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

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Abstract

The objective of this paper is to analyze the different forms of insertion in global value chains. We introduce a measure of upstream integration in production chains based on the value added that each country provides in the initial stages for the global production of final goods. Thus, the regional and global insertion patterns are analyzed through the geographic extension of the production stages. In this study, the focus of the analysis is the Brazilian economy. For this purpose, the value added is decomposed using an interregional 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 upstream and downstream 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 of production; Outsourcing; Global value chains; Input-output analysis.

Classification codes: F15; C67; D57.

1. Introduction

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).

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. 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).

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). Thus, to identify this pattern of specialization, an integration measure that distinguishes the upstream and downstream stages of production from the value–added trade is needed. However, most previous research, e.g., Johnson and Noguera (2012a), Los, Timmer and de Vries (2015) and Koopman, Wang and Wei (2014) measure foreign participation in local production or specify the foreign value added inserted in exports; however, in general, such research does not capture the size of each country's share of the overall output of final goods.

To do so, we introduce a measure of upstream integration in the production chains based in the value added that each country provides in the initial stages for the global production of final goods. This measure is derived from the interregional input–output model and extends the approach used in Johnson and Noguera (2012a) and Los, Timmer and de Vries (2015). This measure, although similar, is not equal to the one found in Koopman, Wang and Wei (2014), who measure the share of value added in each country's exports relative to total exports in global value chains. The main difference between the two approaches is that, while Koopman, Wang and Wei (2014) evaluate the contribution of a country at any stage of production, the measure proposed in this study analyzes the contribution of each country to the last stage of production in the value chains.

The advantage of identifying value chains from their final products is the possibility of incorporating the industry's average position along the global value chains into the international trade insertion measure. This is important because the industry’s average position will determine its international outsourcing standard (Antràs and Chor, 2013). In addition, countries specialize in distinct stages of global chains and thus specialize in activities with a different number of production stages (Baldwin and Venables, 2013). Thereby, this measure incorporates countries’ different specialization standards in the upstream or downstream stages of production chains, as presented in Miller and Temurshoev (2017). Moreover, the measure proposed in this study advances in relation to the previous approach by incorporating the contribution of Los, Timmer and de Vries (2015) to the decomposition of value added in regional and global trade blocs.

This paper, therefore, aims to analyze the different forms of insertion in global value chains. Thus, the regional and global insertion patterns in the value chains are analyzed through the geographic extension of the stages of production. In this study, the focus of the analysis is the Brazilian economy, since its pattern of insertion 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). However, imports and exports within the South American continent accounted for only 20.0% of Brazil's total foreign trade over the past two decades. However, 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, 2017a).

Besides the different modes of insertion in the regional and global blocs of trade, 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 to stimulate gains in competitiveness 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). 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 has made this insertion a tendency (Grossman and Helpman, 2005) and one of the factors that contribute to competitiveness in the world economy (Timmer et al., 2013).

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 (Veiga and Rios, 2017b). 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, 2017b).

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 (Veiga and Rios, 2017b).

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. Therefore, this study is situated in this context and aims to evaluate the pattern of insertion of Brazil into global value chains, and thus to help understand the changes in the country's productive structure. For this, the value added in Brazilian production is decomposed using the interregional input–output model for the period from 1990 to 2015.

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.

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. Thus, a concern of policymakers is the decrease in employment and income levels in specific activities. Thus, this study contributes to increase understanding about Brazil's insertion in the international fragmentation of production, which can be useful in the formulation of industrial policies. This analysis, therefore, 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 Brazilian insertion in value chains is driven mainly by the global fragmentation of production; however, regional insertion has increased more than global insertion.

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). This type of trade stems from differences in production costs and relative prices, which set the terms that determine the incentives for bilateral trade. 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 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 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.

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).[1] 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.

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). In this perspective, Baldwin and Lopez–Gonzalez (2015) suggest that vertical specialization in the 1990s was marked by regional trade blocs

[1] 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).

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.

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 interregional 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.[2] 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**.

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,

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

measured through interregional 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[3]:

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

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

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

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

The vector (*SN x* 1) $\mathbf{g}$ contains the value added generated in each of the country–industries that can be assigned to the global value chains of the final products $f_{ij}(s)$.[4] 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 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. Upstream 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 introduces a measure of 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 $\mathbf{g}$, defined in Eq. (4.2), from its replication for each country of completion of the final good $f_{ij}(s)$. The domestic value added is then subtracted from the vector **g** for each country of completion of the final good. 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:

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

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

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

3.2. Downstream insertion into global chains

In the downstream 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 $\mathrm{VA}_{(j)}(s)$. The vector **g** contains the corresponding levels $\mathrm{VA}_{(j)}(s)$ or each final good produced in Brazil $f_{ij}(s)$, such that:

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

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:

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

The term FVA_s measures the international fragmentation of production chains.[5] 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 share of foreign value added (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,

[5] 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.

assuming larger values as international fragmentation increases.[6] 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 share of foreign value added 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., 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.[7]

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:

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

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

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

[6] 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.

[7] 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.

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:

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

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

[8] Following the definition of Los, Timmer and Vries (2015), the term global added value 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.

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.

