initiate the operations or to undock) presents a negative and statistically significant effect.

The specification (3) estimates the impact of the length of the procedure disaggregated by the impact of the ship waiting time for docking and time docked. According to the estimated coefficients, a reduction of 10% in the waiting time to dock is reflected in an increase of 1% in relative exports, while the time the ship remains docked would generate no relevant impact in local exports. This result strength the coefficients presented on specification (2), by highlighting the importance of negative effects on trade volumes from increasing waiting time. In fact, great part of the docked time is determined by the operation step.

The last specification estimates the impact of the participation of the ineffectiveness time in the total time. Therefore we created a measure of the waiting time as a percentage of the total length of stay. The objective is to estimate the impact over trade from reductions in the time the ship is inoperative as a percentage of the total time it takes to complete the whole procedure. The estimated coefficients indicate that a reduction of 10% in ineffectiveness rate is reflected in an increase of 2.66% in exports.

Putting the results in context, the median number of hours of stay in the sample, as shown at table 1 is 25.5. Therefore, each additional hour of a ship's stay in the median port is equivalent to a reduction of around 2% $(0.514 \times 1/25.5)$ of local exports. More specifically, each hour delayed in the waiting time to dock in the median port, keeping all the rest constant, is equivalent to a reduction of 0.88% $(0.1 \times 1/11.4)$ in local exports.

Additionally to the estimation of the impact of time of port procedures on the volume of trade, we also evaluate the effects of time on the number of exported products. At this stage, the goal is to examine how the time of port procedures can affect the diversification of exports from Brazilian municipalities. Table 4 presents the estimation results of the proposed models.

Table 4: Impacts of port procedures time on the variety of products exported

Dependent variable: ln(Ratio Number of Exported Products)				
	Fixed Effect Models			
	(1)	(2)	(3)	(4)
ln(Ratio Export Coefficient)$_{t-1}$	0.071***	0.072***	0.073***	0.073***
	(0.019)	(0.019)	(0.019)	(0.018)
ln(Ratio Number of Dockings)	0.340***	0.327***	0.248***	0.276***
	(0.078)	(0.078)	(0.076)	(0.075)
ln(Ratio Port Cost)	-0.093	-0.054	-0.090	-0.132
	(0.097)	(0.107)	(0.098)	(0.093)
ln(Ratio Time of Stay)	-0.099**			
	(0.047)			
ln(Ratio Operation Time)		-0.075		
		(0.052)		
ln(Ratio Waiting Time + Undock)		-0.071**		
		(0.030)		
ln(Ratio Waiting Time for Docking)			-0.012	
			(0.009)	
ln(Ratio Docked Time)			-0.082	
			(0.052)	
ln(Ratio Waiting Time Rate)				-0.051
				(0.036)
Constant	-0.235***	-0.228***	-0.187***	-0.210***
	(0.048)	(0.048)	(0.045)	(0.045)
Observations	16,062	16,062	16,062	16,047
Year Dummies	Yes	Yes	Yes	Yes
R^2	0.004	0.004	0.004	0.004

Source: Authors' calculations.
Note: Standard errors robust to heterocedasticity are in parentheses.
*, **, and *** denote statistical significance of 10%, 5% e 1%, respectively.

According to this second group of estimations, the export coefficient presents a positive and statistically significant relation to the variety of exports. This result highlights the idea of the theoretical gravity model, in which regions with higher export capability not only exports a greater volume, but also have a greater variety of products exported. As the results presented before, the number of dockings present a positive and statistically significant relation to the number of exported products. However, the coefficients of the costs of port usage are not statistically significant. This indicates that although the costs may be important to determining the volume of trade, they do not seem to be relevant to explain the variety of trade.

The time of stay in the port procedures have a negative and statistically significant relationship with the number of exported products. A reduction of 10% in the total time of stay on increase by 1% on the number of products exported. Regarding the steps of the port procedure, the results indicate that the operation time is not relevant when the effects on export diversification are analyzed. According to specification (2) in table 4, a reduction of 10% in the waiting time to dock, waiting time do initiate the operations or to undock could increase the number of products exported in 0.71%. The other two specifications, present negative coefficients for the time variables, but none of them is statistically significant.

