REPAE – Revista Ensino e Pesquisa em Administração e Engenharia
Volume 7, número 2 – 2021
ISSN: 2447-6129
Editor Científico: Alessandro Marco Rosini
Gilmara Lima de Elua Roble
Avaliação: Melhores práticas editoriais da ANPAD

PRODUCTIVE STRUCTURE OF THE BRAZILIAN ECONOMYAND KEY SECTORS FOR DEVELOPMENT

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ABSTRACT

The objective of the study was to identify the key sectors and drivers for development in the Brazilian economy with the use of three economic indicators based on the input-output matrix of Brazil in 2017: Rasmussen-Hirschman inter-sectoral linkages, GHS indexes and field of influence. The key sector is that with the effects of chaining the purchase and sale of inputs above the average for the economy. The driving sector, in addition to being key, has a relatively greater dimension of its chaining effects and significant driving impulses on the growth of the economy. The joint and complementary analysis of the identification methods of key and driving sectors led to a list of economic activities that are capable of stimulating the productive system, which should be a priority for investments for their expansion to optimize the use of public and private resources. The key sectors identified were (10) Other food products, (19) Oil refining, (38) Electric power, gas and other utilities, (43) Land transport and (40) Construction. The driving sectors are (19), (38) and (40), because in addition to having the greatest impacts on the production chains in which they operate, they also have a high participation in terms of national production.

Keywords: input-output, key sectors, economic development, productive chain.

Date of receipt: 02/27/2021

Publication acceptance date: 08/06/2021

Date of publication: 30/08/2021

1 INTRODUCTION

The productive structure of a country determines its capacity to generate employment, production and income and impacts on the environment. Considering the limited investment capacity of the public and private sectors, it is important to identify priority sectors to receive resources and that drive economic development through their interconnections with other sectors. The input-output tool makes structural analysis of the economy and identification of key sectors for development possible.

Studies with input-output matrices make it possible to measure the intersectoral linkages within the economic system to obtain detailed information about the flows of goods and services. Thus, this research aims to contribute to studies on the productive structure and sectoral interactions of the Brazilian economy. It is expected to identify the key and driving sectors of the Brazilian productive complex according to the intersectoral linkages, production value and field of influence. The key sector, or key industry, is the one with chain effects due to the purchase and sale of inputs above the economy average. The driving industry, in addition to having higher-than-average chaining effects from the point of view of the input-output matrix, it is characterized by the relatively larger dimension of its chaining effects and significant driving impulses on economic growth. Every driving industry is a key industry, but not every key industry is a driving industry. Driving industries attract satellite companies, input suppliers or users of the former's products as inputs, triggering economic growth (Souza, 1981 and Souza, 2005).

The objective of the study was to identify the key and driving sectors for development in the Brazilian economy using three economic indicators based on the 2017 input-output matrix of Brazil. The method is based on the use of the input-output matrix. product to estimate the Rasmussen-Hirschman (RH) intersectoral linkages indexes, Guilloto, Hewings and Sonis (GHS) indexes and the field of influence. The methods of identifying key and driving sectors are complementary so that the analysis is comprehensive and impartial.

The text is divided into five sections including the introduction. The second section presents the definition of a key sector and recent studies on the subject for the Brazilian economy. The third section presents the methodology based on the input-output matrix and its economic indicators. The fourth section presents the results of the study and analysis identifying the key and driving sectors of the Brazilian economy in 2017 and the fifth section presents the main conclusions.

2 IDENTIFICATIONS OF KEY SECTORS AND RECENT STUDIES FOR BRAZIL

According to Hirschman (1958), economic development would consist of a series of links between economic activities. Thus, Hirschman proposes to look for pressures and incentive processes that will break out and mobilize the greatest possible number of scarce resources, such as capital and entrepreneurial activity, which is the basic argument for his defense of development plans within an explicitly interventionist vision. In this context, Hirschman discusses the regional issue using the concepts of forward linkages and backward linkages. This way, the backward effects are the way found by Hirschman (1958) based on the ideas of Rasmussen (1956) to express the externalities arising from the implementation of industries that, by increasing the demand for inputs in the upstream sector, would make their

minimum production scale viable in the given region. The forward effects result from the supply of inputs, which make the sectors that positioned themselves downstream viable.