The data for the construction of the EORA MRIO database are from national statistical offices. For countries where an official input–output table is unavailable, this table is constructed by combining other macro−economic data for the countries with a template input–output structure based on an average of the tables for Australia, Japan, and United States (Lenzen et al. 2012a).[10] Bilateral trade data comes from the UN Comtrade Database and UN Service Trade Database. The EORA database uses a constrained optimization algorithm to find a solution that best meets the constraints for table estimation. The conflicting constraints for array estimation are addressed through a version of the RAS method called KRAS developed to deal with this issue (Lenzen et al., 2009). The EORA database is available in US dollars and 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 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 interregional 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 the insertion into global value chains in the face of different scenarios of changes in the commercial and industrial policies of Brazil.

[9] The EORA Multi–Region Input–Output Table (MRIO) provides data from the interregional 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.

5. Results

The measures of share of foreign value added (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 downstream 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 upstream 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 share of foreign value added in final products (Table A2 in the Appendix).[12]

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 as well, using data from the input–output tables of WIOD and OECD, respectively. 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 in FVAS for each year between 1995 and 2007, with FVAS only declining in 2008 because of the international financial crisis.

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, 2017b). The main instrument of this

[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. Table A1 in the Appendix presents the sectoral classification used in the study.

[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.

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.

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 existence of a communication and transport infrastructure is one of the determinants for the outsourcing of production in the global economy (Grossman and Helpman, 2005). Therefore, besides the barriers established through import tariffs, infrastructure problems in Brazil, related to transport across regions of the country and port inefficiency (Haddad et al., 2010), are other determinants for the Brazilian economy to be little inserted in global value chains.

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 upstream and downstream 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 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).

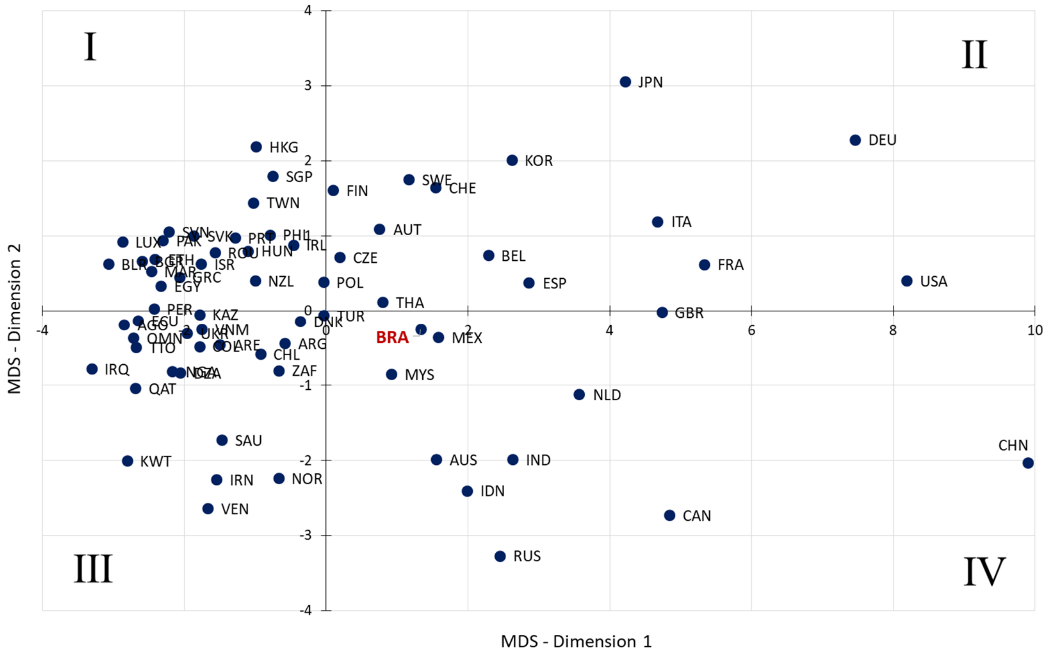
Table 2. Share of value added with origin in Brazil in relation to total foreign value added in value chains (%)

	All sectors		Agriculture, mining, manufacturing and tradable services	
	1990	2015	1990	2015
Sourcing,	0.96	1.37	0.98	1.38
of which				
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 Table A1 in the Appendix. 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.

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, 2017b). 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. Lindé and Pescatori (2017) have indicated that the protectionist trade policy on imports functions as an indirect tax on exporters, making them less competitive. Taglioni and Winkler (2016) have suggested that the reduction in import costs is critical for a country to become a dynamic exporter because a connection between imports and exports is required in the context of global value chains.



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 (Table A1 in the Appendix). 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.

