Gravity Models, Interregional Input-Output and Trade in Value Added. A New Approach Applied to Brazilian Internal and International Trade

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Abstract

WTO, OECD with many others, suggest the trade in value-added would be a "better" measure than gross value to understand the impact of trade on employment, growth, production etc. We use in this work a gravity model founded on the estimation of exports of Brazilian states both in traditional terms of gross value and in terms of value added, estimated from an Input-Output table for 2008. The results of the bilateral gravity model for Brazilian states' exports show that GDP impact is fairly similar when the exports are estimated in gross or in value-added terms. However, the coefficient for distance is smaller and less significant when its impact is estimated for exported value-added.

Keywords: Vertical Specialization, Global supply-chain, Input-Output Analysis, Brazil, Intra-national trade

***JEL classification*:** F12, F14, F15, F63, R12, R15

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I. Introduction

Trade is commonly evaluated in gross terms whereas; the contribution of exports to the exporting country's growth, employment and balance of trade depends solely on the content in domestic value-added. Due to the increasing fragmentation of the "international supply chain", the countries are specialized in "tasks" (design, assembly, transport, distribution, etc.) instead of goods (cars, computers, etc.). For example, China is not specialized in exports of laptops, but after importing the technology and the components, China is specialized in the assembly of the final good. However, trade statistics are still presented in terms of gross value.

The value of goods exported by a country may then be decomposed into imported and domestic value-added and we have a few indications for certain specific goods. For example, the 1998 WTO Annual Report estimated that a mere 37% of the production value of a typical American car is generated in the US. More recent case studies are available for the iPod, iPhone and iPad, the Nokia N95 (Yrkkö *et al.*, 2011), and even … Barbie dolls (WTO-IDE-JETRO, 2011; Maurer *et al.*, 2010; World Economic Forum, 2012). However, this measurement of import content in a specific exported good cannot be generalized to aggregate the total import content of exports either across the whole industry or in the entire country or region. International input-output tables are commonly used as indirect measure of the import or domestic value content of exports (for example, Hummels *et al.*, 2001), and some international organizations are currently supporting the construction of international input-output matrices based on the method introduced by Leontief (see OECD-WTO, 2012).

At the same time, the gravity model frequently used in empirical analyses of international trade becomes debatable in the light of the "international supply chain". The model estimates trade in terms of gross value and hence ignores the share of import content in exports, which is not at all the same for all countries. Moreover, demand concerns not only final consumption, but also intermediate consumption. This raises questions about the use of the importer's GDP as a demand indicator in the model (see Baldwin & Taglioni, 2011).

Brazil's rate of openness is low compared to other large emerging countries such as China. Brazil's poor performance in terms of openness does not imply a low level of specialization along the domestic supply chain. The domestic value-added content of Brazilian exports is probably higher (or the import content lower) since Brazilian specialization is in tasks located at the early stages of the supply chain, such as raw materials, while China is specialized in the final stages (assembly stage) of the production process (Koopman *et al.*, 2008). Considering the high heterogeneity of Brazilian regions in terms of climate, location and factor endowment, there is room for large specialization differences within Brazil. Yet although inter-state trade statistics are available, they are given in gross value and we have no information on the shares of own domestic value-added and import content from other states in states' exports.

The purpose of this article is to estimate correctly the determinants of Brazilian states'external trade whose structure depends also on the internal trade structure, notably the domestic value chain. We estimate Brazilian states' gross exports to the rest of the world, first using a bilateral gravity model inspired by the traditional approach and then the new measurements of exports in value-added terms. The section II develops the theoretical and empirical implications of the move from trade in gross value to trade in value added. The section III is specifically focused on gravity models applied to Brazilian states exports. The section IV compares the results given by a gravity model when we alternatively use exports in gross value and exports in value added. We show that when we control correctly the model, results are quite comparable.

II. Dynamics of Vertical Specialization and Trade Analysis

The Made in the World Initiative (MiWi) launched by the WTO is subtitled *A Paradigm Shift to Analyzing Trade*. The traditional theory of international trade functions in terms of "horizontal" specialization where countries or firms "*become adept at producing particular goods and services from scratch and then export them,*" (Hummels *et al.*, 1998).Gene Grossman and Esteban Rossi-Hansberg (2006) highlight a change in trade structure and call it “trade in tasks”. This increasing dominance of task specialization over product specialization has many implications that could be interpreted as a "paradigm shift" though; the phenomenon is not exactly new.

