Analysis of the domestic value added of Brazilian exports, using Inter-Country Input–Output (ICIO) and Trade in Value Added (TiVA) for the year 2022

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Abstract

This article analyzes the structure of domestic value added incorporated into Brazilian exports using the Trade in Value Added (TiVA) methodology. Using the OECD's Inter-Country Input–Output (ICIO) database for the year 2022, the study estimates the domestic value added generated directly and indirectly by Brazil's exports, as well as its sectoral distribution. The results indicate that the service sectors account for the largest share of exported domestic value added, reflecting their growing integration into global value chains, while industry is heavily dependent on domestic production chains. The breakdown between direct and indirect components highlights the importance of intersectoral linkages for the generation of value associated with Brazilian exports. The findings contribute to the understanding of Brazil's structural role in global value chains and provide input for the debate on industrial and trade policy.

Keywords: Trade in Value Added, Input-Output, Global Value Chains.

JEL Code: F14, F15, F62, R15

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1 Introduction

World production is traded between several countries, since the process that began around 1980, which is called Globalization. It is worth noting that with the advent of increased trade flows between countries, it was required that measurements be consistent with the data that make up exports and imports according to (ZHANG; SCHIMANSKI, 2014).

The globalization process that began in the mid 1980s drove the opening up of trade in Brazil and other economies around the world. It is worth noting that between the 1960s and 1970s, the Brazilian economy experienced a significant leap in industrialization, promoted by the Import Substitution Process. However, by the 1980s, this model had run its course, preventing the country from weathering the period of stagflation and was forced to present its financial and institutional difficulties in the international arena, thus submitting to the influence of the Washington Treaty for trade liberalization in the 1990s, given the high levels of inflation in the country during that period, which caused problems in labor relations at the time, as described in (HILGEMBERG; GUILHOTO, 2004).

The growing integration of (GVCs) has highlighted the need to measure not only the gross value of trade, but also the effective contribution of each country and sector to the generation of international value added, minimizing the problem of double counting. In this context, Trade in Value Added (TiVA) indicators offer a more refined perspective on the role of national economies in international GVC production networks, which aims to highlight the domestic and foreign content incorporated in exports and imports.

This article analyzes the structure of domestic value added incorporated into Brazilian exports using the TiVA methodology. Using the OECD's Inter-Country Input–Output (ICIO) database for the year 2022, the study estimates the domestic value added generated directly and indirectly by Brazilian exports, as well as its sectoral distribution using an input-output matrix based on the objective of quantifying the value added in Brazilian exports, identifying the participation of the sectors that make up the Brazilian economy with greater international integration, which generate economic multiplier effects to according (MILLER; BLAIR, 2009; OECD, 2022).

With the opening up of trade, vertical specialization has intensified, and Brazil can increase its levels of imports and exports, according to Gonçalves Junior et al. (2024). It is important to highlight that Brazilian exports are based on agricultural exports, which account for the largest volume of exports. *commodities* (soybeans, corn, cotton, coffee, orange juice, etc.).

The methodology involves TiVA using data from the OECD's ICIO input-output matrix, which serves as a component in the construction of one of the main TiVA indicators, EXGR_DVA, which is used in other subsequent calculations, suitable for capturing the complexity of interdependencies between sectors and countries. In OECD studies and technical notes, for example, indicators related to value added content and production linkages in various countries, including Brazil, are disclosed to according (OECD, 2022)

The results obtained by sector and for the period 2022 seek to contribute to the understanding of how the Brazilian economy is inserted in CGVs and which sectors present greater weaknesses or potential gains. This diagnosis can guide policies on innovation, logistics, foreign trade, and sustainability, emphasizing that strategic decisions should consider not only the amount of exports but also their composition in terms of added value and imported inputs.

This article is structured in five sections. The first section is the introduction, which presents the relevance of the topic, the motivation for the study, and its objectives. The second section is devoted to a review of the literature, offering an overview of the development of (GVCs) in the context of globalization. The third section describes the methodological procedures used.

The fourth section is devoted to the presentation and discussion of the results. Finally, the fifth section presents the final considerations of the study.

2 Literature Review

2.1 Global value chain and measurement of value added

Before presenting what is known as GVA, there is an important process called vertical integration or vertical specialization, which involves companies specializing in the production of a finished product Hummels, Ishii e Yi (2001), and consists of the process of exporting or importing intermediate goods to be used in the process of generating added value for a given product. This procedure is advocated by the authors, as they analyzed the structure of horizontal verticalization; similarly, Curzel (2015), Backer e Miroudot (2013) note that, as the production process advances, companies face operational difficulties, such as labor costs that increase the cost of the value added generation process for companies, resulting in higher costs to add value to the products of the national economy.

The GVCs are a prominent topic in discussions of international trade, as they relate to how companies engage in the internationalization of production, with an emphasis on the specific process of manufacturing or assembling their products Hummels, Ishii e Yi (2001), which is distributed among different companies worldwide with the aim of minimizing the operational costs of the process for primary or semi-finished products Zhang e Schimanski (2014), it is necessary to assess a recurring problem that generates distorting effects: the double-counting problem.

Hummels, Ishii e Yi (2001), in analyzing the causes of vertical specialization in production, highlights the specialization of economies around the world, referring to the classical theory of international trade based on the comparative advantages of each country. Johnson e Noguera (2012), for example, highlights a practical application of how economies such as that of the United States, which is capital intensive, export products to China, which is a labor intensive economy that is, a country that plays a key role in the product assembly process while Japan is the country responsible for producing the electronic components used in the manufacturing process of the product initially designed by the United States.

The process described by Johnson e Noguera (2012) using the example above—involving the economies of the United States, China, and Japan illustrates the trade flows that commonly occur on a daily basis between countries. From this perspective, when evaluating international trade, we encountered a process of overvaluation that is, the problem of double counting in an economy like China's, which participated in the final stage of production (assembly) and subsequently exported the finished product. However, the value had already been accounted for, embedded in earlier stages in other countries throughout the production chain, and upon arriving in China with an even higher value, gross export and import transactions were measured in duplicate to assess these discrepancies.