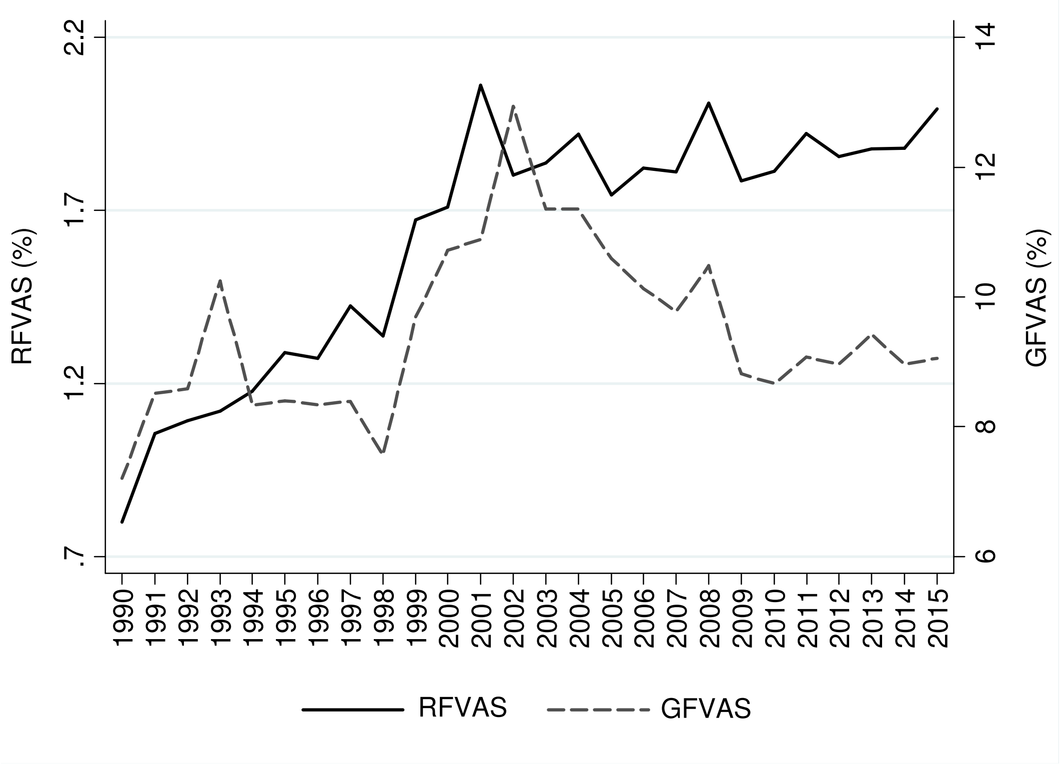
Figure 1. Value added in global production chains by country groups: year 2015.

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 (Table A3 in the Appendix). 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 downstream 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.



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.

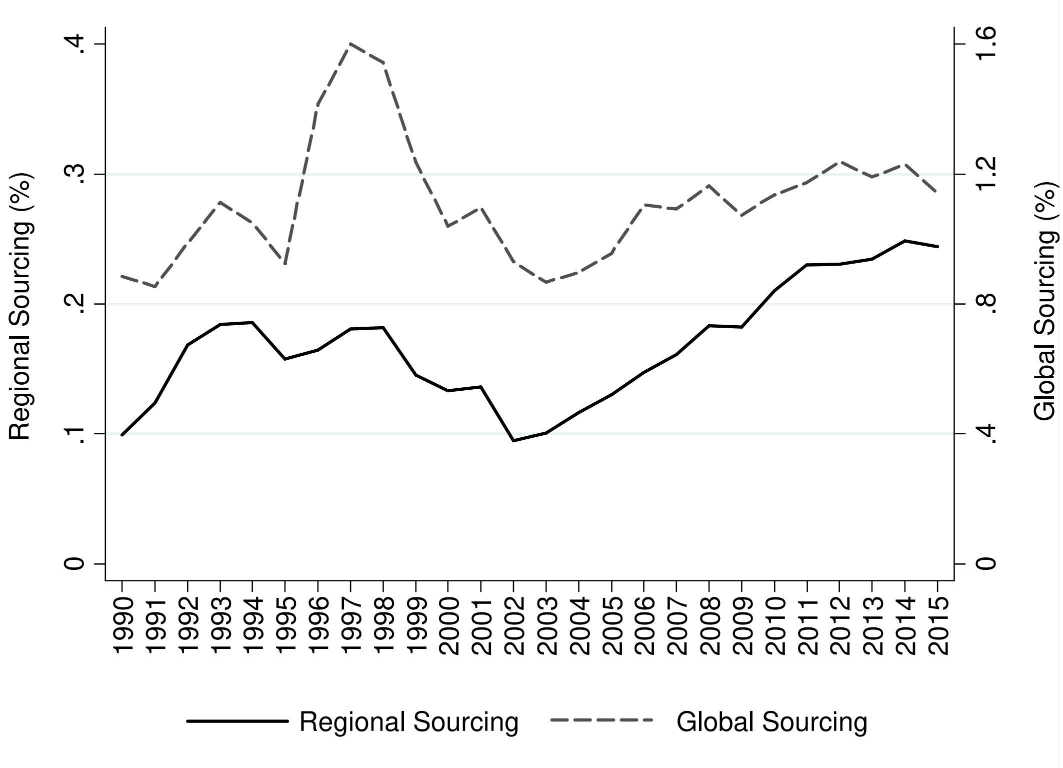
Figure 2. Regional and global fragmentation of the value added inserted in the Brazilian production

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, 2017b). 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, 2017b). Thus, the efforts made through Brazilian trade and industrial policies have been aimed at promoting national vertically–integrated industries producing all stages of production—in a trend that is contrary to the increasing participation in global value chains by the rest of the world economies (Sturgeon et al., 2014). This type of protection for the domestic industry is also incompatible with export–oriented specialization within value chains (Taglioni and Winkler, 2016). 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 upstream 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 upstream 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.



