Regional and global patterns of insertion in value chains: evidence for Brazil

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Abstract
This study evaluates the different patterns of insertion of Brazil into value chains. Thus, the regional and global insertion patterns are analyzed through the geographic extension of the production stages. For this purpose, the value added is decomposed using an intercountry input-output model for the period from 1990 to 2015. The main results show that the insertion into the value chains occurs differently when considering their geographical scope and their forward and backward production stages. The insertion of Brazil in value chains is driven mainly by the global fragmentation of production. However, regional insertion has increased more than global insertion.

Keywords: International fragmentation; Outsourcing; Global value chains; Input-output; Brazil.

Classification codes: F15; C67; D57.

Resumo
Este estudo avalia os diferentes padrões de participação do Brasil nas cadeias de valor. Assim, os padrões de inserção regional e global são analisados através da extensão geográfica das etapas de produção. Para este propósito, o valor adicionado é decomposto usando um modelo de insumo-produto interpaíses para o período de 1990 a 2015. Os principais resultados mostram que a inserção nas cadeias de valor ocorre de maneira diferente quando se considera seu escopo geográfico e suas etapas de produção para frente e para trás. A inserção do Brasil nas cadeias de valor é impulsionada principalmente pela fragmentação global da produção. No entanto, a inserção regional tem aumentado mais do que a inserção global.

Palavras-chave: Fragmentação internacional; Terceirização; Cadeias globais de valor; Insumo-produto; Brasil.

Área 7 - Economia Internacional

1. Introduction

Brazil has undergone productive restructuring in the last decades. This restructuring is marked by a rapid reduction in the share of the processing industry in the national product. In the same period, industrial policies have been directed at increasing domestic value added in production and reducing Brazil's insertion in global value chains as a way of encouraging industrialization through the protection of the national industry (Sturgeon et al., 2014). Thus, the efforts made through industrial policies have been aimed at promoting national vertically–integrated industries producing all stages of production.

The policy to keep Brazil away from global value chains has been put into practice with high import tariffs and incentives for the acquisition of intermediate domestic inputs (Baumann and Kume, 2013). Thus, the recent commercial and industrial policies in Brazil have worked against a greater insertion in global value chains—although the intensification of international production outsourcing is a tendency by the rest of the world economies (Grossman and Helpman, 2005) and one of the factors that contribute to competitiveness in the world economy (Timmer et al., 2013).

Guilhoto and Imori (2014) and Ferraz, Gutierre and Cabral (2015) identified a trend of greater insertion of Brazil in the value chains for the period between 1995 and 2011. The authors also verified that Brazil is one of the worldwide leaders in the share of domestic value added in its exports. While Los, Timmer and de Vries (2015) analyzed the 40 largest economies in the world, they showed an upward trend of the foreign value-added share in the international trade.

Brazil's commercial and industrial policies since the 1970s have been oriented towards the formation of a vertically integrated national industrial park and the establishment of all stages of production. Thus, these policies have been formulated to preserve Brazil's limited exposure to imports, with a strong protectionist tendency (Veiga and Rios, 2017a). The main instrument of this trade policy is the collection of high import tariffs (Messa and Oliveira, 2017). Tariff barriers have a significant effect on blocking trade in value chains, as intermediate inputs cross national borders many times before they become final products. This characteristic of the Brazilian economy, besides reducing its participation in global value chains, may have effects on its productivity. The World Bank (2018) suggests that being the most closed country among the world's major economies is one reason for the low growth of Brazilian productivity. This may be related to the lack of external competition and the blocking of access to new knowledge and technologies through the import of machinery and equipment.

The stimulus to industrialization, focusing on all stages of production in the national territory, has therefore been one of the priorities of the Brazilian political agenda. However, this policy has not been effective in controlling the reduction of the manufacturing industry's share of the country's output. The share of manufacturing in products has also been reduced in other countries. For example, after declining over four decades, manufacturing reached 12.0% in the US and 15.9% in the European Union in 2015—with the exception of fast–growing Asian economies such as China and South Korea, with numbers close to 30.0% (Peneder and Streicher, 2018). Meanwhile, Latin American countries were hit harder by deindustrialization (Rodrik, 2016).

In the case of Brazil, the share of manufacture in total production reached around 25.0% in 1986 and declined to 16.0% in 1996 (Bonelli et al., 2013). During this period, Brazil reduced the nominal average import tariff from 57.5% in 1987 to 11.2% in 1994 (Veiga and Rios, 2017a). Although the country has progressively increased this tariff in the last two decades, to around 32.0% (Castilho and Miranda, 2017), and established policies to encourage the domestic industry, it has not managed to reverse this decline; in 2015, only 12.2% of Brazilian value added originated in the manufacturing industry (IBGE, 2017). In addition, imports of final goods were the ones that increased the most in the last decade. This shows the loss of competitiveness of the Brazilian industry and the difficulties to increase productivity (Ferreira and Silva, 2015; Jacinto and Ribeiro, 2015), which has not been able to compensate for the high internal costs of production despite the protectionist policies.

Brazil's industrial and commercial policies over the last two decades have been aimed at stimulating exports through public financing of production investments (with negative real interest rates for some selected activities) and tax incentives for exporting companies (Veiga and Rios, 2017a). Thus, Brazilian trade policy has been formulated to stimulate exports, while maintaining reduced exposure of the domestic industry to international competitors. However, Taglioni and Winkler (2016) and Lindé and Pescatori (2017) have shown that this type of policy is not effective in stimulating exports in the context of international fragmentation of production. Thereby, in Brazil, although commercial and industrial policies aim to reduce the exposure of the domestic industry to the external market and stimulate its competitiveness, the country has experienced deindustrialization. In this perspective, Peneder and Streicher (2018) show that traditional industrial policies, in a context of intensifying production in global value chains and in contrast to the objectives of the policies, tend to accelerate deindustrialization.

Besides, the pattern of insertion of the Brazilian economy in international trade is marked by distinct characteristics when considering its global or regional integration. Brazilian exports have become resource–intensive, while exports to South America consist mainly of machinery and equipment (Brasil, 2017). The countries of South America, because they are characterized by common linkages of trade and investment, are considered as the regional trade bloc of Brazil in this

analysis.[1] The last significant trade agreements of Brazil were established with the countries of South America, with the creation of the Southern Common Market (Mercosur) in 1991 (agreement between Brazil, Argentina, Paraguay and Uruguay), the trade agreement between Mercosur, Chile and Bolivia in 1996 and between Colombia, Ecuador, and Peru in 2003. Since then, Brazil has been relatively closed to new trade agreements (Thorstensen and Ferraz, 2014). Although there have been negotiations, since the 2000s, Brazil's main agreements have been established only with Mexico, India and South Africa, and they cover a limited group of products (Castilho and Miranda, 2017).

Although imports and exports within the South American continent accounted for only 20.0% of Brazil's total foreign trade over the past two decades, the formulation of the Brazilian trade policy has been focused on agreements with South American countries. This policy has been conceived under the understanding that Brazil's insertion in value chains occurs mainly through the regional fragmentation of production (Veiga and Rios, 2017b)—although this hypothesis is not formulated based on empirical evidence.

Despite the need to understand the shift in the patterns of the international fragmentation of production, most of the studies conducted previously for the Brazilian economy are focused on discussing value chains based on evidence supported by gross export statistics, even though these statistics are not very informative in identifying value–added trade in internationally fragmented production (Johnson and Noguera, 2012a; Koopman, Wang and Wei, 2014). Dietzenbacher, Guilhoto and Imori (2013), Guilhoto and Imori (2014), Ferraz, Gutierre and Cabral (2015), Callegari et al. (2018) and Magacho et al. (2018), who analyze the insertion of Brazil in the global value chains through the trade of value added, are exceptions.

Therefore, this study evaluates the different patterns of insertion of Brazil into value chains. Thereby, this analysis performs a spatial decomposition of foreign value added. This decomposition is done taking into account the backward and forward segments of value chains. The regional and global insertion patterns in the value chains are analyzed through the geographic extension of the stages of production. For this, the value added is decomposed using the intercountry input–output model for the period from 1990 to 2015. This period of analysis allows us to evaluate the insertion into global value chains in the face of different scenarios of changes in the commercial and industrial policies of Brazil. This study can help to understand the recent changes in the country's productive structure.

The paper, in addition to this introduction section, is structured as follows. Section two discusses the growth of global trade in the context of vertical specialization and the challenges of measuring the insertion of countries into global production chains. Section three presents the vertical specialization measures used in this study. Section four informs the source of the data used in the analysis. Section five presents and discusses the results. Finally, section six provides the conclusions and suggestions for policy–making.