Johnson e Noguera (2012) offer a perspective that shifts the approach to measuring international trade in terms of value added, in contrast to the traditional statistical approach based on gross exports, which can lead to double-counting of intermediate inputs in (GVCs). To this end, the authors use the VAX ratio, which measures the share of a country's exports corresponding to domestic value added. By applying this methodology to bilateral trade between the United States and China, the authors show that measuring trade in terms of value added reduces the bilateral trade deficit by between 30% and 40% compared to statistics based on gross exports.

Regarding the importance of countries' adherence to GVCs, according to Filho et al. (2023), member countries of economic blocs, such as those in the BRICS, tend to contribute to economic growth and development, as they benefit from trade gains within the production chain. Within the bloc, Brazil and Russia stand out for their focus on low value added components, that is, technologies classified as low to medium level, while China and India stand out in terms of high technological value added.

An important point raised by Nonnenberg (2014) is that countries classified as poor on the international stage whose productive base is characterized by primary products exhibit a strong dependence on imported factors of production; yet, despite this degree of dependence, this does not yet constitute their effective integration into global value chains. Furthermore, emerging or underdeveloped countries, such as Brazil and most Latin American nations, have been the least developed in terms of technological integration over the past 20 years. An interesting example is China and some countries in East/Southeast Asia, which have achieved higher levels of value added in international products. According to Meng et al. (2019), this is because China possesses comparative advantages in the export of labor, given the high number of workers employed in the final product assembly sector.

2.2 Fragmentation of production and vertical specialization

The authors Hummels, Ishii e Yi (2001) describe the fundamental concepts of vertical specialization in production across countries. In addition, the authors present a conceptual overview of international trade, taking into account the changes brought about by the interconnection of production processes. The authors use an organizational chart to demonstrate how the value added process occurs among three countries, for example, in Country A with the production of intermediate goods, followed by Country B, which imports these goods, which can be used to produce new products, from the goods imported from Country A, adding value and transforming them into final goods, which can then be absorbed by domestic demand in Country B or exported to Country C.

Backer e Miroudot (2013) point out that one of the key factors contributing to the geographic fragmentation of production is related to a country's technological progress, which is reflected in labor quality and costs, operational costs, transaction costs, tax costs, and transportation costs for shipping products to other countries, as well as the availability of and access to natural resources. Still regarding comparative advantages associated with labor Meng et al. (2019), it is emphasized that for economies to achieve trade gains, given their comparative advantages such as China, with its large workforce employed in the assembly of imported products they add labor value to the production of key products in the economic base of other countries.

It is important to note that firms tend to fragment production internationally; when they find comparative advantages in other countries, this makes their firms more competitive (HUMMELS; ISHII; YI, 2001). Integration into GVCs, according to Nonnenberg (2014), may initially occur as a commercial strategy adopted by firms in a given national economy that, in light of the vertical integration of production for a specific *mix* of products, prefer to outsource the production process to other countries where labor is available, and with the technical skills required to meet the companies' objectives, as they are considered low cost for the companies, which allows for adding value to the product. Furthermore, according to Backer e Miroudot (2013), more than 50% of imported products are intermediate goods (raw materials, parts, and components), as well as semi-finished products.

To demonstrate that the fragmentation of international production drives progress in trade relations, Los, Timmer e Vries (2015) analyzed GVCs from a new perspective, using a global input-output matrix (WIOTs) covering 40 countries and 16 sectors for the period from

1995 to 2011. The results indicate that the values of supply chains tend to increase in the international environment through the fragmentation of production. Furthermore, they provided evidence that the values of foreign value added (FVA) were higher in 2011 than in 1995.

2.3 Integration into GVCs and its effects

Companies' production can gain a foothold in the CGV through the type of governance they practice, with the aim of promoting greater integration into the CGV among other countries or economic blocs as they become more efficient in managing their production. Furthermore, as companies have a well structured governance management program between buyers and sellers, this relationship can be beneficial for all parties involved throughout the process. The authors highlight the importance of geographical proximity for the existence of commercial relationships and the specialization of certain products that rely on the use of labor intensive factors. For with the integration of companies, GVCs can expand production, adding value to the intermediate product through improvements in the production process and the product itself, and influencing changes in the function of the chain and the sector along the GVC, as per (HUMPHREY; SCHMITZ, 2002).

With the advent of CGVs, global economies have experienced numerous positive implications, driven by the opening of international trade fostered by globalization, international investment, and industrial development, as exemplified by China over the past 30 years. (BACKER; MIROUDOT, 2013). One can also highlight the competitive advantages identified by the authors Los, Timmer e Vries (2015) regarding the opening of China's economy and other countries with extremely low labor costs, which tend to perpetuate global fragmentation; furthermore, one of the positive factors contributing to an increase in (VAE) favors bilateral agreements over multilateral ones.

This initial action can trigger other effects, such as higher product prices, creating more job opportunities, which in turn raises income levels in both countries, first through value addition, and later through the export of finished products to other countries with demand. Depending on the importing country, the nation may choose to use the product for domestic consumption or as an input, an intermediate product, which can further generate value in its own domestic products by being used as a component, or even add value and re-export them, generating even higher income levels in the production process (NONNENBERG, 2014; HUMMELS; ISHII; YI, 2001).

According to Nonnenberg (2014), the increase in income resulting from the strategic integration of firms into technology intensive GVCs with a high quality labor force can drive both economic growth and economic development, given the rise in income across economies. It can be a challenge for firms and their respective economies to find or even specialize in serving or entering technology intensive GVCs, because as countries gain access to technology intensive economies, developing countries tend to increase economic transactions through increased exports.

Backer e Miroudot (2013) shows that GVCs are not limited to Asia. Although OECD and European countries are more heavily represented, other countries also participate in GVCs, taking into account the sizes of different economies around the world. In the case of Brazil, the work conducted by Dietzenbacher, Guilhoto e Imori (2012) on the role of fragmentation in the production of goods and services indicates that this is not limited to countries, but there is also a growing relationship between the fragmentation of states and regions within certain countries, which contributes to the CVGs of economies.