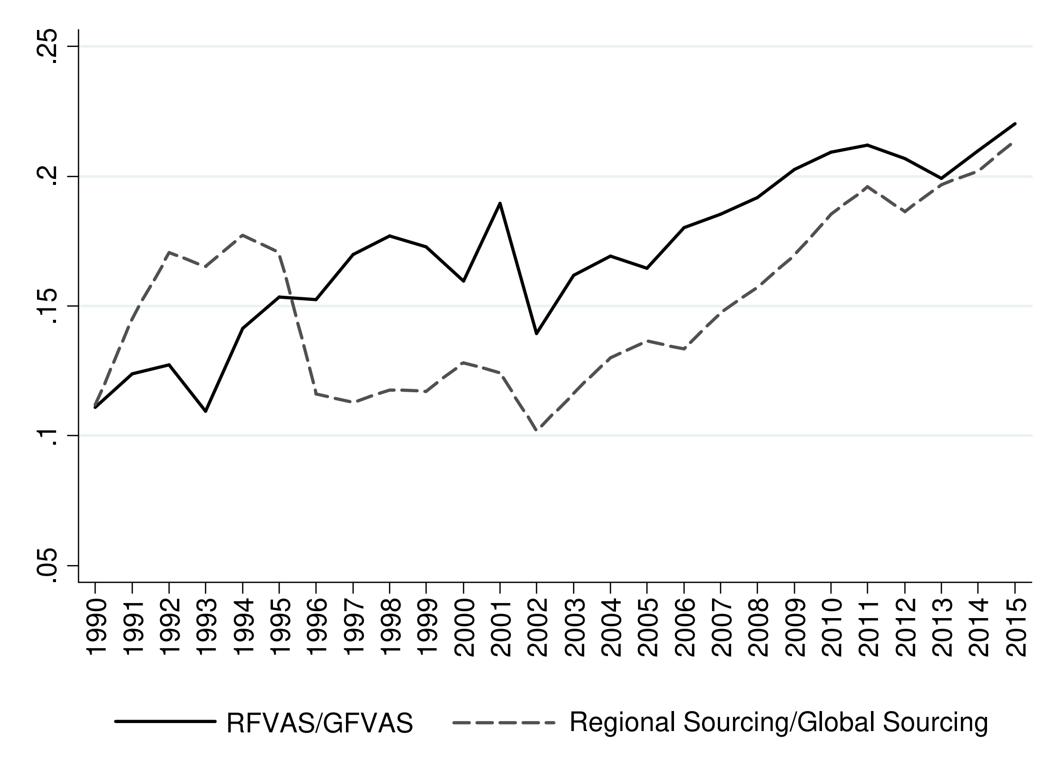
Note: Brazil's participation in the final products of all global production chains is presented to the agriculture, mining, manufacturing, and tradable sectors, as these sectors are more prone to international fragmentation of production.

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

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

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 data allow us to identify the change in the pattern of international fragmentation over time. The regional share of foreign value added present in Brazilian final goods and the upstream insertion of Brazil in the regional production chains 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.

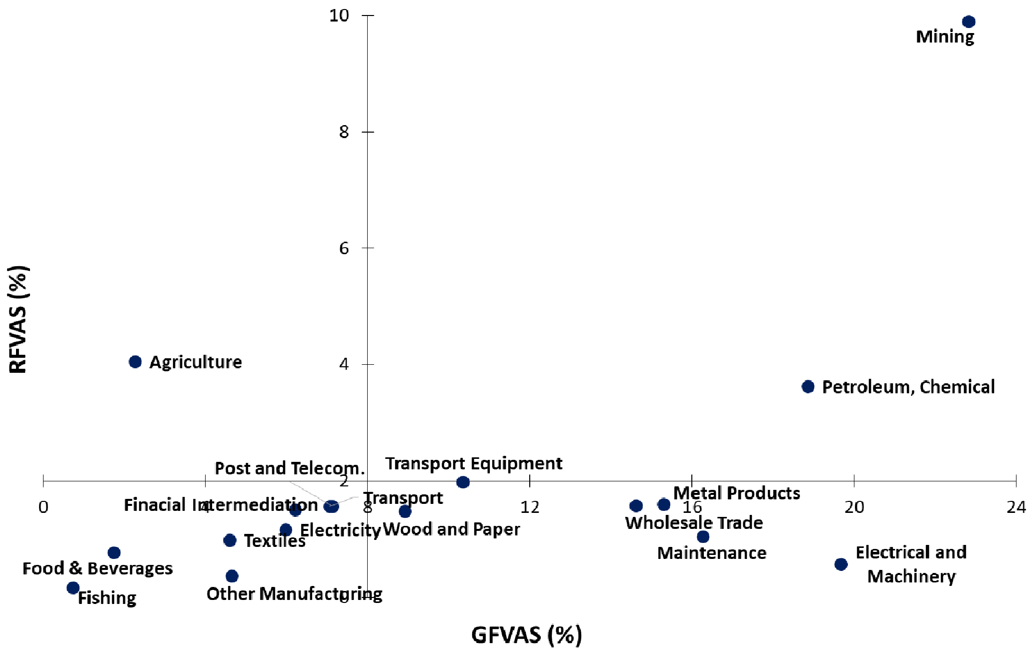
The rise in Brazil's regional integration may be the result of trade agreements within the regional bloc. The last significant trade agreements of Brazil were established with the countries of South America, with the creation of the Southern Common Market (Mercosur) in 1991 (agreement between Brazil, 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).