2. International fragmentation of production and value–added trade

International trade can enable countries to achieve higher levels of production and consumption (Gandolfo, 2014). International trade can stimulate the most efficient distribution of resources in the world market by outsourcing production to global production chains (Yi, 2003; Grossman and Rossi–Hansberg, 2008). The international outsourcing of production is related to companies' decision to carry out part of their productive stages abroad. These stages may involve the

[1] There is no multilateral trade agreement that includes all the countries of South America. Although there are two multilateral agreements, the Union of South American Nations (UNASUR) and the Integration of South American Regional Infrastructure (IIRSA), a free trade area among the countries of the region has not been established. IIRSA is a joint program of the governments of UNASUR countries with the objective of building infrastructure in the continent. UNASUR is comprised of 12 countries and provides for the replacement of the economic cooperation blocs of the Southern Common Market (Mercosur) between Argentina, Brazil, Paraguay, Uruguay and Venezuela, and the Andean Community of Nations (CAN), composed of Ecuador and Peru. The other countries that make up UNASUR are Chile, Guyana and Suriname.

physical production of goods, through the acquisition of intermediate inputs, or services performed at a distance, such as information technology and human resources (Yamashita, 2010). This international fragmentation tends to make countries specialize in specific stages of vertically integrated value chains (Jones, 2000; Hummels, Ishii and Yi, 2001).

The international fragmentation of production is a strategy to increase industrial competitiveness and it has provided the intensification of offshoring in recent decades for two main reasons. First, due to technological progress, which allows for the separation of production processes and the continuous reduction of transport costs (Hummels, 2007). Second, due to coordination capacity through governance in value chains (Gereffi et al., 2005). In addition, the liberalization of international trade, through tariff reduction policies, also contributes to the expansion of fragmentation across national boundaries (Yi, 2003). Overall, increased international outsourcing reduces production costs and adds more stages to global value chains (Yamashita, 2010).

The intensification of the international fragmentation of production chains has altered the structure of global trade in recent decades (Yi, 2003). This international fragmentation is defined by the specialization of countries at specific stages of vertically integrated production chains—referred to as vertical specialization (Hummels, Ishii and Yi, 2001). Thus, bilateral trade in goods has mainly occurred to connect the different stages of these global chains. This has allowed companies to transfer part of their production to cheaper locations abroad (Baldwin and Venables, 2013).

The vertical specialization of production has posed challenges to the theoretical modeling of international trade (Yi (2003), Grossman and Rossi–Hansberg (2008) and Antràs and Chor (2013)), as well as to empirical modeling (Hummels, Ishii and Yi (2001), Koopman, Wang and Wei (2014), Johnson and Noguera (2012a) and Los, Timmer and de Vries (2016)). This happens because, in the context of vertical specialization, trade statistics, measured in gross terms, include inputs that are added in the early stages of production in other countries. Thus, the total volume of gross trade is different from the sum of the value added by each country at different stages of production. Johnson and Noguera (2012a), Koopman, Wang and Wei (2014) and Los, Timmer and de Vries (2016) show that the vertical specialization of production requires the use of specific measures to estimate each country's contribution to international trade.

Therefore, the importance of international trade, as measured by gross measures, may be overestimated because of the double counting of intermediate goods crossing national borders more than once (Koopman, Wang and Wei, 2014).[2] Analyses to measure participation in global value chains mainly use the input–output methodology and start from the work of Hummels, Ishii and Yi (2001) and subsequent contributions made by Johnson and Noguera (2012a), Antràs *et al.* (2012), Koopman, Wang and Wei (2014), Los, Timmer and de Vries (2015) and Gurgul and Lach (2018). The input–output analysis allows us to track all production chains through the structure of industrial interdependence and thus to account for the direct and indirect participation of each country in the global production, taking into account all stages of global value chains.

The vertical specialization measures, calculated in the input–output approach, take as a starting point that production involves a sequential chain of trade, which extends across many countries, with each country specializing in a particular stage of production. The first vertical specialization measure proposed by Hummels, Ishii and Yi (2001) estimates the imported content in exports under the assumption that these exports are fully absorbed abroad. This measure of specialization excludes the scenarios in which production incorporates imported goods that countries produced in the early stages of value chains. Thus, Daudin, Rifflart and Schweisguth (2011), Johnson and Noguera (2012a and 2012b), Timmer *et al.* (2013), Koopman, Wang and Wei (2014) and Los, Timmer and de Vries (2016), using information for the trade flows specified in interregional input–output tables, extend the vertical specialization measure of Hummels, Ishii and Yi (2001) from the value–added content to different decompositions.

[2] The double counting in the gross trade statistics originates from exports that can return to the country of origin in the form of final goods or intermediate inputs; in the case of intermediate inputs, these can be used at other stages of production and re–exported (Koopman et al., 2014).

Input–output analysis, in addition to measuring foreign value added content, allows the identification of the geographic extent of global value chains and the formation of agglomerations of countries at specific stages of production. The regional agglomeration of activities in value chains is driven by the formation of regional trade blocs, which reduce trade barriers preferentially between neighboring countries (Johnson and Noguera, 2017).

The geographical extent of global production chains is analyzed by Johnson and Noguera (2012a), Baldwin and Lopez–Gonzalez (2015) and Los, Timmer and de Vries (2015), which present evidence that vertical specialization has different patterns between countries and sectors of activity. Thus, although some industries locate their assembly activities close to the final markets—with specialized suppliers tending to cluster in their surroundings—other industrial activities are characterized by dispersed production around the world. Thereby, international fragmentation can occur essentially through trade in the regional context, i.e., in groups of geographically close countries, or in the global context, i.e., involving geographically distant countries (Backer, Lombaerde and Iapadre, 2018).

In this perspective, Baldwin and Lopez–Gonzalez (2015) suggest that vertical specialization in the 1990s was marked by regional trade blocs rather than trade in value chains globally. Thus, international fragmentation was concentrated among immediate trading partners, geared to the regional location of trade. In contrast, Los, Timmer and de Vries (2015) show that, in the 2000s, the extent of the international fragmentation1 was mainly global, involving countries from outside a given region. The international fragmentation of production, in addition to showing different characteristics in the regional and global contexts, is also diverse when comparing forward and backward segments of global value chains—in this case, countries play different roles at different levels of value chains (Lejour et al., 2017).

3. Decomposing participation in global production chains

Foreign value–added content is used to evaluate integration into global value chains. The contribution of each country in the production chain can be broken down using an intercountry input–output table. This table contains the values of the flows of intermediate inputs and final goods among all the country–industries—i.e., the *s* industries (*s = 1, ..., S*) in each of the n countries (*n = 1, ..., N*). By combining information on the values of transactions of intermediate inputs (**Z**), final demand (**F**), sectoral production (**x**) and remuneration of primary production factors (**w**), it is possible to estimate the value generated in each of the *SN* industries. Formally, these flows can be represented by the following matrices and vectors:

$$\mathbf{Z} \equiv \begin{pmatrix} z_{11} & z_{12} & \cdots & z_{1N} \\ z_{21} & z_{22} & \cdots & z_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ z_{N1} & z_{N2} & \cdots & z_{NN} \end{pmatrix}, \mathbf{F} \equiv \begin{pmatrix} f_{1j} \\ f_{2j} \\ \vdots \\ f_{Nj} \end{pmatrix}, \mathbf{x}' \equiv \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_N \end{pmatrix}, \mathbf{w}' \equiv \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_N \end{pmatrix}$$

The market equilibrium condition of the input–output system representation for the *SN* industry can be written in matrix form as $\mathbf{x}' = \mathbf{F}\iota + \mathbf{Z}\iota$ and $\mathbf{x} = \mathbf{w} + \iota'\mathbf{Z}$. The term (*SN x* 1) ι is a sum vector.[3] For each sector, the production value (**x**) is equal to the sum of the goods for final (**F**) and intermediate (**Z**) uses, in the domestic and external markets. The external market is defined by exports from *i* to *j*. In sectoral production (**x**), payment is required for the primary factors (**w**) and intermediate inputs (**Z**) of production. From these elements, it is possible to decompose the intermediate inputs required per unit of production, defined in the matrix $\mathbf{A} = \mathbf{Z}(\hat{\mathbf{x}})^{-1}$, and the value added per unit of product, defined in the vector $\mathbf{v} = \mathbf{w}(\mathbf{x})^{-1}$. The term $\hat{\mathbf{x}}$ corresponds to the diagonal matrix formed by the vector **x**.

[3] An apostrophe denotes the transpose of a vector or matrix.