Two events explain why only in recent years the international institutions have turned their attention to the practical repercussions of this trend on international trade statistics and their interpretation[1]:

1) The collapse of international trade from mid-2008 to mid-2009 threw the world suddenly and unexpectedly into deeper world recession. For example, exports fell 38% for the World and a massive 53% for China in just nine months[2]. The vertical specialization implies that the value-added of a component may be recorded several times in the trade statistics, i.e. each time it crosses the border for use in a new stage of the production process. In this case, a $100 drop in national exports of a final good could cause a drop of $200, $300 or more in world exports[3].
2) The proliferation of case studies that decompose the origin of the value-added of a specific final good exported outward also reveal very surprising results. These case studies find a spectacularly weak share of domestic value-added in the value of national exports. The most striking case is probably the iPod 30 gigabit valued at US$300 in the United States, previously exported by China for US$150, but with a Chinese value-added focused on assembly tasks of just US$4 (Dedrik &al., 2009).

The phenomenon is defined more precisely by Hummels *et al.* (1998) as, "*Vertical specialization occurs when a country uses imported intermediate parts to produce goods it later exports”.* Then, the three conditions need to hold:

(1) A good must be produced in multiple sequential stages,
(2) Two or more countries have to specialize in producing some, but not all stages,
(3) At least one stage must cross an international border more than once.
Specialization takes place not only in goods (cars, shoes, etc.), but also in tasks (design, components, assembly procedures, etc.) which make countries interconnected through the production chains. This unbundling of the global economy, or in other words the geographic fragmentation of the production process, is driven by decreasing trade and communication costs which enabled remote management and allowed companies to coordinate long production chains (Baldwin, 2006). The emergence of free trade zones, with their

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[1] For example, WTO&IDE-JETRO published a report on the issue in 2011. The Organization of Economic Cooperation and Development supports the position of the World Trade Organization (WTO) in this area (OECD-WTO, 2002) with the publication of new estimations of trade in value added (TiVA) in May 2013.
[2] WTO statistics.
[3] See, for example, Escaith *et al*. (2010)

advantageous regulations to attract foreign direct investment (FDI), is also helping to drive this process. The WTO is making a particular effort to bring down tariffs on the circulation of intermediate products such as computers, semi-conductors, etc. (e.g. Information Technology Agreement (ITA)).[4] Hence, under this new structure of trade costs, the countries not capable of covering the entire production chain for a good get the chance to produce at least some of the tasks, for which they have a comparative advantage.

The dynamics of vertical specialization are also at work in domestic markets which are characterized by their relatively good trade integration favorable for components trade. Trade in tasks (or vertical specialization) may then occur inside a country when differences in its regions' factor endowments and/or production technology give them the comparative advantage in a specific task. Yet, this internal dimension of specialization driven by trade openness has not been studied, since many international organizations prioritize inter-country vertical specialization.

Under the classical assumptions of traditional trade theories, with factors of production being perfectly mobile in national markets, endowments are uniform in space. If that were true, all the regions in a country would have similar comparative advantages and the company would gain nothing, but face only extra costs from splitting up the production chain across the country. However, in reality, neither factor nor good markets are really "perfectly" integrated and a country's regions may differ in terms of their specializations and production costs. This is especially true for developing and emerging markets, such as Latin American countries, India and China, where regional differences are considerable.

Lastly, trade in tasks is expected to occur relatively more in the exporting sectors, since the gain from economies of scale is another important factor. However, intra-country vertical specialization may occur also in a closed economy where internal demand is large enough to benefit from economies of scale. In that case, trade openness may be a further incentive to deepen this type of specialization and create a dual dynamic of vertical specialization.

Incidentally, recognition of vertical specialization prompts a series of questions on the consistency of the conventional statistical tools and/or on the general concepts of trade literature, including the gravity model. Previously used cross trade measures, which are fairly suitable in a context of "horizontal" specialization, are becoming more and more unreliable in a world where a final good is produced in more than one country or, in general terms, more than one geographic location. In particular, the bilateral trade balances measured in gross trade terms provide very little information on the supply or demand side. The notion of "home" or "origin" of the good is dissociated from the notion of "exporter" and the notion of "destination" from "importer". The gross export values no more reflect the competitiveness of the exporter entity, but the entire product chain, especially when the exporter is situated at the final step of the production process. When there is a large volume of trade in intermediate goods, the use of bilateral gross trade is not appropriate either for the demand side analysis, since trade flows to the importer country would be mostly for the demand of third countries.