The authors Meng et al. (2019) bring an interesting perspective to the discussion of CGV. They address the following question: is CGV a global or regional process? Based on the authors referenced in the article by Meng et al. (2019), the table 1 was developed, which presents the main ideas associated with the conceptual evolution of GVCs.

Table 1: Key authors and ideas associated with the conceptual evolution of Global Value Chains

Author / Year	**Theme / Main Idea**
Baldwin (2012)	Considers Global Value Chains (GVCs) to be one of the most important developments of the 21st century for international trade.
Jones & Kierzkowski (1990)	They introduce the concept of *production fragmentation*, highlighting the international division of production processes.
Arndt (1997)	Emphasizes international outsourcing (offshore sourcing) as a fundamental part of the global reorganization of production.
Campa & Goldberg (1997)	They address the external orientation of companies and their integration into international production chains.
Feenstra (1998)	Discusses the disintegration of production, analyzing the growing geographical separation of the stages of production
Yeats (2001)	Introduces the term "global production sharing," highlighting the sharing of production between different countries.
Hummels et al. (2001); Yi (2003)	They analyze *production specialization*, in which countries focus on specific stages of the value chain.
Grossman & Helpman (2002a, 2002b)	They develop models on outsourcing and the role of multinational firms in the global division of production.
Hanson et al. (2003)	Discuss vertical production networks, emphasizing the chain of processes between countries.
Grossman & Rossi-Hansberg (2008)	They introduce the concept of "trade in tasks," describing international trade as an exchange of productive tasks.
Krugman (1995)	Analyzes *multi-stage production*, in which each location adds little value at each stage of the process.
WTO-IDE (2011)	It states that the production of goods and services is carried out on a global scale, resulting from the global integration of production processes.

Source: Own elaboration based on Melg et al. (2019)

3 Methodology

The study of GVCs is important for understanding how to obtain the real contribution of Value Added (VA) generated by exports per sector for each country/region. In this study, Brazil is considered as a domestic economy. Using the Input-Output analysis methodology, in particular inter-regional and inter-country models, it forms the analytical basis for Trade in Value Added (TiVA) indicators. It is possible to disaggregate the gross value of Brazilian exports, making it possible to identify each country's sectoral contribution to exports, so that the effects of double counting, which is a recurring problem in the System of National Accounts (SNA), can be identified. Double counting occurs when the values of intermediate goods are measured in the gross domestic product according to (MILLER; BLAIR, 2009), (GONÇALVES JUNIOR et al., 2024).

3.1 Inter-Country Input–Output Framework (ICIO)

The interregional Input-Output (IRIO) model provides the theorical foundations for multi-regional and inter-country input-output systems. In this study, this framework underpins the inter-country input-output structure of the OECD ICIO database models are built as folow according to (MILLER; BLAIR, 2009; OECD, 2022).

3.2 Basic Structure

Consider a multi-country input–output system composed of multiple economies c, p, q, where each economy has n industries. The inter-country transactions matrix is partitioned as:

$$Z = \begin{bmatrix} Z^{cc} & Z^{cp} & Z^{cq} \\ Z^{pc} & Z^{pp} & Z^{pq} \\ Z^{qc} & Z^{qp} & Z^{qq} \end{bmatrix}$$

$$x = \begin{bmatrix} x^{c} \\ x^{p} \\ x^{q} \end{bmatrix}$$

The technical coefficients matrix is:

$$A = \begin{bmatrix} A^{cc} & A^{cp} & A^{cq} \\ A^{pc} & A^{pp} & A^{pq} \\ A^{qc} & A^{qp} & A^{qq} \end{bmatrix}$$

where $A_{ij}^{uv} = \frac{Z_{ij}^{uv}}{x_j^v}$, and in matrix form $A = Z\hat{x}^{-1}$.

In the empirical application of this study, each economy corresponds to a country, and the Brazilian economy is treated as a single domestic unit.

3.3 Global Leontief System

The global input–output system underlying the ICIO framework is defined by the Leontief Inverse matrix, which captures both direct and indirect requirements across all countries and sectors. It is written as:

$$B = (I - A)^{-1} = \begin{bmatrix} B^{cc} & B^{cp} & B^{cq} \\ B^{pc} & B^{pp} & B^{pq} \\ B^{qc} & B^{qp} & B^{qq} \end{bmatrix}$$

Where B^{cc} represents the blocks of domestic requirements for country c, and the off-diagonal blocks B^{cp} represent the requirements of country c for inputs from country p.

3.4 Trade in value added - *TiVA*

According to OECD (2022), goods and services are purchased and consumed every year by countless people around the world, and the components of added value in the Global Value Chain are not precisely known, which in turn creates the problem of double counting. This process occurs when a company outsources part of its production to other countries where production costs are more advantageous. It should be noted that when sending a semi-finished product or a raw product, these products can be added value and consumed abroad, or they can be re-exported to their countries of origin, generating double counting in the National Accounts System of the economy.

TiVA was developed by the OECD and, comprising a set of estimates based on foreign trade data from selected countries and a global input-output matrix Nonnenberg (2014), Backer e Miroudot (2013). This led to the methodology developed by the Organisation for Economic Co-operation and Development (OECD), which can be used based on the country's Input-Output Matrix. It considers the value added to the product throughout the production process by each country, which is an important index for correcting the effect of double counting of goods and services in countries(OECD, 2022).

The data basically consists of the breakdown of export values, which comprise four categories: (i) direct domestic value added, (ii) indirect domestic value added, (iii) reimported domestic value added, and (iv) external domestic value added. The sum of (i), (ii), and (iii) corresponds to domestic value added.

It is worth noting that the purpose of the TiVA database is to expand how CGVs work and how trade and investment flows relate. It should be noted that the creation of the database arose from the desire of the G20 member countries. Nevertheless, the database has some limitations, both in terms of time span and the number of countries and sectors covered.