To produce the good (i, s), a combination of local primary inputs and national and imported intermediary inputs from different sectors and countries is required. Then, the good (i, s) is absorbed in the final demand or used as an intermediate input in production. To break down its value, it is necessary to find the product levels associated with the good (i, s) at each stage of production, measured through intercountry input–output tables. To do so, the value chains are identified by the last stage of production of the final good $f_{ij}(s)$. The participation of each country in the international fragmentation of production is measured by the value added inserted in the value chains, following the formulation proposed by Los, Timmer and de Vries (2015). Thus, the value generated in the production of the good (i, s) is derived from the remuneration of capital and labor in the country–industry of production. This is equivalent to identifying the extent to which the country of completion of the final good $f_{ij}(s)$ contributes to the production of that good, which can be decomposed as follows:

$$\mathbf{g}^{\text{stage0}} = \hat{\mathbf{v}}\mathbf{F} \tag{1}$$

where the final demand vector (*SN x 1*) **F** has its real values only in the cells that represent the final demand for the country–industry (*i, s*), while all other values in the final demand are set to zero. The vector **F** is equal to the final internal and external demand for the final products $f_{ij}(s)$. The matrix $\hat{\mathbf{v}}$ is formed by the diagonalization of vector **v**.

The elements $\mathbf{g}^{\text{stage0}}$, with the value added generated in the final stage of production, are equal to zero for all other industries that are not (*i, s*). The production of final goods requires not only capital and labor, but also intermediary inputs from (domestic and foreign) suppliers in the first stage of production. The output of these industries attributable to the final demand for the good (i, s) is equal to **AF** and the value added in the first stage of production can be expressed by:

$$\mathbf{g}^{\text{stage1}} = \hat{\mathbf{v}}\mathbf{A}\mathbf{F} \tag{2}$$

Intermediate products$(\mathbf{AF})$ delivered by suppliers in the first stage of production, in turn, require intermediate inputs from suppliers of the second stage of the value chain. These production levels are equal to $\mathbf{A}(\mathbf{AF})$ and the contributions of the second stage of global value added are:

$$\mathbf{g}^{\text{stage2}} = \hat{\mathbf{v}}\mathbf{A}(\mathbf{AF}) \tag{3}$$

Applying this line of reasoning to the suppliers of all stages of production, the contribution of each country in the global production chains, from the decomposition of the value added inserted in the stages of production, can be defined as follows[4]:

$$\mathbf{g} = \mathbf{g}^{\text{stage0}} + \mathbf{g}^{\text{stage1}} + \mathbf{g}^{\text{stage2}} + \cdots + \mathbf{g}^{\text{stageN}} \tag{4}$$

$$\mathbf{g} = \hat{\mathbf{v}}(\mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \mathbf{A}^3 + \cdots)\mathbf{F} \tag{4.1}$$

$$\mathbf{g} = \hat{\mathbf{v}}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{F} \tag{4.2}$$

The vector (*SN x* 1) **g** contains the value added generated in each of the country–industries that can be assigned to the value chains of the final products $f_{ij}(s)$.[5] To obtain the origin of the value added of $f_{ij}(s)$ in the production chain by country, the elements of **g**, which correspond to the

[4] See Miller and Blair (2009) for the conditions in which the sum converges.

[5] The final demand for the good (i, j) includes household and government consumption and the demand for investment in domestic and foreign markets.

industries in each country, are added to each other. The choice of a specific vector **F** by country of origin of the production of final goods determines the value chain being analyzed. The use of the Leontief inverse matrix, $(\mathbf{I}-\mathbf{A})^{-1}$, ensures that value–added contributions at all stages of supply through direct and indirect requirements in the productive chain structure are taken into account. Los, Timmer and de Vries (2015) show that the main result of this calculation is the possibility of decomposing the value of a final product by the value–added contributions made in any country.

3.1. Forward insertion in global chains

The integration of countries into global production chains may occur differently when considering the forward or backward tracking of such production chains. Therefore, this study measures the forward integration into global value chains, defined as Sourcing_s. This measure is calculated taking as a starting point the decomposition to measure the proposed decomposition by Los, Timmer and de Vries (2015).

The Sourcing_s measure is calculated using the vector **g**, defined in Eq. (4.2), from its replication for each country of completion of the final good $f_{ij}(s)$. Value added from the country of completion in vector **g** is set to zero. The sum of the value added provided by each country *i* for the other completion country *j* is defined as:

$$\text{SVA}_s = \sum_{j \neq i} \text{VA}_{ij}(s), \forall\, j \tag{5}$$

The participation of each country in the supply of value added for the global production chains, from Eq. (5), is defined as follows:

$$\text{Sourcing}_\text{s} = \frac{\text{SVA}_s}{\sum_i \sum_{j \neq i} \text{VA}_i(s)} \tag{6}$$

where $\sum_i \sum_{j \neq i} \text{VA}_i(s)$ is the sum of the foreign value added entered in the global production. The sum of Sourcing_s for each country *i* belonging to the global production chain is equal to 1.

3.2. Backward insertion into global chains

In the backward integration—focused on the origin of the value added for the last stage of production, that is, the country–of–completion—in global chains, the value added in the final goods produced in Brazil is decomposed, following the approach developed in Los, Timmer and de Vries (2015). Thus, the vector **F** of equation (4.2) includes the final demand values only for Brazil, with the other cells specified as zero. The value of the final good produced by industry *s* in Brazil is denoted by FINO_s. The value added from country *j* is defined by $\text{VA}_{(j)}(s)$. The vector **g** contains the corresponding levels $\text{VA}_{(j)}(s)$ or each final good produced in Brazil $f_{ij}(s)$, such that:

$$\text{FINO}_s = \sum_s \text{VA}_{(j)}(s) \tag{7}$$

The contribution of all countries to the value added used in the production of (i, s) is equal to the value of the final product (i, s). The FINO_s measure allows for the definition of the value added along the production chain in which Brazil is integrated, minus the value added produced in Brazil:

$$\text{FVA}_s = \sum_{j \neq Brazil} \text{VA}_{(j)}(s) = \text{FINO}_s - \text{VA}_{(Brazil)}(s) \tag{8}$$

The term FVA_s measures the international fragmentation of production chains.[6] FVA_s, unlike SVA_s, defined in Eq. (5), is the sum of the value added from the *N* countries in the production of country *i*. SVA_s, in turn, is the sum of the contribution of country *i* in the value added inserted in the production of the *N* countries belonging to the global production chain. To measure the importance of foreign value added, FVA_s is expressed as the share of value added in the production of *s*:

$$\mathrm{FVAS}_s = \mathrm{FVA}_s / \mathrm{FINO}_s \tag{9}$$

The foreign value-added share (FVAS) is used to measure the extent of the international fragmentation of the value chains into which Brazil is inserted. This share is an index that varies between zero and one. FVAS assumes zero value when all value added is produced internally, assuming larger values as international fragmentation increases.[7] FVAS includes the value added at each stage of production; Thus, this measure does not present the problem of double counting, defined by Koopman, Wang and Wei, (2014), present in the other vertical specialization metrics that use intermediate inputs imported into production.

3.3. Regional and global fragmentation of value chains

Foreign value added, following the proposed decomposition in Los, Timmer and de Vries (2015), is used to define the international fragmentation of production within regional or global blocs of trade. The focus of the analysis is the insertion of the Brazilian economy into global value chains. In this way, FVA_s is decomposed into the foreign value-added share originating in the region in which Brazil is included, i.e., regional foreign value added (RFVA_s), and the share of the foreign value added that is produced geographically distant from Brazil, i.e., global foreign value added (GFVA_s). The countries of South America, because they are characterized by common linkages of trade and investment, are considered as the regional trade bloc of Brazil.

The regional foreign value added in the final good $f_{ij}(s)$ produced in Brazil is defined as the contribution of the value added of the region to which Brazil belongs minus the contribution of Brazil:

$$\mathrm{RFVA}_s = \sum_{\substack{j \in region \\ of\ Brazil}} \mathrm{VA}_j(s) - \mathrm{VA}_{(Brazil)}(s) \tag{10}$$

Similarly to Eq. (9), the regional share of FVA_s in Brazil's production chains is defined by:

$$\mathrm{RFVAS}_s = \mathrm{RFVA}_s / \mathrm{FINO}_s \tag{11}$$

The change over time in the share of RFVA_s being positive indicates a trend of regional fragmentation of the value chain. Similarly, GFVA_s measures the contribution of value added of all countries outside the region of Brazil[8], as follows:

[6] The approach of measuring international fragmentation from FVA_s is based on tracking the value chain, starting from the final product and tracing the added value, at all stages, needed to produce the final good.

[7] By definition, FVAS cannot be equal to one, because the final stage of production must involve some activity in the country of completion of production.