In sum, the results suggest that time delays on port procedures represent an important determinant of the volume of exports and on export diversification. Moreover, when we estimate the time effect divided into the procedures steps, the ineffectiveness or waiting times are the ones which present relevant impacts.

3.3 Sensibility Analysis

This section presents a set of estimations performed to test the sensibility of the results. The following tables present the estimates of the same specifications of the ones shown in table 3, but with changes in the sample. The goal is to verify how the results are modified as the sample varies in relation to the coverage of ports and products. The first four columns of table 5 presents the estimates only with observations in which the two ports considered on the ratio are located in the same geographic region. This additional restriction reduces the number of observations, but also strengthens the hypothesis made to control for "behind the border" trade facilitation.

Table 5: Sensibility analisys: Exported volume models

Dependent variable: ln(Ratio Exported Value FOB)								
	Same region ports				Without most traded goods			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ln(Ratio Export Coefficient)$_{t-1}$	0.101	0.116*	0.106	0.121*	0.274***	0.279***	0.276***	0.283***
	(0.068)	(0.069)	(0.066)	(0.066)	(0.062)	(0.062)	(0.061)	(0.061)
ln(Ratio Number of Dockings)	1.815***	1.871***	0.586**	1.012***	1.016***	0.945***	0.473**	0.699***
	(0.306)	(0.320)	(0.279)	(0.259)	(0.217)	(0.225)	(0.231)	(0.220)
ln(Ratio Port Cost)	-1.059***	-1.262***	-0.672*	-1.176***	-1.452***	-1.469***	-1.564***	-1.794***
	(0.322)	(0.356)	(0.366)	(0.344)	(0.253)	(0.282)	(0.261)	(0.263)
ln(Ratio Time of Stay)	-0.994***				-0.637***			
	(0.172)				(0.144)			
ln(Ratio Operation Time)		-0.074				-0.210		
		(0.204)				(0.158)		
ln(Ratio Waiting Time + Undock)		-0.733***				-0.413***		
		(0.123)				(0.091)		
ln(Ratio Waiting Time for Docking)			-0.115***				-0.113***	
			(0.021)				(0.021)	
ln(Ratio Docked Time)			-0.446*				-0.193	
			(0.245)				(0.185)	
ln(Ratio Waiting Time Rate)				-0.304***				-0.275***
				(0.073)				(0.073)
Constant	1.353***	1.359***	0.716***	0.862***	-0.460***	-0.433***	-0.291**	-0.363***
	(0.150)	(0.154)	(0.129)	(0.127)	(0.105)	(0.110)	(0.115)	(0.108)
Observations	4,408	4,408	4,408	4,396	8,104	8,104	8,104	8,092
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.099	0.104	0.088	0.077	0.060	0.061	0.063	0.057

Source: Authors' calculations.
Note: Standard errors robust to heterocedasticity are in parentheses.
*, **, and *** denote statistical significance of 10%, 5% e 1%, respectively.

The last four columns presents the estimates without the top 20 products (HS-2digits) exported through the ports included in our sample.[16] In Brazil, many sample ports have some products in which its exports are concentrated. In this sense, the ports can invest more in loading and unloading capacity or even access to the port of specific products. By eliminating the main products exported, the estimates of the procedures

[16]The product categories excluded from sample at this exercise were the following: 02, 09, 10, 12, 15, 17, 20, 23, 24, 26, 27, 28, 39, 40, 47, 72, 84, 85, 87 and 99.

of the time of the impact becomes less susceptible to possible endogeneity that may exist between the exported amount of specific goods and the time for each step of the port procedure.