The use of gross trade measures in intra-country trade specialization can trigger a change in statistical analysis on two levels: in trade by local entities with world markets and among

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[4] "The Ministerial Declaration on Trade in Information Technology Products (ITA) was concluded at the WTO Singapore Ministerial Conference in December 1996. The ITA eliminates duties on IT products covered by the Agreement." See WTO&IDE-JETRO (2011).

themselves. First, the regions specialized in the last stage of the production in the country seem to export more and so are more integrated into world markets. Second, where interregional statistics are available to track trade, a good may be counted many times in the production chain in the internal market. However, the export of the good generally happens only once and so is counted only once; usually at the last stage of the production chain in the country. This statistical bias produces extremely high intra national gross trade values for local entities compared to their actual trade with the rest of the world.

Therefore, a better statistical tool focused on the “origin” and “final destination” of the good is required to analyze bilateral trade relations at national level as they are at international level. Measuring trade using the “value-added” approach enables us to approximate the true origin of exports. This may also be used to determine the value-added contribution at each stage and hence track the value chain through to the end of the production process. In this manner, we capture the supply and demand side determinants of trade, such as the "revealed" competitiveness and comparative advantages of geographic entities that participate at the different stages of production. The bilateral trade flows, estimated on net value, are incidentally corrected for the statistical bias created by the multiple accounting of imported intermediate goods and components embodied in exports.

III. Gravity model and Global Value Chain

First introduced by Tinbergen (1962) with empirical intuitions, the gravity model has since been enriched with robust theoretical underpinnings by different approaches and is used today as the workhorse in the empirical trade analysis. In its standard form, it is derived from a consumer expenditure system in which the price term is eliminated using the general equilibrium structure of the theoretical model. In Anderson and van Wincoop (2003), the demand for the products of *s* by entity *j*, derived by maximizing the CES utility function of consumer *j*, is as follows:

$$x_{ij} = \left(\frac{\beta_i p_i t_{ij}}{P_j}\right)^{1-\sigma} Y_j \qquad \textbf{(1)}$$

where p_i is the supply price of *i*, t_{ij} the iceberg trade costs and P_j the consumer price index in *j*. The aggregate exports of *i* to all partners *j* are equal to the total output of *i:*

$$Y_i = \sum_j x_{ij} \qquad \textbf{(2)}$$

The above market clearance condition is then used to eliminate the relative price term (p_i) in expenditure equation (1). The equilibrium prices are then:

$$(\beta_i p_i)^{1-\sigma} = \frac{Y_i}{\sum_j \left(t_{ij}/P_j\right)^{1-\sigma} Y_j} \qquad \textbf{(3)}$$

Hence, the trade from *i* to *j* in equilibrium is:

$$x_{ij} = \frac{Y_i}{\Omega_i}\left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} Y_j \qquad \textbf{(4)}$$

Where,

$$\Omega_i = \sum_j \left(t_{ij}/P_j\right)^{1-\sigma} Y_j \qquad \textbf{(5)}$$

The above model relies on the assumption that the products exported from *i* to *j* are produced solely in *i*. In empirical gravity literature, x_{ij} is measured as the gross exports of *i* to *j*, while Y_i is measured on a value-added basis by the GDP of entity *i*. However, under vertical specialization, the origin of the value-added and the exporter of the good are no longer the same and the volume of aggregate gross exports is much higher than the amount of domestic value-added due to the high or increasing import content of exports or, in other words, intermediate goods imported and re-exported. However, as discussed by Baldwin and Taglioni (2011), GDP can be used to measure gross output provided the import content of exports is similar across entities and over time. This is understandable since, in this case, the ratio of imported intermediate goods in exports may be considered as a constant in the econometric estimations as long as it is fixed for the whole sample. Nevertheless, trade relation dependencies are not uniform across countries and world trade today is characterized by a varying extent of trade in tasks across trade partners. Furthermore, trade in intermediate goods has grown sharply in recent years.