[8] Following the definition of Los, Timmer and Vries (2015), the term global value added is used to define the value added that is geographically distant from the location of the last stage of production. Therefore, this measure should not be interpreted as value added anywhere in the world, as it would, by definition, be equal to the value of the final product.

$$\mathrm{GFVA}_s = \sum_{\substack{j \notin region \\ of\ Brazil}} \mathrm{VA}_j(s) \tag{12}$$

The share of Brazilian production in the global value chain is defined as follows:

$$\mathrm{GFVAS}_s = \mathrm{GFVA}_s / \mathrm{FINO}_s \tag{13}$$

The $\mathrm{Sourcing}_s$ measure can also be decomposed to the value added originating in Brazil and supplied to the regional and global trading block. Thus, Brazil's participation in the production of the countries of the regional value chain is defined by Regional Sourcing ($\mathrm{RS_s}$):

$$\text{Regional SVA}_s = \sum_{j \neq i} \mathrm{VA}_{ij}(s), \forall\, j \in \text{region of Brazil} \tag{14}$$

$$\mathrm{RS_s} = \frac{\text{Regional SVA}_s}{\sum_i \sum_{j \neq i} \mathrm{VA}_{ij}(s)} \tag{15}$$

Brazil's participation in the supply of value added in the global chain is defined by Global Sourcing ($\mathrm{GS_s}$):

$$\text{Global SVA}_s = \sum_{j \neq i} \mathrm{VA}_{ij}(s), \forall\, j \notin \text{region of Brazil} \tag{16}$$

$$\mathrm{GS_s} = \frac{\text{Global SVA}_s}{\sum_i \sum_{j \neq i} \mathrm{VA}_{ij}(s)} \tag{17}$$

4. Database

The regional and global fragmentation of value chains is analyzed using the data provided by the full EORA Multi–Regional Input–Output Table (MRIO). The construction of this database is described in Lenzen *et al.* (2012a) and Lenzen *et al.* (2013a). The full EORA MRIO contains data for 190 regions of the world, specifying 26 sectors of activity,[9] and covers the period from 1990 to 2015.[10] The data for the construction of the EORA MRIO database are from national statistical offices. Bilateral trade data comes from the UN Comtrade Database and UN Service Trade Database. The EORA database assumes that its regional specification sufficiently covers the global economy.

Changes in the national accounts system may cause interruptions in the continuity of the input–output tables of Brazil estimated by EORA. However, Lenzen *et al.* (2013b) show that this does not generate imbalances in sectoral aggregated analyzes—the focus of the present study. A detailed description of the price corrections and of all the discontinuities and corrections implemented

[9] The EORA Multi–Region Input–Output Table (MRIO) provides data from the intercountry input–output table with the breakdown of 56 sectors of activity into the Brazilian economy. However, this matrix does not have a harmonized version for all world economies, making it impossible to aggregate foreign value added results at the industrial level.

[10] Owen *et al.* (2016), Steen–Olsen *et al.* (2016) and Owen (2017) analyzed the results of economic indicators constructed from the Interregional Input–Output Tables of the Global Trade Analysis Project (GTAP), World Input–Output Database (WIOD), Multi–Region Input–Output Table (EORA) and Inter–Country Input–Output (OECD–ICIO) and found that global added value accounts are similar between these databases, although differences exist at the country and individual sector levels.

in the input–output tables for the Brazilian economy, used in the estimation of the full EORA MRIO, is found in Lenzen *et al.* (2012b) and Lenzen *et al.* (2013b).

The choice of using the EORA other than other databases of intercountry input–output tables is motivated by its complete regional specification for the South American countries. This allows us to measure the geographical origin of all regional trade flows in Brazil. In addition, the historical series of the full EORA MRIO makes it possible to evaluate the evolution of Brazil's insertion into global value chains.

5. Results

The measures of foreign value-added share (FVAS) and Sourcing are used to quantify the vertical specialization of Brazil and its insertion in regional and global trade blocs. FVAS is a measure of backward integration into global chains, that is, in terms of the purchase of inputs. On the other hand, the Sourcing measure, defined by the share of value added produced in Brazil in relation to total foreign value added in all value chains, evaluates the forward integration in production chains.

Table 1 shows the distribution of value added in the final goods produced in Brazil in two groups: for all activity sectors and for the sectors related to agriculture, mining, manufacturing and tradable services.[11] Domestic value added measures domestic share in domestic production—that is, discounting foreign value added. The regional and global foreign value added (FVAS) in the final goods produced in Brazil increased for the two groups of sectors from 1990 to 2015. This suggests that production in Brazil became more connected to global value chains throughout this period, although the country has one of the lowest FVAS among world economies—Brazil ranks 157th out of 188 countries in terms of foreign value-added share in final products.[12]

Table 1. Origin of value added in final goods produced in Brazil (%)

	All sectors		Agriculture, mining, manufacturing and tradable services	
	1990	2015	1990	2015
Domestic value added	93.73	92.01	92.00	89.06
Foreign value added (FVAS), of which	6.27	7.99	8.00	11.04
Regional (RFVAS)	0.65	1.48	0.86	2.06
Global (GFVAS)	5.62	6.51	7.14	8.98

Source: Authors' calculations from the EORA Multi–Region Input–Output Table (MRIO) database.

The Brazilian commercial policy, besides being formulated with the objective of creating barriers to imports, also aims to increase and diversify exports. Therefore, the insertion of Brazil in the forward and backward flows of global value chains is expected to occur differently. To measure these diverse standards of insertion, the Sourcing measure is used. This measure assesses the importance of the Brazilian economy for global production chains based on the share of value added with origin in Brazil in relation to the foreign value added included in the final goods produced anywhere in the world.

Brazil's contribution to the provision of value added to global production chains is shown in Table 2. In 2015, Brazil contributed 1.4% of foreign value added in the final products of all global

[11] Non–transactional services are not included in the analysis because their production is not traded internationally. These sectors are characterized by services rendered locally.

[12] One of the reasons for the low FVAS in the Brazilian economy is the high import tariffs practiced in the country. However, this is not the only measure to assess insertion in value chains. For example, the United States and Japan also have low FVAS. In this case, it is worth mentioning that FVAS is influenced by the size of the manufacturing industry's share of the total product; the stage of technological development of the country and its degree of dependence on imports of foreign technologies, in addition to the industrial structure and its productive links with the rest of the world – that is, the type of industrial specialization in the country and the stages of production that are outsourced abroad.

production chains—0.2% for the production of South American countries (Regional Sourcing) and 1.1% for the production in the rest of the world (Global Sourcing).

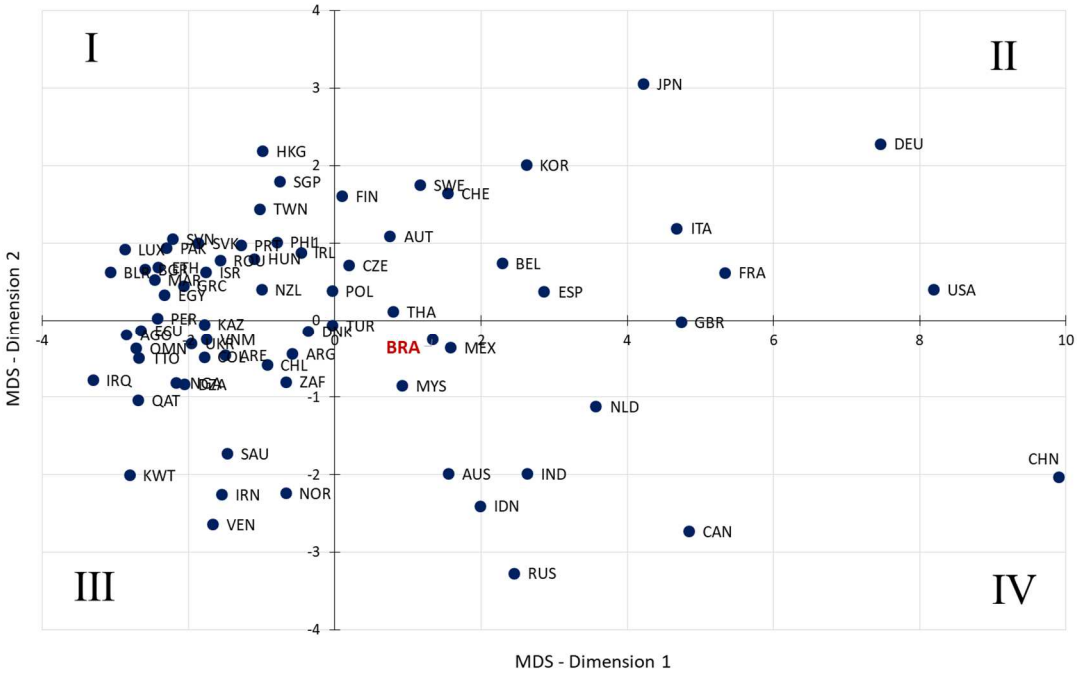
Table 2. Share of value added with origin in Brazil in relation to total foreign value added in value chains (%)

	All sectors		Agriculture, mining, manufacturing and tradable services	
	1990	2015	1990	2015
Sourcing, of which	0.96	1.37	0.98	1.38
Regional Sourcing (RS)	0.10	0.24	0.10	0.24
Global Sourcing (GS)	0.86	1.13	0.88	1.14

Source: Authors' calculations from the EORA Multi–Region Input–Output Table (MRIO) database.