In general, the control variables maintain their signals and statistical significance. Considering the time variables, the pattern shown in table 3 maintained, i. e, the time of port procedures continue to represent an important determiner of trade volume, and the most important steps of the procedure, are those related to the ineffectiveness. Furthermore, the magnitude of the coefficients of time variables increased in comparison to those presented in table 3. In fact, according to this new set of estimates, a decrease of 10% on relative time of stay is reflected in an increase between 6.37% and 9.94% on local exports. Reductions of 10% in the ineffectiveness or in the time to undock are associated with increases between 4.13% and 7.33% on relative exports.

From table 5, the coefficient of waiting time to dock is the one that presented less variation. According to the results, a reduction of 10% on the time that a ship waits to dock would increase the relative exports of Brazilian cities between 1.13% and 1.15%. Moreover, when the sample consider the same region ports only, the time docked becomes statistical significant at 10% level. The specifications (4) and (8) also presented coefficients for the waiting time rate relatively higher if compared to the results presented before.

Regarding the models estimated with the ratio of the number of products as the dependent variable, we performed the same sensibility tests as done before. The first four columns of table 6 present the estimations only with ratios build with ports from a same geographical region. The last four columns eliminate the main products exported in the period.

According to the results, the coefficients of the control variables maintain the same general pattern, in terms of signals and statistical significance, of the ones presented on table 4. Considering the estimations with ports from same regions the coefficient of the total time of stay becomes statistically insignificant. The only measures that represent relevant impacts to the number of products are the waiting time to initiate the operations and the time to undock.

On the other hand, considering the estimations without the most traded products, the results are more close to those presented on table 4. In this case, a 10% reduction on total time of stay would increase the number of exported goods in around 1%. Moreover, a 10% reduction on the ineffectiveness time or in the time to undock would increase 0.96% the number of products exported.

Table 6: Sensibility analysis: Number of products models

Dependent variable: ln(Ratio Number of Exported Products)								
	Same region ports				Without most traded goods			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ln(Ratio Export Coefficient)$_{t-1}$	0.054***	0.058***	0.059***	0.053***	0.072***	0.074***	0.074***	0.072***
	(0.019)	(0.020)	(0.021)	(0.020)	(0.018)	(0.018)	(0.019)	(0.018)
ln(Ratio Number of Dockings)	0.307***	0.292***	0.145	0.224**	0.283***	0.302***	0.191**	0.223***
	(0.093)	(0.097)	(0.100)	(0.089)	(0.083)	(0.085)	(0.085)	(0.081)
ln(Ratio Port Cost)	-0.158	-0.104	-0.058	-0.150	-0.174*	-0.160	-0.170	-0.219**
	(0.132)	(0.143)	(0.144)	(0.134)	(0.104)	(0.114)	(0.106)	(0.100)
ln(Ratio Time of Stay)	-0.087				-0.099**			
	(0.060)				(0.050)			
ln(Ratio Operation Time)		-0.096				-0.040		
		(0.082)				(0.057)		
ln(Ratio Waiting Time + Undock)		-0.069*				-0.096***		
		(0.039)				(0.031)		
ln(Ratio Waiting Time for Docking)			-0.014				-0.010	
			(0.009)				(0.008)	
ln(Ratio Docked Time)			-0.174*				-0.089	
			(0.099)				(0.064)	
ln(Ratio Waiting Time Rate)				-0.043				-0.053**
				(0.038)				(0.026)
Constant	0.113***	0.107**	0.051	0.065	-0.214***	-0.224***	-0.173***	-0.197***
	(0.042)	(0.043)	(0.045)	(0.043)	(0.045)	(0.045)	(0.043)	(0.042)
Observations	6,087	6,087	6,087	6,074	9,978	9,978	9,978	9,963
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.004	0.005	0.005	0.004	0.006	0.006	0.006	0.006

Source: Authors' calculations.
Note: Standard errors robust to heterocedasticity are in parentheses.
*, **, and *** denote statistical significance of 10%, 5% e 1%, respectively.