Fisrt of all before to calculale the $EXGR\_DVA$, is important to define the $EXGR_{c,i,p}$ that is definided like equation 1: Country c's total gross exports for industry i are obtained by summing exports of intermediate goods and services and exports of final demand. Thus, total gross exports are:

$$\text{EXGR}_{c,i} = \sum_p \text{EXGR}_{c,i,p} = \sum_p \left(\text{EXGR\_INT}_{c,i,p} + \text{EXGR\_FNL}_{c,i,p}\right) \tag{1}$$

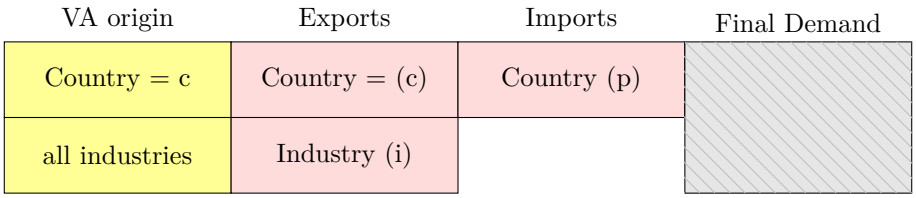
Where $\text{EXGR\_INT}_{c,i,p}$ represents gross exports of intermediate goods from industry i in country c to partner p, and $\text{EXGR\_FNL}_{c,i,p}$ is gross exports of final demand goods and services, where c and $p \in \{1, \ldots, N\},\ c \neq p$.

3.4.1 Domestic value added content of gross exports - EXGR_DVA

The Domestic value added content of gross exports, USD Million are use to construct the index of value added by country. The guide from Guilhoto, Webb e Yamano (2021) use country to define country/region.

The $EXGR_{c,p}$ represents a $K \times 1$ vector of gross exports from country c to partner country p for all K industries, where $c \neq p$.$EXGR_c$ is a $K \times 1$ vector of total exports of country c. $V_c = [v_{c1} \dots v_{ck}]$ is a $1 \times K$ row vector with domestic value added shares of output for each industry i in country c, while V_p generally represents value added shares of the partner country p. V_p denotes the diagonalised matrix of vector V_c, i.e. a $K \times K$ matrix with elements $V_c = [v_{c1} \dots v_{ck}]$ on the diagonal and 0 elsewhere. $\mathbf{B} = (\mathbf{I} - \mathbf{A})^{-1}$, is the global Leontief inverse matrix with NK×NK dimensions, where A is the global $I - O$ coefficient matrix. $B_{c,c}$ is a $K \times K$ diagonal block matrix of B representing total domestic gross output required for one unit increase of country c demand. $B_{c,c}$ is also $K \times K$ block matrix, and it represents the total gross output from country p required for a one unit increase in country c demand. The indicators based on origins of Value Added in gross Exports and imports are construted by three important blocks os indicatores that we can see as follow: i) Domestic value added content of gross exports, ii) Decomposition of domestic value added content of gross exports and iii) Foreign value added content of gross exports (backward participation in GVCs.

Figure 1: Domestic value added content of gross exports



Source: Adapted by the authors from OCDE (2021).

$EXGR\_DVA_{c,i,p}$ denotes the domestic value added content of exports, by industry i in the Brazilian economy (country c). For country c, EXGR and EXGR_DVA exclude intra-country flows. The domestic economy is therefore treated as a single aggregated unit, with no distinction between subnational regions, considering not only the goods and services exported by the industry, according to (GUILHOTO; WEBB; YAMANO, 2021).

$$EXGR\_DVA_{c,i,p} = V_c B_{c,c} EXGR_{c,i,p} \tag{2}$$

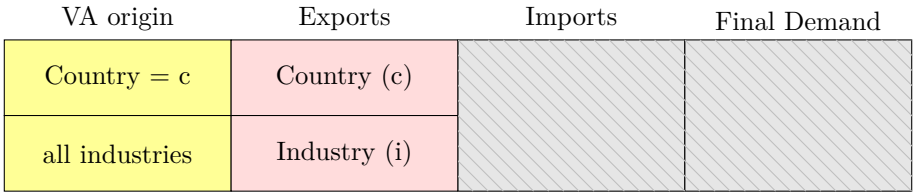
Where:

$EXGR\_DVA_{c,i,p}$ — is a $k \times 1$ vector with all entries equal to zero except those corresponding to industry i. The brazilian economy c, $EXGR\_DVA$ exclude intra-regional trade, the states are treated as single economy. Besides, the domestic value added content of gross exports can be divide futher into three componentes: 1º) direct domestic industry value addes $EXGR\_DDC$, 2º) indirect domestic value added $EXGR\_IDC$ and 3º) and re-imported domestic value added $EXGR\_RIM$.

3.4.2 Domestic value added share of gross exports, percentage - EXGR_DVASH

The $EXGR\_DVASH$ indicator is a measure of domestic value added intensity, which allows us to assess the extent to which Brazilian exports in each sector actually contribute to the generation of domestic income in the economy.

Figure 2: Domestic value added share of gross exports, percentage



Source: Adapted by the authors from OCDE (2021).

The share of domestic value added in gross exports is available by industry for partner world is defined as domestic value added in gross exports, $EXGR\_DVA_{c,i}$, as a percentage of total gross exports, $EXGR_{c,i}$:

$$\text{EXGR\_DVASH}_{c,i} = \frac{\sum_p \text{EXGR\_DVA}_{c,i,p}}{\sum_{p,i} \text{EXGR}_{c,i,p}} \times 100 \tag{3}$$

It is a "DVA intensity measure" and reflects how much value added, generated anywhere in the domestic economy, is embodied per unit of total gross exports by industry, i. For regions c, $EXGR$ and $EXGR\_DVA$ exclude intra-regional trade and for $EXGR\_DVA$, intra-region value added flows are treated as domestic value added. Hence, for $EXGR\_DVASH$, a region is treated as a single economy.