The share of value added provision in global value chains (Sourcing) was calculated for each industry specified in EORA Multi–Region Input–Output Table (MRIO) database. Sourcing measures at the industrial level are represented in Figure 1, in two dimensions. A multidimensional scaling (MDS) technique was used to identify groups of countries with similar patterns of insertion in global value chains. In quadrants I and II, the focus is on technology–intensive and specialized countries in the final stages of production of global value chains. Quadrant III concentrates resource–intensive countries that contribute the most to value in the early stages of global value chains. In quadrant IV, in turn, are countries specializing in the production of agricultural goods, mining, and food, wood and petrochemical industries. Brazil is in an intermediary position; i.e., despite having a comparative advantage in the production of natural resource–intensive goods, the Brazilian industrial structure is diversified and the country is able to participate in value chains in some more advanced stages of production.

Figure 1. Value added in global production chains by country groups: year 2015.



Note: The multidimensional scaling (MDS) technique organizes a set of variables in a few dimensions using the similarities (or distances) between every pair of observation (Johnson and Wichern, 2007). For the application of the MDS technique, the Sourcing measure was used for each country by sector of activity. MDS configuration: method (modern MDS), loss criterion (stress), transformation (identity). Only the first 70 countries ranked by share in total exports were included in the Figure.

Source: Authors' calculations from the EORA Multi–Region Input–Output Table (MRIO) database.

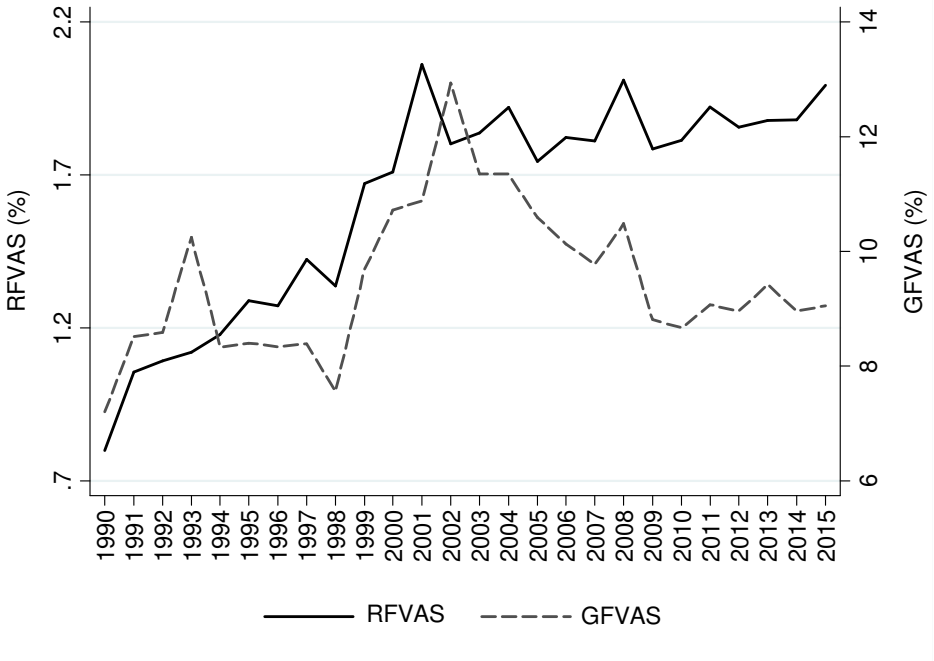
In the ranking of 188 countries, which assesses share in the supply of value added for the global production chains, Brazil occupies the 20th position. This pattern of insertion of the Brazilian economy can be better understood through the analysis of its regional and global insertion in the next section.

5.1. Brazil's regional and global insertion in value chains

Brazil's regional and global patterns of insertion into value chains are analyzed through the decomposition of the geographical origin of the value–added trade. Figure 2 shows the decomposition of the foreign value added inserted in the Brazilian production originating in the regional and global trade blocs, calculated through the RFVAS and GFVAS measures. The regional trade bloc is formed by the countries of South America, while the global trade bloc is composed of all the other countries that form the global value chains.

The regional and global backward fragmentation of Brazilian production increased until 2001 (Figure 2). Starting in 2002, the GFVAS showed a downward trend and the RFVAS remained stable until 2009. The regional and global insertion of Brazil showed a tendency to increase from 2010. The global trade bloc contributed with 9.0% and the regional–market bloc provided 2.0% of the foreign value added in Brazilian production in 2015. The results show that the countries of South America have a small share in the production of final goods in Brazil. This result is different from the evidence presented by Baldwin and Lopez–Gonzalez (2015), who interpreted the international fragmentation of production occurring mainly within regional trade blocs. The result of our study is similar to the evidence found by Los, Timmer and de Vries (2015), who identified the global fragmentation of value chains as being greater than the regional fragmentation for OECD country groups.

Figure 2. Regional and global fragmentation of the value added inserted in the Brazilian production



Note: The share of foreign value added in final products is presented to the agriculture, mining, manufacturing, and tradable services sectors as these sectors are more prone to international fragmentation of production.
Source: EORA Multi–Region Input–Output Table (MRIO) database.

The increase in FVAS between 1990 and 1993 is partly linked to the trade liberalization policy, which reduced the nominal average import tariff from 57.0% in 1987 to 13.0% in 1993. The reduction of GFVAS from 2002 onwards may have been caused by the policy of increasing import tariffs and encouraging the acquisition of domestic inputs through sectoral public financing schemes

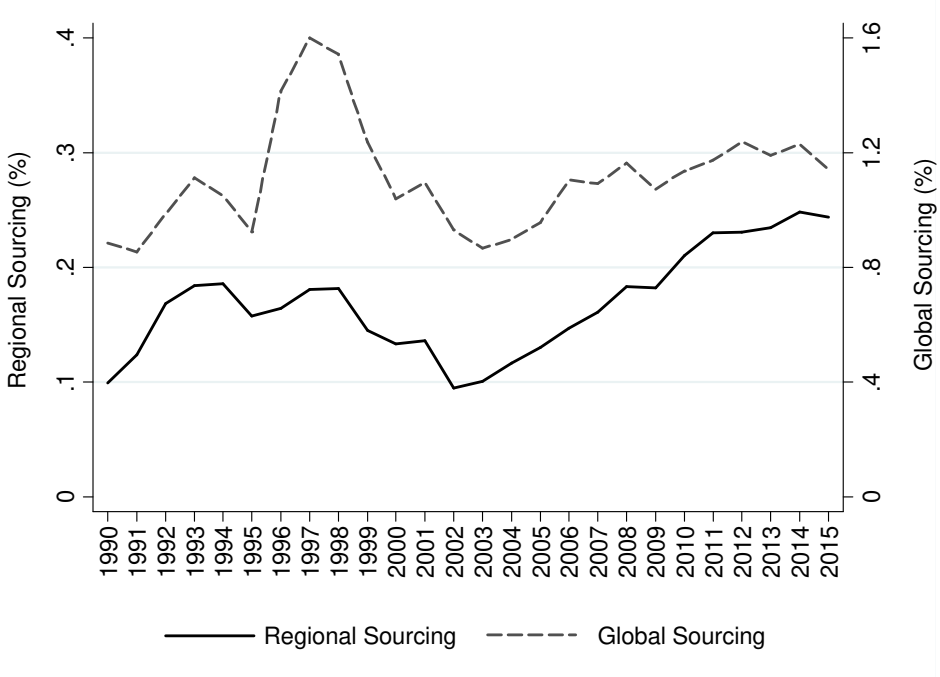
for investment, tax incentives and government procurement (Veiga and Rios, 2017a). In this way, Brazil has been practicing higher levels of import protection than other developing countries. In addition, import tariffs are higher on machinery and equipment than tariffs imposed on imports of other types of industrial inputs—this trend is contrary to other countries (Baumann and Kume, 2013).