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

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

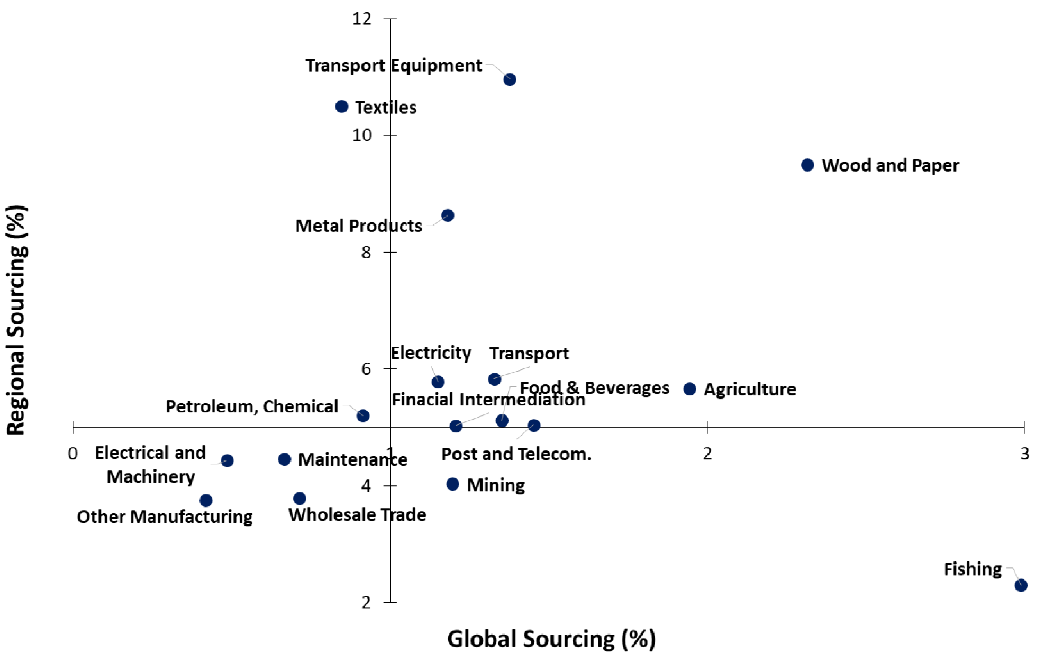
Brazil's regional insertion in value chains has intensified in the last decade. However, its standard of insertion at the industry level did not show significant changes. Thus, Figures 5 and 6 show the integration into value chains at the industry level for the year 2015. The industries of mining, petrochemical, metal products, electronics, and machinery are the industries that most use GFVAS, while natural resource–intensive goods such as agriculture and mining have higher RFVAS. Value–added exports to the rest of the world (Global Sourcing) are concentrated in agricultural products and the wood and paper industry. For South America, the supply of value added (Regional Sourcing) is concentrated in the industries of transport equipment, textiles, and metal products. Although Brazil is an important exporter of mineral products, this industry has less importance in value–added exports.



Note: The figure shows only the activity sectors of tradable goods. The complete classification of each industry shown in the Figure is presented in Table A1 in the Appendix.

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

Figure 5. Regional and global fragmentation of value added inserted in Brazilian production: industrial distribution (2015)



Note: The figure shows only the activity sectors of tradable goods. The complete classification of each industry shown in the Figure is presented in Table A1 in the Appendix.

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

Figure 6. Regional and global supply of value added produced in Brazil: industrial distribution (2015)

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 7a—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 7b 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 7 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 7 show that the insertion of Brazil into the value chains presents different standards when considering the upstream and downstream stages of the production chains.

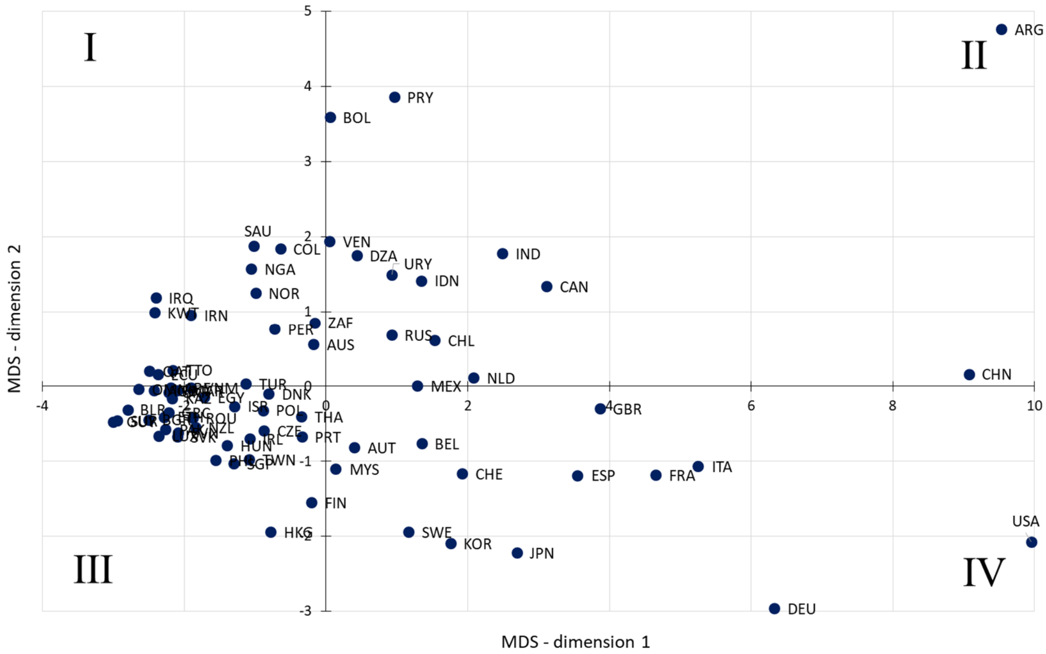


Fig. 7.a – Decomposition of foreign value added (FVAS) in Brazilian final products by country of origin