Another problem in the theoretical model concerns the measurement of j's expenditure (Baldwin and Taglioni, 2011). The model assumes that the demand of j is for the final consumption. Therefore, *j's* expenditure is its total income, which is again measured by the GDP of entity *j*. However, if *j* is not the final demand market, but is solely the point where the good is transformed before being re-exported, then *j's* GDP does not reflect its expenditure on imported goods.

IV. Model and data

We aim to measure the impact of exporter state characteristics under the assumption of an inter-state vertical specialization. However, we first estimate the structure of Brazilian states' gross exports with the rest of the world by using a traditional gravity approach. To this end, we take the exports of 27 states with 81 countries in 2008 (see Appendix 3). Then, we can estimate the following bilateral model in its simplest traditional form:

$$\ln(X_{ij}) = \beta_0 + \beta_1 \ln(GDP_i) + \beta_2 \ln(R_i) + \beta_3 \ln\left(dist_{ij}\right) + \alpha_j + \varepsilon \qquad \text{(Model I)}$$

Where X_{ij} denotes gross exports from Brazilian exporter state *i* to destination country *j*, $\ln\left(dist_{ij}\right)$ is the natural logarithm of the distance between state *i* and partner country *j* and GDP_i is the gross domestic product of state *i*. On the importer side, we simply take fixed effects (α_j) which is the most convenient way to control correctly for the impact of importer country characteristics[5]. R_i is the remoteness of state *i* from the rest of the world ($m \neq j$, aside from its partner country *j*. This is measured in keeping with Head (2003) by[6]:

$$R_i = 1/\sum_{m \neq j}[GDP_m/Dist_{im}]$$

The higher R_i, the more distant state *i* from countries *m* ($m \neq j$) and/or the closer to countries whose *GDP*s are relatively small. The more remote the state, the higher trade can be expected to be between *i* and its partner *j* since exporter state *i*'s access to other markets *m* is limited.

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5 In this manner, we avoid an eventual estimation bias sourcing from the importer side of the model, which would otherwise complicate to concentrate on the correct measurement of the vertical specialization assumed uniquely among the exporter states.

6 We have also tested the model with a remoteness index calculated in line with McCallum (1995). However, the results do not differ a lot.

The traditional bilateral model, as introduced in Model I, will return biased estimates when trade in intermediate goods dominates. The exported product does not necessarily originate in Brazilian exporter state *i*. Generally, at least part of it is produced in other states. Gross trade between exporter state i and its partner j depends not only on their characteristics but also on *i*'s trade with other supplier states and *j's* exports with the rest of the world. If this is ignored, the model will generate structure-biased estimates depending on the nature of the correlation between exporter and/or importer characteristics and the rest of the production chain. Empirically, this bias may occur, for example, if vertical specialization is more probable between close trade partners[7]. We then expect to get higher export values between close partners since they are not trading solely for final consumption, but also for re-export. In this case, if vertical specialization is not controlled for, the impact of the bilateral distance variable will be overestimated since the real destination of the gross exports is in part a more distant country.

Hence, differently than the bilateral structure of trade in final goods, trade for processing needs a multilateral structure, namely the dependencies of the final exporter and its bilateral partner with third, fourth or more partners. Aiming to solve this problem in Model II, we take up the proposal put forward by Baldwin and Taglioni (2011) and replace the exporter variables (GDP and remoteness) with exporter fixed effects. We already have importer fixed effects for the importer. We then estimate the following bilateral trade equation with exporter and importer fixed effects, which should provide a better measurement of the Brazilian states' trade structure:

$$\ln(X_{ij}) = \beta_0 + \beta_1 \ln\left(dist_{ij}\right) + \alpha_i + \alpha_j + \varepsilon \qquad \text{(Model II)}$$

where X_{ij} is again gross exports from exporter state *i* to destination country *j* and $\ln\left(dist_{ij}\right)$ is the natural logarithm of the distance between state *i* and partner country j. α_i and α_j are, respectively, the exporter fixed effects of *i* and importer fixed effects of *j*. Model II then assumes that the characteristics of the production chain as far as exporter *i* are specific to *i* and that the characteristics of the production chain from importer *j* onwards are specific to *j*. This structure should provide a better measurement of the impact of bilateral distance on bilateral gross exports.