From 2010 onwards, Brazilian trade and industrial policies have aimed at intensifying the protection of the national industry (Veiga and Rios, 2017a). These policies adopted in Brazil have aimed at increasing domestic content in production. However, during this period there has been a growth of imported goods in the manufacturing industry. This justifies the upward trend in GFVAS between the years 2010 and 2013 (Figure 2). On the other hand, the policy of encouraging integration with South American countries may have contributed to the upward trend of RFVAS.

The forward integration of Brazil into global value chains in regional and global trade blocs is measured by Regional Sourcing and Global Sourcing. Figure 3 shows the evolution of the regional and global forward insertion of Brazil in the value chains between 1990 and 2015. The value added with origin in Brazil and inserted in the final products of South America (0.24%) and in the rest of the world (1.14%) is a measure of the country's contribution to global production chains.

The evolution of the Sourcing measure shows that the value added produced in Brazil, which composes the other countries' final goods, showed an upward tendency concentrated in three different periods: between 1991 and 1993, between 1995 and 1997 and from 2004 (Figure 3). The first period refers to the trade liberalization in Brazil. The second period refers to the 38.0% drop in the effective real exchange rate, which preceded the change in the country's exchange rate policy. The third point corresponds to the 42.0% devaluation of the real exchange rate between 2004 and 2009 and the expansion of the prices of natural resource–intensive products in the international market. Since Brazil specializes in exports of these products, this may be related to the increase in the Sourcing measure in this period.

Figure 3. Regional and global supply of value added produced in Brazil



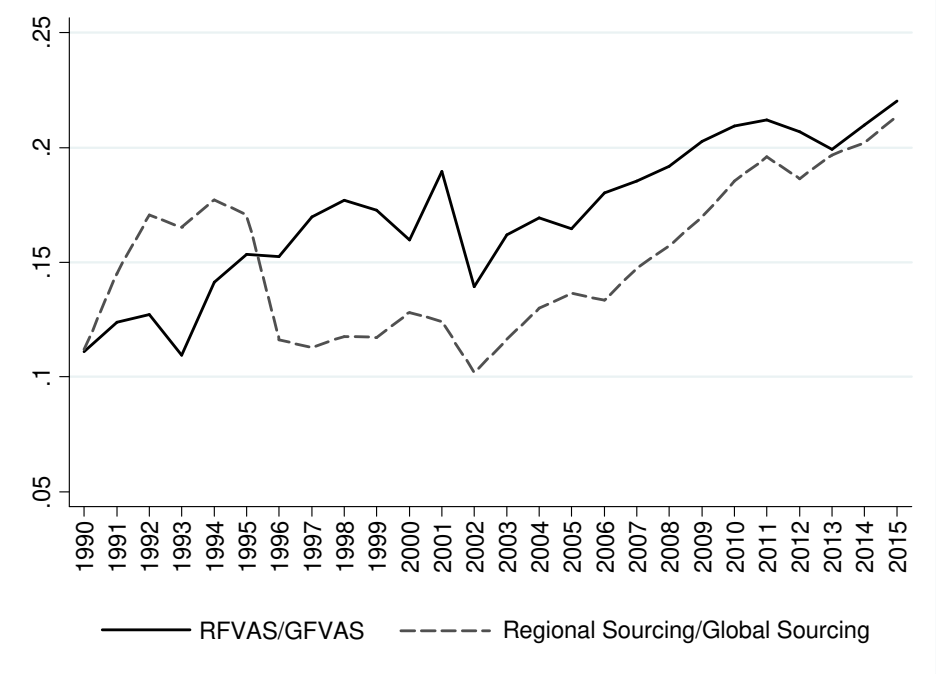
Note: Brazil's participation in the final products of all global production chains is presented to the agriculture, mining, manufacturing, and tradable sectors, as these sectors are more prone to international fragmentation of production.
Source: EORA Multi–Region Input–Output Table (MRIO) database.

Figure 4 shows the relative importance of the regional insertion in relation to the global insertion for the activity sectors related to tradable goods between 1990 and 2015. These results allow us to identify the change in the pattern of international fragmentation over time. The RFVAS and Regional Sourcing have increased in relation to the global share. Therefore, although the Brazilian

insertion in the value chains has been driven mainly by the global fragmentation of production, its regional insertion has increased more than its global insertion.

The value added in Brazilian production is decomposed by country of origin. For this, the MDS technique applied to the FVAS was used for each industry. The results are shown in Figure 5a—in quadrant I are the countries that provide the most value added from mineral products to Brazil; quadrant II concentrates the countries that supply value added in agricultural, mining, textile, food, and wood industries; in quadrant III are the countries that are not representative in the supply of value added for Brazil; and quadrant IV displays the main value added suppliers concentrated across the technology–intensive industries.

Figure 4. Trend of regional and global fragmentation of Brazilian production



Source: EORA Multi–Region Input–Output Table (MRIO) database.

Figure 5b shows the Brazilian value added exports—this is, the value added that will be used in the last stage of production in the other countries of the value chains. In quadrants I and III the countries that are not traditional trade partners of Brazil. In quadrant II are the destination countries of value–added exports in agricultural products, mining, textile, food, and wood industries. Quadrant IV, in turn, presents the destinations for value–added exports in goods that are technology–intensive and closer to the last stages of production of value chains—such as machinery and electrical equipment, metal products, petrochemical industry, and transport equipment.

The proximity is important in international trade. In a context of international fragmentation of production, the connectivity of value chains is marked by geographical proximity and agglomeration of the main production countries in a few places, which are the center of globally connected regional chains—such as the regional chains with a center in the United States, European Union and Southeast Asia (Lejour et al., 2017). Thereby, the economies, even if well structured, with relatively low unit labor costs and high connectivity, will have a negative impact on trade if their neighbors fall short of the same metrics (World Bank, 2017). Figure 5 shows that Brazil's main trading partners in terms of FVAS and Sourcing are geographically distant, with the exception of Argentina. This may be a restrictive factor for Brazil to take advantage of the benefits of greater trade integration and international fragmentation of production. In addition, the results presented in Figure 5 show that the insertion of Brazil into the value chains presents different standards when considering the forward and backward stages of the production chains.

Figure 5. Insertion of Brazil in the downstream and upstream segments of global value chains: 2015

Fig. 5.a – Decomposition of FVAS in Brazilian final products by country of origin

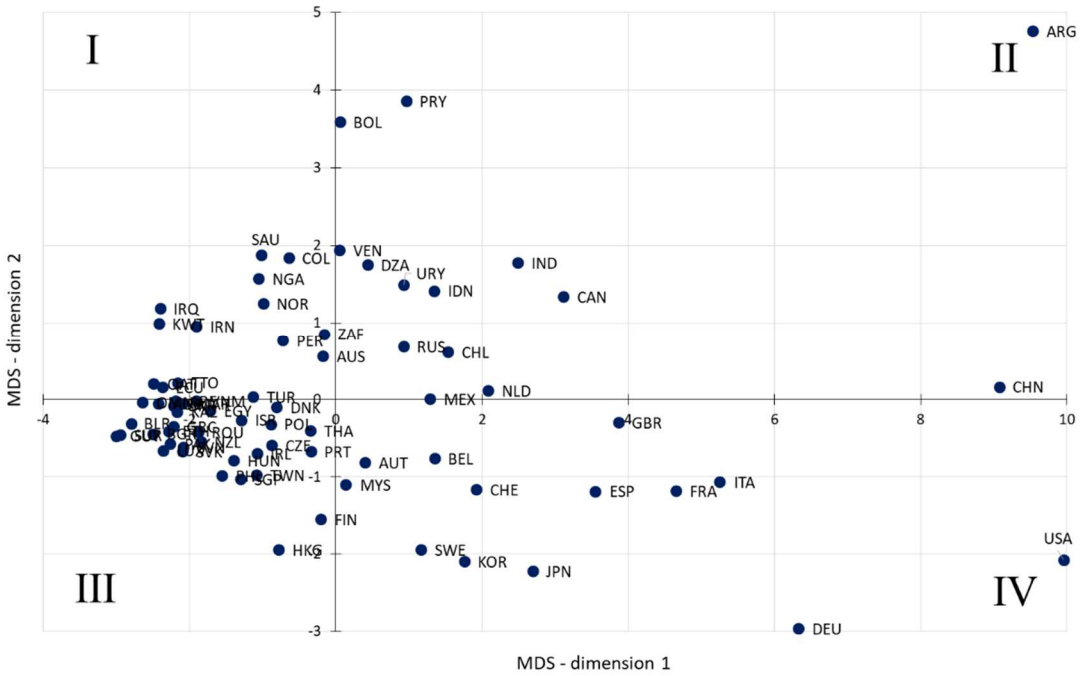
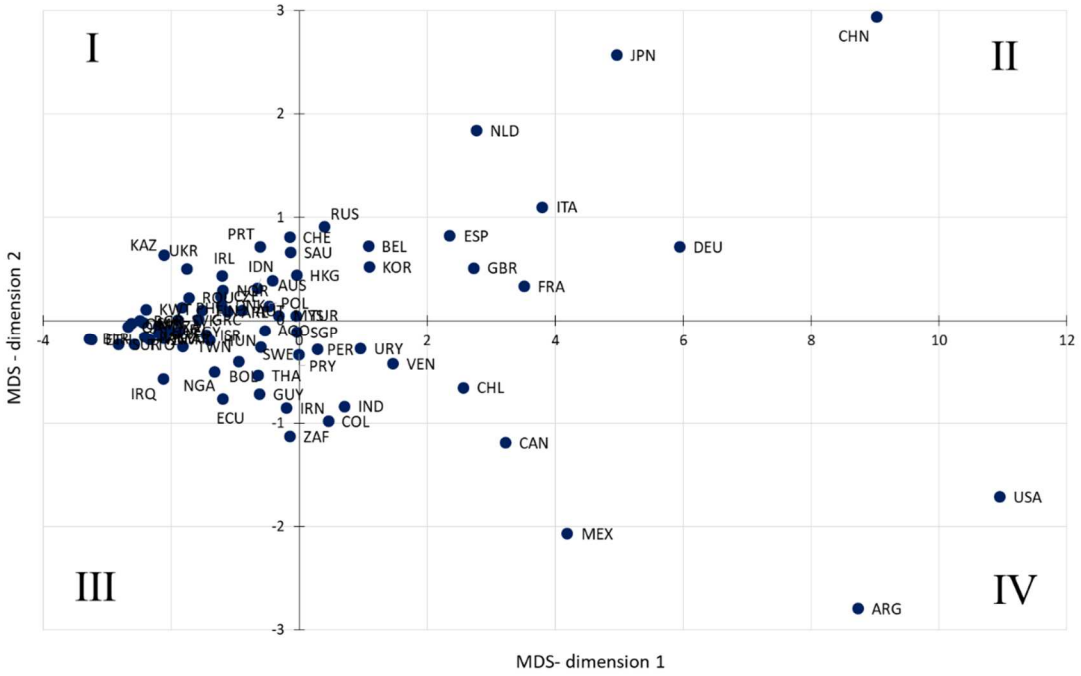