The Rasmussen-Hirschman intersectoral linkages indexes do not consider the dimension of economic activities, therefore, other indexes based on the input-output matrix were designed to identify key sectors such as Cella-Clements and GHS. The development of the field of influence approach aimed to visually analyze the main links between sectors in the economic system and constitute a complementary methodology to the linkage indexes. Recent studies that used the methods described to analyze the Brazilian economy in the period of 1959 to 2011 are Guilhoto et al. (1994), Sesso Filho et al. (2009), Guilhoto and Sesso Filho (2005), Guilhoto and Sesso Filho (2010), Brene et al. (2014) and Bertussi et al. (2020).

Guilhoto et al. (1994) estimated three linkage indexes, Rasmussen-Hirschman, Cella-Clements and GHS (Guilhoto, Hewings and Sonis) for the sectors of Brazil in the years 1959, 1970, 1975 and 1980. The results of the indicators showed that the featured sectors in the period were Agriculture, Construction, Chemicals and Transport. During the period of analysis of the study, there was a loss of importance in Agriculture and an increase in the indexes of the industrial sectors.

Sesso Filho et al. (2009) developed a study based on the input-output tool to analyze the structural transformations of the Brazilian economy in the 1990-2003 period. The authors divided the period into three phases according to the research results. The first phase between 1990 and 1996 was marked by major structural transformations, with intersectoral reallocation of production, added value and employment, an increase in the induced effect and the participation of trade, services and agriculture in production and a fall in the number of busy people. The second phase, in the 1997-1998 period, showed less structural change, with relative stability in the participation of sectors in production, in added value and in the absorption of employed persons. The end of the analysis period, between the years 1999-2003, showed a drop in the values of the induced effect of the sectors, an increase in the participation of agriculture and industry in production and added value, and a reduction in the participation of these sectors in the number of employed persons. As for labor productivity, measured by the value added per person, there was an increase in agriculture and industry and a reduction in trade and services.

Guilhoto and Sesso Filho (2005) estimated the input-output matrix of Brazil from preliminary data from the National Accounts and applied the methodology for the years 1994 and 1996 with calculation of economic indicators. The top five key sectors in the period according to the Rasmussen-Hirschman indexes were Steel, Non-Ferrous Metallurgy, Other Metallurgical Products, Pulp, Paper & Printing, Miscellaneous Chemicals and the Textile Industry. For the GHS they were Agriculture, Petroleum Refining, Other Food Products, Construction, Trade and Transport and Services provided to families.

Guilhoto and Sesso Filho (2010) estimated the RH and GHS indexes for the year 2005, the index results indicated the key sectors were Food and beverages, Textiles, Pulp, paper and printing, Petroleum refining, Chemicals, Resin manufacturing and elastomers, Rubber and plastic articles, Steel and steel manufacturing, Metal products and Vehicle parts and accessories.

Brene et al. (2014) analyzed the theme of the deindustrialization process of the Brazilian economy from the perspective of economic indicators calculated from the national input-output matrices estimated for the years 2000 and 2007. Thus, the multipliers of production, employment, added value and import and the Rasmussen-Hirschman intersectoral linkages indexes were estimated. The authors highlighted the loss of importance of industrial sectors in the economy and emphasized the need to resume strategic planning of the productive structure such as industrial policy.

Bertussi et al. (2020) developed a study to identify key sectors in the Brazilian economy in 2011, the Rasmussen-Hirschman indexes showed the sectors Manufacturing industry, Electricity, Gas, water and sewage and Transport as key.