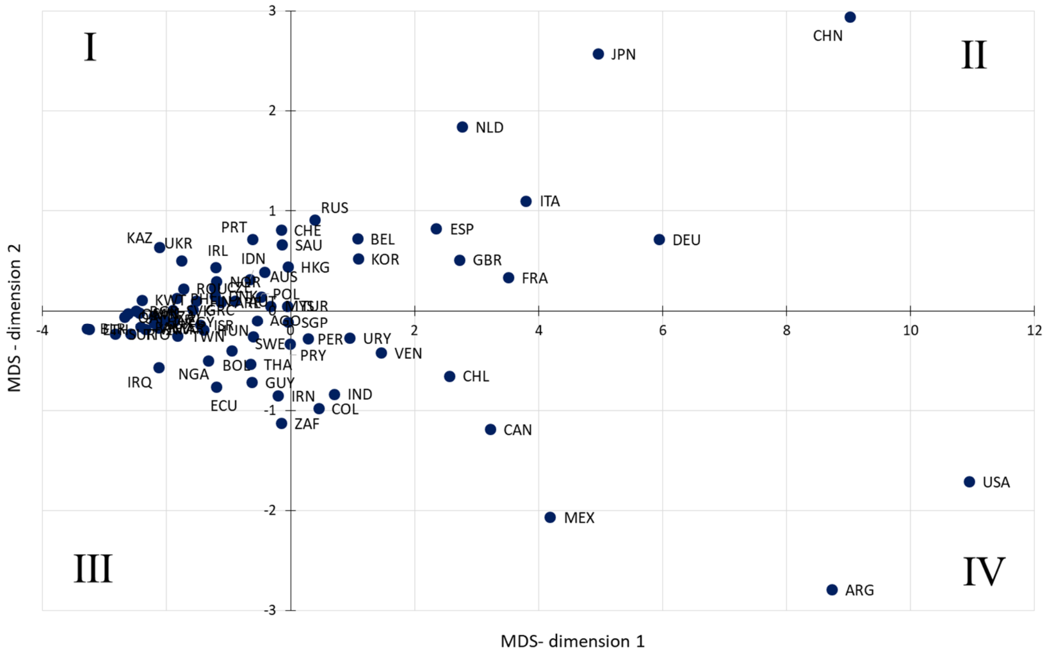


Fig. 7.b – Decomposition of value–added with origin in Brazil (Sourcing) by country of destination

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 (Table A1 in the Appendix). MDS configuration: method (modern MDS), loss criterion (stress), transformation (identity).

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

Figure 7. Insertion of Brazil in the downstream and upstream segments of global value chains: year 2015

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 upstream and downstream segments of value chains. We have introduced a measure of upstream integration in the production chains based on the value added that each country provides in the initial stages for the global production of final goods. This paper, therefore, had as objective to analyze the different forms of insertion in the global value chains. Thus, the regional and global patterns of this insertion are analyzed through the geographical extension of the production stages. 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.

The main results show that the insertion of countries into value chains occurs differently when considering their geographic scope and upstream and downstream production stages. We also find that the upstream and downstream 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.

Industrialization is an important issue in developing countries, such as Brazil, which has undergone rapid deindustrialization. Changes in the industrial structure of these countries can have consequences on their productivity and, consequently, on their long–term economic growth. In the context of growing international outsourcing of production, the formulation of industrial policies taking into account that the production processes are increasingly fragmented in different territories is fundamental. 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. It is worth noting that economic growth in developing countries over the past two decades, with the exception of Asian countries, has not been driven by the traditional industrialization mechanism. The growth of these countries was driven by capital flows, external transfers, or commodity booms, raising questions about their sustainability (Rodrik, 2016). In this way, traditional industrial policies must be rethought in a context of rising international outsourcing of production (Peneder and Streicher, 2018). Thus, mapping the different dimensions of value chains is an important step for countries to identify at which stages of production they have more comparative advantages of insertion into each regional production chain.

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Appendix

Table A1. Sectoral classification

Industry
Agriculture
Fishing
Mining and Quarrying
Food & Beverages
Textiles and Wearing Apparel
Wood and Paper
Petroleum, Chemical and Non–Metallic Mineral Products
Metal Products
Electrical and Machinery
Transport Equipment
Other Manufacturing
Recycling
Electricity, Gas and Water
Construction
Maintenance and Repair
Wholesale Trade
Retail Trade
Hotels and Restraurants
Transport
Post and Telecommunications
Finacial Intermediation and Business Activities
Public Administration
Education, Health and Other Services
Private Households
Others
Re–export & Re–import

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

Table A2. Ranking FVAS (2015)