Fig. 5.b – Decomposition of value–added with origin in Brazil (Sourcing) by country of destination



Note: The multidimensional scaling (MDS) technique organizes a set of variables in a few dimensions using the similarities (or distances) between each pair of observation (Johnson and Wichern, 2007). For the application of the MDS technique, the value–added measure was used for each country by sector of activity. MDS configuration: method (modern MDS), loss criterion (stress), transformation (identity).

Source: Authors' calculations from the EORA Multi–Region Input–Output Table (MRIO) database.

6. Conclusions

The study performed a spatial decomposition of foreign value added inserted in global value chains. This decomposition is done taking into account the forward and backward segments of value chains. In this study, the focus of the analysis is the Brazilian economy, since its pattern of insertion in international trade has distinct characteristics when considering its global or regional integration.

This analysis presents new evidence regarding the position that Brazil occupies in the value chains and the spatial extent of this productive fragmentation. The main results show that the insertion of countries into value chains occurs differently when considering their geographic scope and forward and backward production stages. We also find that the forward and backward insertion of Brazil in the value chains is driven mainly by the global fragmentation of production. However, the regional insertion has increased more than the global insertion.

Brazil is relatively closed to international trade and little inserted in value chains. Protectionist policies have been directed to keep Brazil away from greater integration in value chains, with incentives for the realization of all stages of production in the national territory. Thus, the Brazilian industry has remained little integrated to the international fragmentation of production. In addition, the reduced number of trade agreements hinders the country's insertion into the value chains.

Further integration into global value chains may be an alternative to increase economic growth capacity. Although this insertion can promote gains in industrial competitiveness, it can also reduce the level of activity in industries with less capacity to compete in the external market. Thereby, a concern of policymakers is the decrease in employment and income levels in specific activities.

In the context of growing international outsourcing of production, the formulation of industrial policies should take into account that the production processes are increasingly fragmented in different territories. This affects how to take advantage of a country's comparative advantages in specific stages of the production process. In this context, industrial and commercial policies in Brazil are formulated based on two main issues. First, to encourage domestic industry through high import tariffs, with the risk of generating a loss of competitiveness and hampering the integration of value chains. Second, reducing import tariffs and encouraging greater participation in global production chains, but at the risk of loss of employment and income in activities where national industries are unable to compete with foreign industries.

It should be borne in mind that there are distant forms of insertion in the global production chains, both in relation to the stages of production and to the geographical scope of these production chains. Although the Brazilian industry does not have the technological capacity to compete in more advanced stages of production of certain industries, the country may have advantages in specializing in intermediary stages of these chains in which it is a net exporter of manufactured goods. To do this, it is necessary to consider that value chains have a geographical scope—that is, the global value chain is formed by several regional production chains.

Mapping the different dimensions of value chains is an important step for Brazil to identify at which stages of production have more comparative advantages of insertion. Thus, this study contributes to an increased understanding of Brazil's insertion in the international fragmentation of production, which can be useful in the formulation of industrial policies.

References

Antràs, P., Chor, D., 2013. Organizing the Global Value Chain. Econometrica 81, 2127–2204. https://doi.org/10.3982/ECTA10813

Antràs, P., Chor, D., Fally, T., Hillberry, R., 2012. Measuring the Upstreamness of Production and Trade Flows. Am. Econ. Rev. 102, 412–416. https://doi.org/10.1257/aer.102.3.412

Baldwin, R., Lopez-Gonzalez, J., 2015. Supply-chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses. World Econ. 38, 1682–1721. https://doi.org/10.1111/twec.12189

Baldwin, R., Venables, A.J., 2013. Spiders and snakes: Offshoring and agglomeration in the global economy. J. Int. Econ. 90, 245–254. https://doi.org/10.1016/j.jinteco.2013.02.005

Baumann, R., Kume, H., 2013. Novos padrões de comércio e política tarifária no Brasil, in: Bacha, E., Bolle, M.B. (Eds.), O Futuro Da Indústria No Brasil: Desindustrialização Em Debate. Civilização Brasileira, Rio de Janeiro, p. 276.

Bonelli, R., Pessoa, S., Matos, S., 2013. Desindustrialização no Brasil: fatos e interpretação, in: Bacha, E., Bolle, M.B. (Eds.), O Futuro Da Indústria No Brasil: Desindustrialização Em Debate. Civilização Brasileira, Rio de Janeiro, p. 276.

Brasil, 2017. Ministério da Indústria, Comércio Exterior e Serviços. Sistema de Análise das Informações de Comércio Exterior (Alice Web). Secretaria de Comércio Exterior, Brasília.

Callegari, J., Melo, T.M., Carvalho, C.E., 2018. The peculiar insertion of Brazil into global value chains. Rev. Dev. Econ. 22, 1321–1342. https://doi.org/10.1111/rode.12386

Castilho, M., Miranda, P., 2017. Tarifa aduaneira como instrumento de política industrial: A evolução da estrutura de proteção tarifária no Brasil no período 2004-2014, in: Messa, A., Oliveira, I.T.M. (Eds.), A Política Comercial Brasileira Em Análise. IPEA, Brasília, p. 380.

Daudin, G., Rifflart, C., Schweisguth, D., 2011. Who produces for whom in the world economy? Can. J. Econ. 44, 1403–1437. https://doi.org/10.1111/j.1540-5982.2011.01679.x

De Backer, K., De Lombaerde, P., Iapadre, L., 2018. Analyzing Global and Regional Value Chains. Int. Econ. 153, 3–10. https://doi.org/10.1016/j.inteco.2018.01.003

Dietzenbacher, E., Guilhoto, J., Imori, D., 2013. The role of Brazilian regions in the global value chain. TD Nereus 13-2013, Universidade de São Paulo.

Ferraz, L., Gutierre, L., Cabral, R., 2015. A indústria brasileira na era das cadeias globais de valor, in: Barbosa, N., Marconi, N., Pinheiro, M., Carvalho, L. (Eds.), Indústria e Desenvolvimento Produtivo No Brasil. Elsevier, Rio de Janeiro, pp. 645–677.