Another way of solving the disassociation between the origin of the exported goods and the exporter is to find another measurement of trade focusing on the origin of exports. This means dropping off the value-added originating from other states, otherwise included in the gross exports from state *i* to country *j*. These values are calculated using the Inter-State Input-Output Table for 2008. In Model III below, we analyze the characteristics of exporter state *i* in terms of their impact on the value-added exported and produced by state *i*:

$$\ln(XVA_{ij}) = \beta_0 + \beta_1\ln(GDP_i) + \beta_2\ln(R_i) + \beta_3 \ln\left(dist_{ij}\right) + \alpha_j + \varepsilon \qquad \text{(Model III)}$$

This is similar to Model I with the difference that the dependent variable is not gross exports, but the value-added produced by state i and exported by state i to destination country *j*

[7] For example, according to Wolf (1997) due to the spatial non-linearities of transaction costs the production of tasks will be spatially concentrated, instead of being spread out geographically, and trade in intermediate goods will take place among close entities.

(XVA_{ij}). Model IV, including exporter and importer fixed effects, is also estimated for the purpose of comparison with Model II:

$$\ln(XVA_{ij}) = \beta_0 + \beta_1 \ln\left(dist_{ij}\right) + \alpha_i + \alpha_j + \varepsilon \qquad \text{(Model IV)}$$

We estimate the above four models in cross-section for 2008. For the purpose of comparison, we use two types of estimator: Ordinary Least Square (OLS) and Pseudo Poisson Maximum Likelihood (PPML), which has been widely used in the literature since Santos Silva and Tenreyro (2006). The PPML model is a better tool for estimating gravity models in the way it deals with the model's existing estimation bias due to heteroskedasticity in the trade data. Another advantage of PPML is that the model estimates the gravity equation in its multiplicative form and hence deals with zero trade values better. The log-linearization procedure in OLS returns zero trade values for missing data points, which can cause a bias when they are not random.

National GDP values are given in current dollars and are drawn from the World Bank's *World Development Indicators* database. GDP values for the Brazilian states are provided by the IBGE (*Instituto Brasileiro de Geografia e Estatística)* in local currency units. They are converted into current dollars by applying the exchange rate taken from WDI. The distance variable is calculated by the author using the geographical coordinates of the capitals of the states and the countries as furnished by the *World Gazetteer* website.

The Brazilian inter-state input-output system for 27 regions (26 states and the Federal District) for 2008 was estimated based on a combination of different sources of data and methodologies. We first detail the data available to estimate the Brazilian input-output table and then address the construction of the inter-state input-output system.

The most recent input-output system released by the Brazilian Statistical Office (IBGE) refers to 2005 (IBGE, 2008). However, using the information available in the Brazilian System of National Accounts (IBGE, 2010) and the methodology presented by Guilhoto & Filho (2005) (2010), we can estimate an input-output system for 2008 (see Yücer & alii, 2014 and appendix 1). The estimated national input-output system was then used as the basis to estimate the inter-state system for Brazil based on the methodology presented in Guilhoto &Filho(2010).

Table 1 shows the results for the bilateral gravity model with dependent variables: states' bilateral gross exports (Model I and II) and bilateral exported value-added (Model III and IV). For ease of reading, we present the models that are similar in terms of their explanatory variables side by side. Estimates for Model I – with GDP and Remoteness – are shown in the first and third column of the table, the former in OLS and the latter in PPML. In keeping with the literature, both estimators show that GDP has a positive impact and that bilateral distance drives down states' gross exports to countries. Remoteness is significantly positive as expected, although at 1% under OLS and at 10% under PPML.

In Model I, the distance variable is larger in absolute terms when estimated by PPML and is significant at 1%. It is smaller and significant only at 10% when estimated by OLS. This can appear surprising at first sight since the PPML estimator, compared to OLS, generally estimates a smaller impact of bilateral distance on exports. In our sample, however, since the Brazilian states are very close to each other and so have similar distances from the rest of the world, the bilateral trade barriers vary more by importer country than by exporter state and are hence captured in part by the importer fixed effects. Apparently, PPML manages better to isolate the impact of bilateral distance from the importer fixed effects while OLS estimates a smaller impact of distance on exports. This may be explained by the PPML estimator's ability to solve the bias due to the heteroskedasticity in the data.