3.4.3 Industry domestic value added contribution to gross exports, as a percentage of total gross exports - EXGR_TDVAIND

This indicator reflects the share, in total gross exports, of domestic value added in an industry's exports. The sum over all industries is the total domestic value added share of gross exports ($EXGR\_DVASH$)

$$\text{EXGR\_TDVAIND}_{c,i} = \frac{\sum_p \text{EXGR\_DVA}_{c,i,p}}{\sum_{p,i} \text{EXGR}_{c,i,p}} \times 100 \tag{4}$$

While $EXGR\_DVASH_{c,i}$ measures the intensity of Domestic value added in an industry's exports, $EXGR\_TDVAIND_{c,i}$ captures the magnitude compared to other industries. Note that the sum of $EXGR\_TDVAIND$ across industries equals $EXGR\_DVASH$ for total industry.

3.4.4 Domestic value added in gross exports, partner shares, percentage - EXGR_DVApSH

For each state and industry, this indicator shows the importing partner distribution of domestic value added in gross exports.

$$\text{EXGR\_DVApSH}_{c,i,p} = \frac{\text{EXGR\_DVA}_{c,i,p}}{\sum_p \text{EXGR\_DVA}_{c,i,p}} \times 100 \tag{5}$$

The next TiVA indicators focus on decomposition of domestic values added content of gross exports.

3.4.5 Direct domestic industry value added content of gross exports, USD million - EXGR_DDC

Direct domestic value added content of exports, $EXGR\_DDC_{c,i}$, measures the direct value added contribution made by industry i in state c to the production of goods and services exported by industry i to the world

$$EXGR\_DDC_c = \hat{V}_c \text{diag} B_c EXGR_c \tag{6}$$

Where $EXGR\_DDC_c$ is a $K \times 1$ vector representing the industry dimension and A_c is a local $I - O$ coefficient matrix from state s single Input-Output table and $B_c = (1 - A_c)^{-1}$ is the local Leontief inverse. Matrix $\text{diag}B_c$ constists of the diagonal elements of the local Leontief inverse, i.e. those entries of the matrix displaying the direct requirements. $EXGR\_DDC_{c,i}$ is the *i-th* elements of the $K \times 1$ vector $EXGR\_DDC_c$, and gives direct domestic value added content os gross export of a given industry *i*.

3.4.6 Indirect domestic content of gross exports (originating from domestic intermediates), USD million - EXGR_IDC

Indirect domestic value added contents of exports, $EXGR\_IDC_{c,i}$, corresponds to the value added originating from other, upstream, domestic industries (different from industry i) in **contry** c that are incorporated in the exports of industry i.

$$EXGR\_IDC_c = \hat{V}_c \text{offdiag} B_c EXGR_c \tag{7}$$

Where $EXGR\_IDC_c$ is a $K \times 1$ vector representing the industry dimension and A_c is a local $I - O$ coefficient matrix from **country** c single Input-Output table and $B_c = (1 - A_c)^{-1}$ is the local Leontief inverse. Matrix $\text{diag}B_c$ constists of the diagonal elements of the local Leontief inverse, i.e. those entries of the matrix displaying the direct requirements. $EXGR\_IDC_{c,i}$ is the *i-th* elements of the $K \times 1$ vector $EXGR\_IDC_c$, and gives direct domestic value added content os gross export of a given industry *i*.

It does not include domestic value added that has has retuned, via imports, after previously being exported (embodied in intermediates) i.e. only the value added directly generated by domestic industries in producing goods and services prior to exports is covered.

3.4.7 Re-imported domestic value added content of gross exports, USD million - EXGR_RIM

Re-imported domestic value added content of exports, $EXGR\_RIM_{c,i}$, measures the domestic value added content, from any industry in **country** c, which has been exported for the production of intermediate goods or services abroad and subsequently embodied in imports used in the poduction of exports by industry i in **country** c.

$$EXGR\_RIM_{c,i} = EXGR\_DVA_c - EXGR\_DDC_c - EXGR\_IDC_c \tag{8}$$

Where $EXGR\_RIM_{c,i}$ is a $K \times 1$ vector representing the industry dimension, and the other variables are as defined before.

$EXGR\_RIM_{c,i}$ is the *i-th* elements of the $K \times 1$ vector $EXGR\_RIM_c$, and gives the re-imported domestic value added content of gross of a given industry i.

And the last two indicators of foreign value added content of gross exports (backward participation in GVCs) as definied as below in equation 9 and 10, respectively.

3.4.8 Foreign value added content of gross exports, , USD million - EXGR_FVA

Foreign value added content of gross exports captures the value of imported intermediate goods and services that are embodied in a domestic industry´s exports. The value added can come from any foreign upstream in the production chain.

$$EXGR\_FVA_{c,i} = \hat{V}B_{ci}EXGR_{c,i} \tag{9}$$

B_{ci} is the column of B corresponding to *inputs used by industry* i in **country** c, where the rows corresponding to input from origin industries in **country** c are set to zero.

Note the $EXGR\_FVA$ includes re-imported foreign value added that was previously exported by **country** c (c.f. $EXGR\_RIM$).

3.5 Foreign value added share of gross exports, percentage - EXGR_FVASH

The share of foreign value added in gross exports is avaliable by industry for partnes world, and is defined as foreign value added embodied in gross exports $EXGR\_FVA_{c,w,i}$, as a percentage of total gross exports, $EXGR_{c,w,i}$.

$$EXGR\_FVASH_{c,i} = \frac{\sum_p EXGR\_FVA_{c,i,p}}{\sum_p EXGR_{c,i,p}} \times 100 \tag{10}$$

3.6 Database and empirical implementation

This article uses the OECD (2022) interregional input-output database, built as part of the Trade in Value Added (TiVA) project, which provides consistent matrices of intermediate transactions, total production, final demand, and value added. The information refers to the year 2022 and is compatible with the System of National Accounts.

From the matrices of intermediate transactions $(\boldsymbol{Z})$, total production $(\boldsymbol{X})$, final demand $(\boldsymbol{FD})$, and value added $(\boldsymbol{VA})$, the technical coefficients and the inverse of Leontief of the interregional system were obtained, following the classic Input-Output approach presented in Miller e Blair (2009). Based on this structure, trade indicators in value added were calculated according to the methodological recommendations of the OECD (2022) and Girotto (2021).