Studies show that the Rasmussen-Hirschman indexes tend to present industrial sectors as key, while other indexes that consider the dimension of relations between sectors include the service sectors as the most important. The list of key sectors for the development of the Brazilian economy has changed with the productive structure throughout recent history, with Agriculture and base industries (Construction and Steel) from the 1950s to the 1980s passing to agribusiness and service sectors from the 1990s to 2010. The two sectors that remained on the key list throughout the period were Transport and Chemicals, as they are present in most of the productive chains of the economic system. This study advances in identifying key sectors for the Brazilian economy, as it analyzes the most recent data for the year 2017. In addition, it considers the dimension of the sectors (production value) to indicate the driving sectors.

3 METHODOLOGY

Leontief's input-output model based on Leontief (1951) and Leontief (1956) is constituted by a system of linear equations, which represent the distribution of production within the economy. Initially, the intent was to obtain detailed accounting data for transactions between sectors in physical units. However, since more than one product is sold per sector, problems arose in measuring intersectoral flows, which led to the representation of the input-output matrix in monetary terms. The economic system is summarized to present the structure of the economy with its flows of goods and services between sectors and relationships with final demand. The basic input-output equations according to Miller and Blair (2009) are:

$$X = (I - A)^{-1}Y \quad (1)$$

X is the total production vector, by sector, of dimension *nx1*.
Y is the final demand vector, by sector, of dimension *nx1*;
A is the matrix of technical coefficients;
I is an *nxn* identity matrix;

It is assumed, in the Leontief model, that the amount of input in sector *i* used by sector *j* is directly proportional to the production of sector *j*, it is then possible to calculate the technical coefficients of production a_{ij}:

$$a_{ij} = \frac{z_{ij}}{X_j} \quad (2)$$

z_{ij} it is the supply of inputs from sector *i* to sector *j*;
Xj is the sectorial production of sector *j*.

The technical coefficient represents a relation of how much sector *j* buys from sector *i* given the total production of sector *j*, called *Xj*. Technical production coefficients are fixed relationships between sectors and their inputs.

Leontief's inverse matrix is given by

$$B = (I - A)^{-1} \quad (3)$$

and its elements are b_{ij}.

In $B=\left(I-A\right)^{-1}$, the element b_{ij} must be interpreted as being the total production of sector *i* that is necessary to produce a unit of final demand of sector *j*.

3.1 Rasmussen/Hirschman intersectoral linkages index

Based on Leontief's basic model, defined above, and following Rasmussen (1956) and Hirschman (1958), it is possible to determine which would be the sectors with the greatest linkage power within the economy, that is, both the backward links indexes, which would provide how much such a sector would demand from others, and the forward links, which shows the quantity of products demanded from other sectors of the economy by the sector in question, can be calculated

In this way, defining b_{ij} as being an element of the inverse matrix of Leontief B, B^* as being the average of all the elements of B; and B_{*j}, B_{i*} as being respectively the sum of a column and a typical row of B, we have, then, that the indexes would be the following:

Backlinks Indexes (Dispersion Power):

$$U_j=\left[B_{*j}/n\right]/B^* \tag{4}$$

Forward link rates (Dispersion Sensitivity):

$$U_i=\left[B_{i*}/n\right]B^* \tag{5}$$

Values greater than 1 for the above indexes relate to above-average sectors and, therefore, key sectors for economic growth. One of the criticisms of these indexes is that they do not consider the different levels of production in each sector of the economy, which is considered when working with the Pure Index of Inter-Industry Links, as will be seen below.

3.2 GHS Model

Guilhoto, Sonis and Hewings (1996) developed a work, which consists of the integration of the main techniques used in the analysis of input-output structures, aiming to decompose and distinguish the impact of a sector/region of the economy on its various components. To do this, they deal with two methods; the focus on key sectors, initially associated with Hirschman (1958) and Rasmussen (1956), which are modified by Cella (1984), Clements (1990), Clements and Rossi (1992) and Guilhoto, et.al. (1994), and the pure linkages approach identified with the sources of change in the economy and the internal and external effects of Miyazawa's (1976) multipliers.