Table 1: Bilateral gravity model estimates

Model	I	III	I	III	II	IV	II	IV
Estimator :	OLS	OLS	PPML	PPML	OLS	OLS	PPML	PPML
	$\ln(X_{ij})$	$\ln(XVA_{ij})$	X_{ij}	XVA_{ij}	$\ln(X_{ij})$	$\ln(XVA_{ij})$	X_{ij}	XVA_{ij}
$\ln(GDP_i)$	1.340	1.327	0.922	0.927				
	(0.065)**	(0.065)**	(0.054)**	(0.060)**				
$\ln(R_i)$	6.869	6.635	1.992	1.633				
	(0.940)**	(0.944)**	(1.092) $^+$	(1.223) $^+$				
$\ln(Dist_{ij})$	-0.356	-0.305	-0.602	-0.513	-0.519	-0.472	-0.613	-0.555
	(0.304) $^+$	(0.292) $^+$	(0.206)**	(0.204)*	(0.286) $^+$	(0.280) $^+$	(0.220)**	(0.232)*
Constant	150.909	144.687	51.812	42.090	15.774	15.040	17.421	16.548
	(22.693)**	(22.752)**	(24.856)*	(27.699)**	(2.547)**	(2.490)**	(2.001)**	(2.101)**
Exporter fe	No	No	No	No	Yes	Yes	Yes	Yes
Importer fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2 or Pseudo R^2	0.51	0.52	0.77	0.77	0.64	0.64	0.84	0.84
N	1,692	1,670	2,187	2,187	1,692	1,670	2,187	2,187

Robust standard errors are in parentheses: All inferences are based on a Huber-White sandwich estimate of variance. Pseudo R^2 in the table is calculated for PPML estimates by McFadden's Pseudo R^2 and are not comparable with OLS R^2. $^+p<0.1$; $*p<0.05$; $**\ p<0.01$

Model II gives better results in that the exporter fixed effects also control for unobservable characteristics and that the goodness-of-fit, measured in terms of R^2 for OLS and Pseudo R^2 for PPML, is increasing from Model I to Model II for both. The gravity results for the distance variable seem more sensitive to the control of unobservable characteristics by exporter fixed effects when it is estimated in OLS. In Table 1, the size of the OLS-estimated distance variable decreases from -0.356 in Model I to -0.519 in Model II. The PPML-estimated coefficients, however, are relatively similar for both models: -0.602 in Model I and -0.613 in Model II.

Another point of note is that the OLS-estimated distance coefficient approaches the PPML estimate when exporter fixed effects are introduced into Model II. The impact of distance estimated by OLS is -0.519 and -0.613 by PPML in Model II, while the difference is greater in Model I: -0.356 estimated by OLS and -0.602 estimated by PPML. In line with Baldwin and Taglioni (2011), Model II with exporter fixed effects should be a better empirical model since it also controls for the structure of the whole value chain until the exporter state. By accepting their assumption and following our comparison between Model I and Model II, we can conclude that the trade structure of Brazilian states is estimated quite well by PPML even when the exporter fixed effects are replaced by observable exporter characteristics.

Last but not least, our estimation with the new measurement of trade, based on exported value-added, slightly reduces the impact of distance and remoteness in absolute terms. The impact of GDP changes very slightly without any clear conclusion. This result can be explained by the across-the-board uniformity of states' vertical specialization. The smaller impact of distance and remoteness on exported value-added, compared to their impact on gross exports, may be due to Brazil's production structure in which the states exporting primary goods, high in the states' own value-added, are located in the same region (South-East: Minas Gerais (MG), Espírito Santo (ES) and Rio de Janeiro (RJ)) where the natural conditions required for rich natural resources are found.

V. Conclusion:

Our work discusses the implications of the "new trade paradigm" – reflected in the geographical fragmentation of the production process – on the traditional statistical and empirical trade analysis tools and, specifically, the gravity model. We take a theoretical approach to show that measuring exports in value-added terms is more appropriate for the gravity model estimates and the model should be extended to control for the multilateral nature of vertical specialization.

We use the Brazilian Inter-State Input-Output table for 2008, to calculate states' value-added directly on its own and indirectly via other states. The results of the bilateral gravity model for Brazilian states' exports show that GDP impact is fairly similar when the exports are estimated in gross or in value-added terms. However, the coefficient for distance is smaller and less significant when its impact is estimated for exported value-added. This finding needs to be interpreted with care because, given that the sample covers solely Brazilian states' exports, the bilateral distance variable varies more by destination country than it does by state of origin.