All empirical implementation was performed in R software, ensuring accounting consistency between production, final demand, and value added.

In the empirical analysis, we compute: (i) total domestic value added (DVA), and (ii) its decomposition into direct and indirect components. And other TiVA indicators are presented for completeness within the methodological framework but are not explored empirically in this study.

This approach allows for a focused assessment of the role of domestic production networks in shaping the value added embodied in Brazilian exports.

4 Results and Discussion

4.0.1 Domestic value added and its decomposition into direct and indirect components

The table 2 presents the domestic value added (DVA) embodied in Brazilian exports, aggregated by major sectoral groups. All monetary values are expressed in current U.S. dollars (USD million). The results indicate that services account for most of the value added, at approximately 44%, generated by export activities, followed by industry with 40% and agriculture with 16%. This finding reflects the increasingly important role of service activities, such as land transport, which accounts for 20%, administrative activities and complementary services, with 6%, public administration and defense with 4%, water transport with 3%, professional, scientific, and technical activities with 3%, and accommodation and food services with 2%, which support production for export, even when the goods exported are mainly manufactured or primary products.

The prominence of services in domestic value added reflects their role as upstream activities within production chains. Even when exports are concentrated in primary or manufactured goods, a substantial share of value is generated indirectly through service sectors such as transportation, logistics, administrative support, and professional activities.

This finding challenges the traditional view of Brazilian exports as predominantly commodity-based. While agriculture and industry dominate in gross export terms, the TiVA approach reveals that a significant portion of domestic income associated with exports is generated within service sectors, highlighting the importance of intersectoral linkages in the Brazilian economy.

Group	DVA	Share (%)
Agriculture	52,082.88	0.16
Industry	130,200.12	0.40
Services	140,839.89	0.44

Table 2: Domestic value added in Brazilian exports (USD million)

Industry is the second largest group in terms of value added in Brazilian exports in 2022, comprising the following sectors with the highest representation: oil and natural gas extraction, with 9%; metal ore extraction, with 9%; food, beverage, and tobacco industries, with 3%; basic metallurgy, with 3%; chemical products, with 2%; and coke, petroleum derivatives, and biofuels, with 2%.

Agriculture ranks third, comprising the following sectors: agriculture, livestock, and related services, leading with 15%; forestry and logging, with 1%; and fishing and aquaculture, with less than 0.01% of the value added in exports. Service sectors act as upstream suppliers within production chains, generating value indirectly through their provision of intermediate inputs to exporting industries, while agriculture and manufacturing sectors are more directly associated with downstream export activities.

In the following table 3 presents the 10 most relevant sectors [1] in terms of domestic value added embodied in Brazilian exports in 2022, highlighting the decomposition into direct and indirect components. This breakdown allows for a more detailed assessment of how value is generated within production chains and distributed across sectors.

Direct VA generated within the sector itself reflects wages paid in the sector, operating

[1] See the appendices for all 50 sectors based on the OECD Inter-Country Input–Output (ICIO) database for the year 2022.

Ranking	Sector	Group	DVA	Direct VA	Indirect VA	Share
1	Land transport	Services	65 828.02	13 050.83	52 777.19	0.20
2	Agriculture, forestry and related services	Agriculture	49 466.30	11 116.50	38 349.80	0.15
3	Extraction of crude petroleum and natural gas	Industry	29 662.97	200.13	29 462.84	0.09
4	Extraction of metal ores	Industry	28 377.64	41.22	28 336.43	0.09
5	Administrative and support service activities	Services	19 395.08	2 334.12	17 060.96	0.06
6	Public administration and defence	Services	12 189.33	679.21	11 510.11	0.04
7	Manufacture of food products, beverages and tobacco	Industry	10 403.27	5 311.92	5 091.36	0.03
8	Water transport	Services	10 289.86	574.97	9 714.89	0.03
9	Professional, scientific and technical activities	Services	9 589.13	810.61	8 778.52	0.03
10	Basic metals	Industry	8 562.03	25.18	8 536.85	0.03

Table 3: Sectoral participation in domestic value added of Brazilian exports (USD million)

surplus, and net taxes on production, and is a measure of internal income generation intensity. For example, in Table 3, the agriculture, livestock, and related services sector generates indirect VA of US$38,349.8 million, which indicates that it is a sector highly dependent on other economic sectors. In addition, direct VA of US$11,116.5 million shows that it is a sector that generates income, wages, and taxes in the country.

Direct VA reflects the income generated within the sector itself, including wages, operating surpluses, and net taxes on production, while indirect VA captures the contribution of upstream sectors through intermediate inputs. Notably, the service sectors are the main generators of value added in exports.

A similar pattern is observed in the sectors of crude petroleum and natural gas extraction and metal ore extraction. These sectors present very high levels of indirect value added, amounting to US$29,462.84 million and US$28,336,43 million, respectively, while their direct contributions remain relatively low. This indicates that, despite their importance in export composition, these sectors generate limited income internally and depend heavily on upstream industries, resulting in strong backward linkages and significant multiplier effects in the domestic economy.

The results also indicate that sectors such as agriculture, livestock, and related services exhibit a strong dependence on indirect value added, with US$38,349.8 million generated through upstream linkages, compared to US$11,116.50 million in direct value added. This pattern suggests that these sectors rely heavily on inputs from other industries, reinforcing their role as demand-driven sectors within the production network.

In contrast, the food, beverage, and tobacco industry exhibits a more balanced structure, with US$5,311.92 million in direct value added and US$5,091.36 million in indirect value added. This suggests that the sector combines internal income generation with a moderate dependence on upstream inputs, reflecting a more integrated position within the production chain.

The table 4 presents the decomposition of domestic value added embodied in Brazilian exports into three major groups agriculture, industry, and services, distinguishing between direct and indirect components.