The main contribution of these authors lies in the assembly of different matrix decompositions to formally link these two approaches: key sectors and the sources of change in the economy. This technique is fundamental in the sense of identifying the degree of final demand impacts in certain regions and on all others.

The authors carry out a consolidation of these approaches, based on matrix A and defined as follows:

$$A=\begin{bmatrix} A_{jj} & A_{jr} \\ A_{rj} & A_{rr} \end{bmatrix} \tag{6}$$

Where:

A_{jj} and A_{rr} represent square matrices of direct technical coefficients of sector *j* and the rest of the economy (economy minus sector *j*), respectively, while A_{jr} and A_{rj} represent rectangular matrices of the direct inputs acquired by sector *j* from the rest of the economy and the direct inputs acquired by the rest of the economy in sector *j*.

Taking as base (3) and making a triple multiplicative decomposition of the inverse Leontief matrix, we obtain:

$$B = (I - A)^{-1} = \begin{pmatrix} B_{ij} & B_{jr} \\ B_{rj} & B_{rr} \end{pmatrix} = \begin{pmatrix} D_{ij} & 0 \\ 0 & D_{rr} \end{pmatrix} \begin{pmatrix} D_j & 0 \\ 0 & D_r \end{pmatrix} \begin{pmatrix} I & A_{jr}D_r \\ A_{rj}D_j & I \end{pmatrix} \quad (7)$$

Where:

$$\Delta_j = \left(I - A_{jj}\right)^{-1} \quad (8)$$

$$\Delta_r = \left(I - A_{jj}\right)^{-1} \quad (9)$$

$$\Delta_{jj} = \left(I - \Delta_j A_{jr} \Delta_r A_{rj}\right)^{-1} \quad (10)$$

$$\Delta_{rr} = \left(I - \Delta_r A_{rj} \Delta_j A_{jr}\right)^{-1} \quad (11)$$

Starting from the Leontief model, $X = (I - A)^{-1}Y$, and from formulation (11) and its dismemberments, important indicators are derived that can be used, according to Guilhoto, Sonis and Hewings (1996), to:

a) classify regions according to their importance within an economy and
b) identify how the production process takes place in the economy.

$$\begin{pmatrix} X_j \\ X_r \end{pmatrix} = \begin{pmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{pmatrix} \begin{pmatrix} \Delta_j Y_j + \Delta_j A_{jr} \Delta_r Y_r \\ \Delta_r A_{rj} \Delta_j Y_j + \Delta_r Y_r \end{pmatrix} \quad (12)$$

presents new definitions for backward (PBL) and forward (PFL) connections through:

$$PBL = \Delta_r A_{rj} \Delta_j Y_j \quad (13)$$

$$PFL = \Delta_j A_{jr} \Delta_r Y_r \quad (14)$$

PBL will indicate, especially through ($\Delta_j Y_j$), the pure impact of the value of total production in region *j* on the rest of the economy. It is said that the impact is pure because, according to Guilhoto, Sonis and Hewings (1996, p.17), it is free:

a) of the demand for inputs that region *j* produces for region *j*
b) of returns from the rest of the economy to the region and vice versa. In turn, the PFL, through $(\Delta_r Y_r)$, will indicate the pure impact of the value of total production in the rest of the economy *r* on region *j*.