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Appendix 1 -Estimating the Inter-State Input-Output System for Brazil for 2008

The steps followed for the estimation of the inter-state system for Brazil can be summarized as follow (see Yücer & alii, 2014):

- Using information from the IBGE surveys of Agriculture, Industry, Trade, Transport, Services, and Civil Construction, a first estimate is made of total output by 56 industries and 110 commodities for each of the Brazilian states;
- These initial estimates are then balanced to match the total output at the level of 17 industries presented in the Brazilian Regional Accounts (IBGE);
- These output estimates are also used to estimate the supply tables for each of the Brazilian states. The states' supply tables are estimated in such a way as to be consistent with the national supply table;
- The tax, imports, and the input-output system's final demand components are estimated for the 56 industries for each of the Brazilian states, which are also consistent with the value-added components in the national input-output table[8].
- Using cross-industry location quotients for intermediate consumption and simple location quotients for final demand, a first estimation is made of flows of goods and services among the Brazilian states;
- Using the work done by Vasconcelos and Oliveira (2006), which estimates the flow of goods among Brazilian states for 1999, and taking into consideration the growth of the states from 1999 to 2008, a second estimation is made of flows of goods and services among the Brazilian states;
- The third and final estimation of flows of goods and services among the Brazilian states is made taking into consideration the following: a) the inter-state input-output system should be consistent with the national table; b) the change in inventories should be zero when they are zero in the national table; c) the change in inventories in each state, when related to the total output of the corresponding sector should be in a range no greater than 30% of this relation found in the national table;
- The third estimation produces a commodity by industry inter-state input-output system for Brazil. The supply tables for each of the states are then used to obtain the industry-by-industry inter-state system used in this work.

[8]Sources and information are: imports and exports by state: Ministry of Development, Industry and External Trade; tax collection in each state, government spending: Ministry of Finance and the State Secretaries of Finance, IBGE; payments to workers by industry and state: Ministry of Labor and IBGE Household Survey; household spending: *Household and Household Consumption Patterns surveys*; value-added generated at the level of 17 industries, by state: *Brazilian Regional Accounts*, IBGE; investment is based on the level of the Civil Construction in each state (IBGE).

Appendix 2: List of Countries and Brazilian states

Angola	Ghana	Philippines
United Arab Emirates	Greece	Poland
Argentina	Guatemala	Puerto Rico
Australia	Hong Kong. China	Portugal
Austria	Croatia	Paraguay
Belgium	Indonesia	Qatar
Bangladesh	India	Romania
Bulgaria	Ireland	Russian Federation
Bahrain	Israel	Saudi Arabia
Canada	Italy	Senegal
Switzerland	Jamaica	Singapore
Chile	Jordan	El Salvador
China	Japan	Slovenia
Colombia	Korea. Rep.	Sweden
Costa Rica	Kuwait	Syrian Arab Republic
Cuba	Lebanon	Thailand
Cyprus	Libya	Trinidad and Tobago
Germany	St. Lucia	Tunisia
Denmark	Morocco	Turkey
Dominican Republic	Mexico	Taiwan
Algeria	Malaysia	Ukraine
Ecuador	Nigeria	Uruguay
Egypt. Arab Rep.	Netherlands	United States
Spain	Norway	Venezuela. RB
Finland	Pakistan	Vietnam
France	Panama	Yemen. Rep.
United Kingdom	Peru	South Africa

List of Brazilian states and their abbreviations:

ACRE	AC	PARA	PA
ALAGOAS	AL	PERNAMBUCO	PE
AMAZONAS	AM	PIAUI	PI
AMAPA	AP	PARANA	PR
BAHIA	BA	RIO DE JANEIRO	RJ
CEARA	CE	RIO GRANDE DO NORTE	RN
DISTRITO FEDERAL	DF	RONDONIA	RO
ESPIRITO SANTO	ES	RORAIMA	RR
GOIAS	GO	RIO GRANDE DO SUL	RS
MARANHAO	MA	SANTA CATARINA	SC
MINAS GERAIS	MG	SERGIPE	SE
MATO GROSSO DO SUL	MS	SAO PAULO	SP
MATO GROSSO	MT	TOCANTINS	TO
PARAIBA	PB		