Group	Direct VA	Indirect VA
Agriculture	11,378.34	40,704.54
Industry	13,577.09	116,623.03
Services	20,212.72	120,627.17

Table 4: Decomposition of value added in Brazilian exports (USD million)

Agriculture accounts for the smallest share of both direct and indirect value added. However, this does not imply a limited role in exports. Instead, it reflects a production structure that is highly dependent on upstream sectors, such as machinery, transportation, and intermediate

services, which contribute significantly to the value embedded in agricultural exports.

Industry exhibits a substantial level of indirect value added, amounting to US$116,623.03 million, indicating strong backward linkages and a significant capacity to generate multiplier effects across the economy. This suggests that industrial production relies heavily on inputs from other domestic sectors, amplifying its overall economic impact.

Service sectors stand out as the largest contributors to both direct and indirect value added, with US$20,212.72 million and US$120,627.17 million, respectively. This highlights their dual role within the production structure: not only do they generate income internally, but they also act as key upstream suppliers, supporting export-oriented activities across agriculture and industry.

Overall, the results indicate that Brazilian exports are highly intensive in indirect value added, particularly through service related activities such as logistics, trade, administrative support, financial intermediation, and technological services. This reinforces the importance of production networks and intersectoral linkages in shaping the country's export structure.

5 Conclusion

The results of the article indicate strong participation by the service and industrial sectors in generating domestic added value incorporated into Brazilian exports, while agriculture appears as the third economic group in terms of representativeness.

The sectoral analysis identified the composition of each sector and its share in the Brazilian economy, namely services, industry, and agriculture. The service sector stands out as having the largest share in domestic value added, highlighting different paths for sectoral and trade policies, given the culture based on exports of primary products, such as low value added agricultural commodities. It should be noted that services add value through industry and agriculture.

The results show that a significant part of the added value is generated indirectly, through upstream sectors that supply inputs to exporting industries. This pattern is especially pronounced in manufacturing activities, where complex supply chains amplify the indirect effects on exports. Within the services group, the most relevant sectors are transportation and storage, financial services, and business services. These sectors play a key role as upstream suppliers of intermediate services, reinforcing the importance of production networks in the Brazilian economy.

In addition, TiVA indicators suggest that Brazil's integration into global value chains is characterized by a strong domestic component, particularly in services and upstream industrial activities. Although foreign inputs remain important, the results indicate that a considerable part of the value related to exports is generated domestically, supporting employment and income across a wide range of sectors.

Therefore, it can be concluded that an effective strategy for increasing domestic value added, and consequently greater resilience and productivity gains, depends on measures that strengthen integration into global chains and requires attention to environmental and employment conditions, as the impact of international shocks can be transmitted through inputs and intersectoral production relationships.

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Competing interests

The author declare no competing interests

Use of Artificial Intelligence Tools

The author used OpenAI as a language support tool during the preparation of this manuscript, specifically to improve clarity, grammar, and readability. The tool was not used to generate original scientific ideas, results, or interpretations. All outputs were critically reviewed and edited by the author, who takes full responsibility for the content of the manuscript.

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Appendices

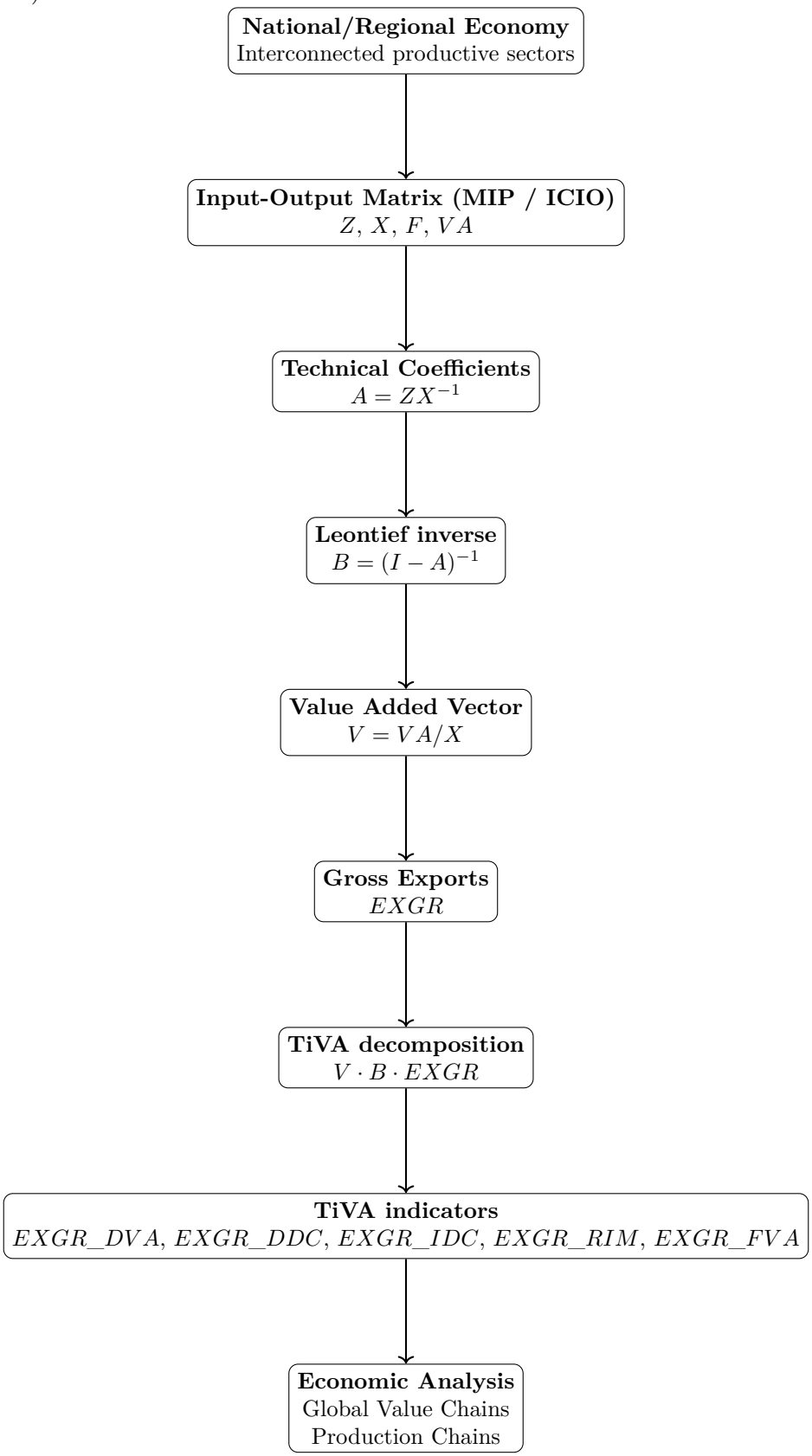
.1 A1 - Sectoral participation in domestic value added embodied in Brazilian exports