From the tests conducted, we can conclude that each additional hour in the port procedures time imply in negative impacts on Brazilian exports, regardless of the sample analyzed and the restrictions on constructed reasons. While it may occur some variation in the magnitude of the coefficients and in the relative importance of each step, the overall picture that the ineffectiveness steps are the most important, does not change.

4 Final Remarks

In this study, we built an innovative database with municipal exports data, distinguishing the port used, country of destination, and with products aggregated at four-digit Harmonized System (HS) for the period of 2010 to 2012. A gravity equation in differences adapted for disaggregated data was estimated by the fixed effects estimator.

According to the measures analyzed, the Brazilian ports composing the sample present an average stay time of 28 hours and 12 minutes. From this total, an average of 15 hours and 42 minutes is spent with the ship docked, and the rest is wasted in waiting. The ports from the sample present an average time of inaction (Time waiting for docking and waiting for the beginning of operations) of 45.17%, in 2012. These results indicate the presence of a bottleneck in the flow of the Brazilian production to the international market. Because of the growth in Brazilian trade flows in the last decade, these limitations became even more evident, and point to the necessity of investments that increase the port capacity. Consequently, reducing the inefficiency that generates such high percentages of ineffectiveness time in Brazilian ports.

In general, the results suggest that the reduction in port procedures delays can guarantee to Brazilian exporters a better access to the international market. In fact, reducing the time of port procedures imply ultimately in a reduction of exporter costs, ensuring that the product arrives at the destination market with higher quality and at a lower final cost, improving their competitiveness abroad. According to the estimates made, a reduction of 10% in total time of stay may increase the municipal exports in around 5.1%.

The study also presents empirical evidence that the time in port also affects the variety of products that a municipality can export. According to the results, a reduction of 10% at the relative time a ship stays in the port can increase the number of product categories around 1%. This result although more modest than the estimated coefficients for the trade volume models, is statistically significant and lead to the conclusion that the time spent specifically in port procedures is also an important determiner of the variety of sectors involved in international trade.

The results also suggest that the steps of ineffectiveness time are the most important determinants of trade volume and variety. A reduction of 10% in the waiting time or in the time do undock could increase the export volume in 3.5%. An equivalent reduction but on the waiting time to dock increase municipal exports volume in around 1%. However, reductions on the time of operation or on the time docked seem to have no significant impact on the volume of trade. For the time effects over the variety of trade, a reduction of 10% on the ineffectiveness time or on the time to undock can increase the number of product categories in around 0.7%.

In a world scenario where tariff barriers has been falling gradually as trade facilitation elements gain importance in trade negotiations and public policy agendas, this study provides evidence of the high and statistically significant impact of the slowdown in Brazilian ports on the country's exports. In this sense, the results suggest that investments in the expansion and modernization of port infrastructure that would ensure increased access to ports and reducing waiting times for ships, that confer greater speed ports to carry out the loading and unloading operations would generate significant impacts on exports both in the intensive and extensive margins.

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A Appendix

A.1 Quality of port infrastructure, WEF

Table 7: Quality of port infrastructure Ranking

Country	Quality Index	Rank
Singapore	6.8	1
Netherlands	6.8	1
Hong Kong, China	6.6	3
United Arab Emirates	6.4	4
Finland	6.4	4
Panama	6.4	4
Belgium	6.3	7
Sweden	5.8	9
Denmark	5.7	14
United States	5.7	14
United Kingdom	5.7	14
Canada	5.5	19
Chile	5.2	29
Japan	5.2	29
Jamaica	5.1	34
Australia	5	39
South Africa	4.7	47
Uruguay	4.7	47
China	4.5	53
Thailand	4.5	53
Mexico	4.4	60
Ecuador	4.2	67
India	4.2	67
Guatemala	4.1	73
Russian Federation	3.9	83
Argentina	3.7	92
Peru	3.7	92
Colombia	3.5	103
Paraguay	3.4	111
Brazil	2.7	130
Bolivia	2.5	140
Venezuela	2.5	140
Kyrgyz Republic	1.3	147

Source: Elaborated from World Economic Forum, *Global Competiveness Report*