Rank	País	(%)	Rank	País	(%)	Rank	País	(%)	Rank	País	(%)
1	Hong Kong	62.4746	48	Spain	24.6054	95	South Africa	18.2164	142	Senegal	12.4226
2	Singapore	55.8317	49	Iceland	24.3007	96	Gambia	17.5564	143	Burundi	12.3854
3	Luxembourg	48.0784	50	Bahamas	24.1387	97	Oman	17.2723	144	Mali	12.2423
4	Ireland	44.5272	51	Thailand	23.6202	98	UAE	16.7125	145	Cuba	12.1373
5	Tanzania	43.9097	52	Israel	23.2692	99	New Zealand	16.6532	146	Zambia	12.1141
6	Hungary	42.1964	53	Switzerland	23.2536	100	Malawi	16.4027	147	Syria	11.9514
7	Slovakia	41.7480	54	Namibia	23.2454	101	Bermuda	16.0992	148	USA	11.9321
8	San Marino	40.8655	55	Cyprus	23.0629	102	Mexico	16.0799	149	New Caledonia	11.6138
9	Viet Nam	39.7862	56	Cape Verde	22.9706	103	Costa Rica	15.9878	150	Venezuela	11.6100
10	Swaziland	39.1934	57	Fiji	22.8284	104	Madagascar	15.8174	151	Peru	11.4997
11	Estonia	38.3935	58	Croatia	22.3932	105	Bolivia	15.7029	152	Gabon	11.4744
12	Malaysia	38.1140	59	Poland	22.3794	106	Serbia	15.5769	153	Yemen	11.2273
13	Belgium	38.0820	60	Tajikistan	21.9751	107	Bosnia and Herzegovi	15.5706	154	Haiti	11.1290
14	Lithuania	36.0448	61	Romania	21.9642	108	Cayman Islands	15.2909	155	Algeria	11.1225
15	Lesotho	35.8693	62	Norway	21.9466	109	Nepal	14.9618	156	Colombia	11.1002
16	Guyana	35.6643	63	Germany	21.8944	110	Rwanda	14.8044	157	Brazil	11.0432
17	Belarus	35.2303	64	Vanuatu	21.8567	111	Guinea	14.7703	158	Indonesia	10.8760
18	Czech Republic	34.0214	65	Albania	21.8174	112	Sierra Leone	14.6916	159	India	10.7146
19	Slovenia	33.9289	66	Georgia	21.7822	113	Uruguay	14.5868	160	Russia	10.0894
20	Aruba	33.7258	67	Bulgaria	21.7527	114	Philippines	14.4571	161	Sri Lanka	9.9839
21	Netherlands	32.9623	68	Taiwan	21.6339	115	Saudi Arabia	14.2925	162	Cameroon	9.7763
22	Malta	32.9248	69	Tunisia	21.6080	116	Central African Repub	14.1022	163	Afghanistan	9.5831
23	Mauritius	32.3819	70	Jamaica	21.4119	117	Burkina Faso	14.0994	164	Ghana	9.5242
24	South Korea	31.2372	71	El Salvador	21.3357	118	Iran	13.9347	165	Mozambique	9.2337
25	Kyrgyzstan	30.4968	72	Lebanon	21.0326	119	Congo	13.8252	166	Kuwait	8.6262
26	TFYR Macedonia	30.3707	73	Italy	21.0249	120	Armenia	13.7845	167	Laos	8.5702
27	Greenland	30.2611	74	Honduras	20.9108	121	Uganda	13.6779	168	Bangladesh	8.1029
28	Austria	29.4678	75	Mauritania	20.4582	122	Paraguay	13.6156	169	Azerbaijan	8.0946
29	Netherlands Antilles	28.6986	76	Chile	20.4445	123	Australia	13.5600	170	Cote dIvoire	8.0756
30	Ukraine	28.4747	77	French Polynesia	20.0236	124	Kazakhstan	13.4868	171	Angola	7.5910
31	Sweden	28.4685	78	Jordan	20.0194	125	DR Congo	13.4160	172	Moldova	7.5204
32	Denmark	27.7024	79	Togo	19.7880	126	Liberia	13.4087	173	Egypt	7.4569
33	Montenegro	27.5477	80	Cambodia	19.6142	127	Libya	13.2897	174	Eritrea	7.4156
34	Antigua	27.5445	81	France	19.5850	128	Japan	13.2698	175	Somalia	7.2876
35	Latvia	27.3713	82	Turkey	19.5761	129	Ecuador	13.2312	176	North Korea	7.1714
36	British Virgin Islands	27.3319	83	Panama	19.2137	130	Benin	13.2293	177	Nigeria	6.9859
37	Bhutan	27.3211	84	Macao SAR	19.2095	131	Argentina	13.1738	178	Uzbekistan	6.9109
38	Seychelles	26.7272	85	Gaza Strip	19.1807	132	Guatemala	13.1506	179	Ethiopia	5.7589
39	Portugal	26.4452	86	UK	19.1274	133	Bahrain	13.1007	180	Iraq	5.6442
40	Belize	26.1862	87	Andorra	19.1011	134	Brunei	13.0846	181	Pakistan	5.4262
41	Sao Tome and Princip	25.8766	88	Mongolia	18.8251	135	Papua New Guinea	13.0833	182	Chad	5.4039
42	Maldives	25.8091	89	Nicaragua	18.7920	136	Niger	13.0272	183	Qatar	5.0449
43	Finland	25.7269	90	Suriname	18.7626	137	Morocco	12.9145	184	Monaco	3.7818
44	Barbados	25.6485	91	Samoa	18.5374	138	Zimbabwe	12.8412	185	Liechtenstein	3.4515
45	Greece	25.6358	92	Canada	18.5238	139	Dominican Republic	12.8355	186	Myanmar	1.7025
46	Turkmenistan	25.5970	93	Kenya	18.3055	140	Trinidad and Tobago	12.7109	187	South Sudan	1.5761
47	Botswana	25.0902	94	Djibouti	18.2729	141	China	12.6289	188	Sudan	0.6425

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

Table A3. Ranking Sourcing (2015)