Sector code	Sector	Group	DVA	Direct VA	Indirect VA	Share
BRA_45T47	Land transport	Services	65 828.02	13 050.83	52 777.19	0.20
BRA_01	Agriculture, forestry and related services	Agriculture	49 466.30	11 116.50	38 349.80	0.15
BRA_06	Extraction of crude petroleum and natural gas	Industry	29 662.97	200.13	29 462.84	0.09
BRA_07	Extraction of metal ores	Industry	28 377.64	41.22	28 336.43	0.09
BRA_69T75	Administrative and support service activities	Services	19 395.08	2 334.12	17 060.96	0.06
BRA_77T82	Public administration and defence	Services	12 189.33	679.21	11 510.11	0.04
BRA_10T12	Manufacture of food products, beverages and tobacco	Industry	10 403.27	5 311.92	5 091.36	0.03
BRA_49	Water transport	Services	10 289.86	574.97	9 714.89	0.03
BRA_64T66	Professional, scientific and technical activities	Services	9 589.13	810.61	8 778.52	0.03
BRA_24A	Basic metals	Industry	8 562.03	25.18	8 536.85	0.03
BRA_20	Chemicals and chemical products	Industry	7 402.45	623.90	6 778.55	0.02
BRA_19	Coke, refined petroleum products and biofuels	Industry	6 971.02	347.41	6 623.62	0.02
BRA_52	Accommodation and food services	Services	6 600.20	631.98	5 968.22	0.02
BRA_62T63	Real estate activities	Services	4 770.22	624.06	4 146.15	0.01
BRA_35	Water supply, sewerage and waste management	Industry	4 390.67	113.55	4 277.12	0.01
BRA_17T18	Paper, printing and reproduction of recorded media	Industry	4 136.57	456.38	3 680.19	0.01
BRA_28	Motor vehicles	Industry	3 685.03	1 388.77	2 296.25	0.01
BRA_29	Other transport equipment	Industry	3 319.21	1 657.66	1 661.55	0.01
BRA_31T33	Electricity, gas and steam	Industry	3 154.89	575.74	2 579.15	0.01
BRA_24B	Fabricated metal products, except machinery	Industry	2 768.16	40.90	2 727.27	0.01
BRA_25	Electrical equipment	Industry	2 642.73	217.20	2 425.52	0.01
BRA_02	Forestry and logging	Agriculture	2 406.50	245.42	2 161.08	0.01
BRA_22	Rubber and plastic products	Industry	2 385.77	154.28	2 231.49	0.01
BRA_84	Education	Services	2 090.56	219.60	1 870.96	0.01
BRA_16	Wood products	Industry	1 991.53	205.35	1 786.18	0.01
BRA_94T96	Domestic services	Services	1 664.14	32.49	1 631.65	0.01
BRA_13T15	Textiles, wearing apparel and leather	Industry	1 630.82	741.63	889.19	0.01
BRA_23	Other non-metallic mineral products	Industry	1 514.10	87.06	1 427.04	0.00
BRA_61	Financial and insurance activities	Services	1 430.51	148.96	1 281.55	0.00
BRA_58T60	Information technology services	Services	1 376.04	147.61	1 228.43	0.00
BRA_27	Machinery and equipment	Industry	1 288.16	426.60	861.56	0.00
BRA_50	Air transport	Services	1 269.01	71.29	1 197.72	0.00
BRA_36T39	Construction	Industry	1 148.96	0.08	1 148.88	0.00
BRA_55T56	Telecommunications	Services	1 079.35	433.95	645.40	0.00
BRA_41T43	Wholesale and retail trade	Services	923.33	1.38	921.95	0.00
BRA_302T309	Repair and installation of machinery	Industry	908.56	462.76	445.80	0.00
BRA_05	Mining of coal and lignite	Industry	907.01	10.10	896.90	0.00
BRA_53	Publishing, audiovisual and broadcasting activities	Services	848.23	12.85	835.38	0.00
BRA_08	Mining of other non-metallic minerals	Industry	771.18	23.19	747.99	0.00
BRA_21	Pharmaceutical products	Industry	758.94	299.56	459.38	0.00
BRA_85	Human health and social work activities	Services	738.66	68.38	670.28	0.00
BRA_09	Mining support service activities	Industry	671.30	14.46	656.84	0.00
BRA_26	Computer, electronic and optical products	Industry	590.89	148.29	442.60	0.00
BRA_51	Warehousing and postal activities	Services	344.14	101.20	242.94	0.00
BRA_90T93	Other service activities	Services	323.98	189.86	134.12	0.00
BRA_03	Fishing and aquaculture	Agriculture	210.07	16.42	193.65	0.00
BRA_301	Furniture and other manufacturing	Industry	156.25	3.77	152.48	0.00
BRA_68	Real estate activities	Services	56.90	54.17	2.73	0.00
BRA_86T88	Arts, entertainment and recreation	Services	33.20	25.20	7.99	0.00
BRA_97T98	Activities of extraterritorial organisations	Services	0.00	0.00	0.00	0.00

Table 5: Sectoral participation in domestic value added embodied in Brazilian exports

.2 B1 - Methodology based on Input-Output Matrix as the basis for indicators Trade in Value Added (TiVA)

Figure 3: Methodology based on Input-Output Matrix as the basis for indicators Trade in Value Added (TiVA)



Source: Own elaboration based on Guilhoto, Webb e Yamano (2021)