Ferreira, P.C., da Silva, L.F., 2015. Structural transformation and productivity in Latin America. B.E. J. Macroecon. 15, 903–932. https://doi.org/10.1515/bejm-2014-0020

Gandolfo, G., 2014. International Trade Theory and Policy, 2nd ed, Springer Texts in Business and Economics. Springer Berlin Heidelberg, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-37314-5

Gereffi, G., Humphrey, J., Sturgeon, T., 2005. The governance of global value chains. Rev. Int. Polit. Econ. 12, 78–104. https://doi.org/10.1080/09692290500049805

Grossman, G., Helpman, E., 2005. Outsourcing in a global economy. Rev. Econ. Stud. 72, 135–159. https://doi.org/10.1111/0034-6527.00327

Grossman, G.M., Rossi-Hansberg, E., 2008. Trading Tasks: A Simple Theory of Offshoring. Am. Econ. Rev. 98, 1978–1997. https://doi.org/10.2307/29730159

Guilhoto, J., Imori, D., 2014. Brazilian Role in the Global Value Chains. Working Paper Series 2014-24, Department of Economics, FEA-USP.

Gurgul, H., Lach, Ł., 2018. On using dynamic IO models with layers of techniques to measure value added in global value chains. Struct. Chang. Econ. Dyn. 47, 155–170. https://doi.org/10.1016/j.strueco.2018.07.004

Hummels, D., 2007. Transportation Costs and International Trade in the Second Era of Globalization. J. Econ. Perspect. 21, 131–154. https://doi.org/10.1257/jep.21.3.131

Hummels, D., Ishii, J., Yi, K.-M., 2001. The Nature and Growth of Vertical Specialization in World Trade. J. Int. Econ. 54, 75–96. https://doi.org/10.1016/S0022-1996(00)00093-3

IBGE, 2017. Sistema de Contas Nacionais - Brasil 2015. IBGE, Rio de Janeiro.

Jacinto, P. de A., Ribeiro, E.P., 2015. Crescimento da produtividade no setor de serviços e da indústria no brasil: dinâmica e heterogeneidade. Econ. Apl. 19, 401–427. https://doi.org/10.1590/1413-8050/ea119450

Johnson, R.A., Wichern, D.W., 2007. Applied Multivariate Statistical Analysis, 6th ed. Pearson Prentice Hall, New Jersey. https://doi.org/10.1198/tech.2005.s319

Johnson, R.C., Noguera, G., 2017. A Portrait of Trade in Value-Added over Four Decades. Rev. Econ. Stat. 99, 896–911. https://doi.org/10.1162/REST_a_00665

Johnson, R.C., Noguera, G., 2012a. Accounting for intermediates: Production sharing and trade in value added. J. Int. Econ. 86, 224–236. https://doi.org/10.1016/j.jinteco.2011.10.003

Johnson, R.C., Noguera, G., 2012b. Proximity and Production Fragmentation. Am. Econ. Rev. 102, 407–411. https://doi.org/10.1257/aer.102.3.407

Jones, R., 2000. Globalization and the theory of input trade. MIT Press, Cambridge, MA.

Koopman, R., Wang, Z., Wei, S.J., 2014. Tracing value-added and double counting in gross exports. Am. Econ. Rev. 104, 459–494. https://doi.org/10.1257/aer.104.2.459

Lejour, A., Rojas-Romagosa, H., Veenendaal, P., 2017. Identifying hubs and spokes in global supply chains using redirected trade in value added. Econ. Syst. Res. 29, 66–81. https://doi.org/10.1080/09535314.2017.1282436

Lenzen, M., Kanemoto, K., Moran, D., Geschke, A., 2012a. Mapping the structure of the world economy. Environ. Sci. Technol. 46, 8374–8381. https://doi.org/10.1021/es300171x

Lenzen, M., Moran, D., Kanemoto, K., Geschke, A., 2013a. Building Eora: a Global Multi-Region Input–Output Database at High Country and Sector Resolution. Econ. Syst. Res. 25, 20–49. https://doi.org/10.1080/09535314.2013.769938

Lenzen, M., Moura, M.C.P., Geschke, A., Kanemoto, K., Moran, D.D., 2012b. A Cycling Method for Constructing Input-Output Table Time Series from Incomplete Data. Econ. Syst. Res. 24, 413–432. https://doi.org/10.1080/09535314.2012.724013

Lenzen, M., Schaeffer, R., Karstensen, J., Peters, G.P., 2013b. Drivers of change in Brazil's carbon dioxide emissions. Clim. Change 121, 815–824. https://doi.org/10.1007/s10584-013-0930-1

Lindé, J., Pescatori, A., 2017. The Macroeconomic Effects of Trade Tariffs: Revisiting the Lerner Symmetry Result, IMF Working Paper N. 17/151. IMF Working Paper N. 17/151, Washington, D.C.

Los, B., Timmer, M.P., de Vries, G.J., 2016. Tracing value-added and double counting in gross exports: Comment. Am. Econ. Rev. 106, 1958–1966. https://doi.org/10.1257/aer.20140883

Los, B., Timmer, M.P., de Vries, G.J., 2015. How global are Global Value Chains? A New Approach to Measure International Fragmentation. J. Reg. Sci. 55, 66–92. https://doi.org/10.1111/jors.12121

Magacho, G.R., McCombie, J.S.L., Guilhoto, J.J.M., 2018. Impacts of trade liberalization on countries' sectoral structure of production and trade: A structural decomposition analysis. Struct. Chang. Econ. Dyn. 46, 70–77. https://doi.org/10.1016/j.strueco.2018.04.003

Messa, A., Oliveira, I.T.M., 2017. A política comercial brasileira em análise. IPEA, Brasília.

Miller, R.E., Blair, P.D., 2009. Input-output analysis: foundations and extensions. Cambridge University Press, Cambridge.

Owen, A., 2017. Techniques for Evaluating the Differences in Multiregional Input-Output Databases, Developments in Input-Output Analysis. Springer International Publishing, Cham.

https://doi.org/10.1007/978-3-319-51556-4

Owen, A., Wood, R., Barrett, J., Evans, A., 2016. Explaining value chain differences in MRIO databases through structural path decomposition. Econ. Syst. Res. 28, 243–272. https://doi.org/10.1080/09535314.2015.1135309

Peneder, M., Streicher, G., 2018. De-industrialization and comparative advantage in the global value chain. Econ. Syst. Res. 30, 85–104. https://doi.org/10.1080/09535314.2017.1320274

Rodrik, D., 2016. Premature deindustrialization. J. Econ. Growth. https://doi.org/10.1007/s10887-015-9122-3

Steen-Olsen, K., Owen, A., Barrett, J., Guan, D., Hertwich, E.G., Lenzen, M., Wiedmann, T., 2016. Accounting for value added embodied in trade and consumption: an intercomparison of global multiregional input–output databases. Econ. Syst. Res. 28, 78–94. https://doi.org/10.1080/09535314.2016.1141751

Sturgeon, T., Guinn, A., Zylberberg, E., 2014. A indústria brasileira e as cadeias globais de valor. Elsevier, Rio de Janeiro.

Taglioni, D., Winkler, D., 2016. Making Global Value Chains Work for Development. World Bank Group, Washington, D.C.

Thorstensen, V., Ferraz, L., 2014. O isolamento do Brasil em relação aos acordos e mega-acordos comerciais. Bol. Econ. e Política Int. - IPEA Jan/Abr, 5–17.

Timmer, M.P., Los, B., Stehrer, R., de Vries, G.J., 2013. Fragmentation, incomes and jobs: An analysis of european competitiveness. Econ. Policy 28, 613–661. https://doi.org/10.1111/1468-0327.12018

Veiga, P.M., Rios, S.P., 2017a. Inserção em Cadeias Globais de Valor e Políticas Públicas: o Caso do Brasil, in: Oliveira, I.T.M., Carneiro, F.L., Silva Filho, E.B. (Eds.), Cadeias Globais de Valor, Políticas Públicas e Desenvolvimento. IPEA, Brasília, pp. 399–434. https://doi.org/10.1017/CBO9781107415324.004

Veiga, P.M., Rios, S.P., 2017b. Cadeias Globais de Valor e Implicações para a Formulação de Políticas, in: Oliveira, I.T.M., Carneiro, F.L., Silva Filho, E.B. (Eds.), Cadeias Globais de Valor, Políticas Públicas e Desenvolvimento. IPEA, Brasília, pp. 17–48.

World Bank, 2018. Emprego e crescimento: a agenda da produtividade (Portuguese). World Bank Group, Washington, D.C.

World Bank, 2017. Measuring and Analyzing the Impact of GVCs on Economic Development, Global Value Chain Development Report. The World Bank, Washington DC.

Yamashita, N., 2010. International fragmentation of production: the impact of outsourcing on the Japanese economy. Edward Elgar Publishing, Cheltenham and Northampton, MA.

Yi, K.-M., 2003. Can Vertical Specialization Explain the Growth of World Trade? J. Polit. Econ. 111, 52–102. https://doi.org/10.1086/344805