Rank	País	(%)	Rank	País	(%)	Rank	País	(%)	Rank	País	(%)
1	China	10.3876	48	New Zealand	0.3568	95	Uruguay	0.0341	142	Liberia	0.0052
2	USA	9.7998	49	Kazakhstan	0.3548	96	Ghana	0.0338	143	Albania	0.0051
3	Germany	8.0137	50	Qatar	0.3400	97	Dominican Republic	0.0333	144	South Sudan	0.0051
4	Japan	5.3626	51	Portugal	0.3337	98	Papua New Guinea	0.0328	145	Uganda	0.0047
5	UK	4.2547	52	Viet Nam	0.2734	99	Congo	0.0324	146	Greenland	0.0047
6	France	4.1223	53	Colombia	0.2624	100	Panama	0.0279	147	Guyana	0.0045
7	Italy	3.5616	54	Romania	0.2567	101	Turkmenistan	0.0277	148	Fiji	0.0044
8	Canada	3.3525	55	Angola	0.2471	102	Zambia	0.0273	149	Botswana	0.0043
9	South Korea	3.0705	56	Slovakia	0.2152	103	Georgia	0.0272	150	Aruba	0.0043
10	Russia	3.0165	57	Belarus	0.2126	104	Moldova	0.0272	151	Haiti	0.0043
11	Netherlands	2.5280	58	Trinidad and Tobago	0.2102	105	Gabon	0.0249	152	Tanzania	0.0042
12	Spain	1.9847	59	Iraq	0.1975	106	Cameroon	0.0243	153	Bahamas	0.0041
13	Belgium	1.9738	60	Ethiopia	0.1974	107	Iceland	0.0234	154	Togo	0.0039
14	Switzerland	1.9338	61	Oman	0.1911	108	North Korea	0.0225	155	Mali	0.0036
15	Australia	1.9137	62	Greece	0.1682	109	Cuba	0.0218	156	Barbados	0.0035
16	India	1.8829	63	Pakistan	0.1568	110	TFYR Macedonia	0.0203	157	Niger	0.0034
17	Indonesia	1.8317	64	Slovenia	0.1522	111	DR Congo	0.0202	158	Swaziland	0.0033
18	Mexico	1.5109	65	Peru	0.1478	112	Sudan	0.0201	159	Liechtenstein	0.0032
19	Malaysia	1.5085	66	Egypt	0.1463	113	Malta	0.0191	160	Maldives	0.0032
20	Brazil	1.3728	67	Luxembourg	0.1422	114	Mongolia	0.0181	161	Burkina Faso	0.0030
21	Sweden	1.2673	68	Ecuador	0.1373	115	Lebanon	0.0177	162	Bhutan	0.0029
22	Venezuela	1.0861	69	Bulgaria	0.1208	116	Serbia	0.0173	163	French Polynesia	0.0026
23	Austria	1.0834	70	Morocco	0.1205	117	Kyrgyzstan	0.0153	164	Belize	0.0026
24	Thailand	1.0695	71	Libya	0.1105	118	Mauritius	0.0143	165	Benin	0.0025
25	Norway	1.0402	72	Bolivia	0.0801	119	Nepal	0.0138	166	Gaza Strip	0.0024
26	Singapore	0.9733	73	Syria	0.0789	120	Bosnia and Herzegovi	0.0136	167	Montenegro	0.0022
27	Saudi Arabia	0.9331	74	Zimbabwe	0.0785	121	Senegal	0.0128	168	Seychelles	0.0021
28	Iran	0.8464	75	Lithuania	0.0761	122	Netherlands Antilles	0.0128	169	Eritrea	0.0020
29	Czech Republic	0.7926	76	Estonia	0.0630	123	Laos	0.0127	170	Sierra Leone	0.0020
30	Taiwan	0.7558	77	Sri Lanka	0.0610	124	Honduras	0.0126	171	Andorra	0.0019
31	South Africa	0.7488	78	Bangladesh	0.0596	125	New Caledonia	0.0115	172	Cayman Islands	0.0019
32	Finland	0.7316	79	Azerbaijan	0.0595	126	El Salvador	0.0112	173	San Marino	0.0019
33	Poland	0.7292	80	Croatia	0.0583	127	Madagascar	0.0107	174	Monaco	0.0018
34	Hong Kong	0.7211	81	Latvia	0.0566	128	Cyprus	0.0105	175	Rwanda	0.0017
35	Denmark	0.6834	82	Brunei	0.0563	129	Cambodia	0.0099	176	Bermuda	0.0017
36	Philippines	0.6752	83	Tunisia	0.0550	130	Mauritania	0.0096	177	British Virgin Islands	0.0017
37	Ireland	0.6200	84	Costa Rica	0.0524	131	Guinea	0.0091	178	Burundi	0.0015
38	Kuwait	0.5516	85	Uzbekistan	0.0494	132	Namibia	0.0088	179	Vanuatu	0.0014
39	UAE	0.5394	86	Myanmar	0.0470	133	Jamaica	0.0087	180	Lesotho	0.0014
40	Argentina	0.5127	87	Macao SAR	0.0464	134	Armenia	0.0086	181	Central African Repub	0.0014
41	Turkey	0.5092	88	Yemen	0.0432	135	Tajikistan	0.0077	182	Cape Verde	0.0013
42	Chile	0.5062	89	Cote dIvoire	0.0428	136	Nicaragua	0.0074	183	Samoa	0.0013
43	Algeria	0.4953	90	Paraguay	0.0419	137	Suriname	0.0070	184	Antigua	0.0012
44	Hungary	0.3879	91	Bahrain	0.0417	138	Chad	0.0066	185	Djibouti	0.0012
45	Israel	0.3872	92	Kenya	0.0374	139	Malawi	0.0061	186	Sao Tome and Princip	0.0010
46	Nigeria	0.3685	93	Guatemala	0.0365	140	Afghanistan	0.0056	187	Gambia	0.0007
47	Ukraine	0.3590	94	Jordan	0.0357	141	Mozambique	0.0055	188	Somalia	0.0004

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