Using (6.22), it can be deduced that:

$$\begin{pmatrix} X_j \\ X_r \end{pmatrix} = \begin{pmatrix} \Delta_{jj}\Delta_j Y_j + \Delta_{jj}\Delta_j A_{jr}\Delta_r Y_r \\ \Delta_{rr}\Delta_r A_{rj}\Delta_j Y_j + \Delta_{rr}\Delta_r Y_r \end{pmatrix} = \begin{pmatrix} X_j^j + X_j^r \\ X_r^j + X_r^r \end{pmatrix} \quad (15)$$

What makes it possible to divide the economy's production level into two components:

$$X_j^j = \Delta_{jj}\Delta_j Y_j \quad (16)$$

$$X_j^r = \Delta_{jj}\Delta_j A_{jr}\Delta_r Y_r \quad (17)$$

In X_j^j, we obtain the value of the total production of region *j* provided by the final demand of region *j*, while X_j^r it provides the value of the total production of region *j* arising from the final demand of the rest of the economy. We can also get two other components:

$$X_r^j = \Delta_{rr}\Delta_r A_{rj}\Delta_j Y_j \quad (18)$$

$$X_r^r = \Delta_{rr}\Delta_r Y_r \quad (19)$$

X_r^j provides the value of the total production of the rest of the economy due to the final demand of region *j*, while X_r^r provides the value of the total output of the rest of the economy due to the final demand of the rest of the economy.

It appears, therefore, that these techniques provide a powerful instrument that integrates the main methods used, enabling, at the same time, the decomposition of impacts between regions, which makes it possible to analyze the integration of a national economy.

The GHS model was applied by Guilhoto, Hewings and Sonis (1997) to identify the interdependence, linkages and multipliers in Asia through a group of input-output tables for some countries in this continent, also using the values of the United States in the 1975 and 1985. As for the main results, the authors emphasize that, in addition to identifying the key sectors, the method allows detecting the sources of changes in the economy, as it becomes possible to break the sector/region impact in the economy in various components.

3.3 Field of influence

Although the Rasmussen/Hirschman indexes assess the importance of a given sector in terms of its impacts on the system, it is difficult to visualize the main links within the economy, that is, which coefficients, if changed, would have a greater impact in the economic system. The concept of field of influence (see Sonis and Hewings, 1989) describes how changes in direct coefficients are distributed in the economic system, thus allowing the determination of which relationships between sectors would be most important within the productive process. Therefore, the notion of field of influence is not dissociated from that of linkage indexes.

Considering the elements of the matrix of technical coefficients, we have that $A = |a_{ij}|$ represents the matrix of direct coefficients and, from then on, $E = |\varepsilon_{ij}|$ as being the matrix of incremental variations in the direct input coefficients. The corresponding Leontief inverse matrices are given by $B = [I - A]^{-1} = |b_{ij}|$ and by $B(\varepsilon) = [I - A - \varepsilon]^{-1} = |b_{ij}(\varepsilon)|$. Following Sonis and Hewings (1989), if the variation is small and only occurs in a direct coefficient, that is:

$$\varepsilon_{ij} = \begin{cases} \varepsilon & i = i_1, j = j_1 \\ 0 & i \neq i_1, \text{or}, j \neq j_1 \end{cases} \quad (20)$$

the field of influence of this variation can be approximated by the expression:

$$F(\varepsilon_{ij}) = \frac{[B(\varepsilon_{ij}) - B]}{\varepsilon_{ij}} \quad (21)$$

$F(\varepsilon_{ij})$ is a matrix (nxn) of the coefficient influence field. a_{ij}.

In order to determine which coefficients would have the largest fields of influence, it is necessary to associate with each matrix $F(\varepsilon_{ij})$ a value that would be given by:

$$S_{ij} = \sum_{k=1}^{n}\sum_{l=1}^{n}\left[f_{kl}(\varepsilon_{ij})\right]^2 \quad (22)$$

in which S_{ij} is the value associated with the matrix $F(\varepsilon_{ij})$. Therefore, the direct coefficients that have the highest values of S_{ij} they will be those with the greatest fields of influence within the economy.

3.4 Data sources

Brazil's input-output matrix for the year 2017 was estimated based on preliminary data from the National Accounts and presents 67 economic sectors or activities. The matrix is provided by NEREUS (2021) and the references for the construction were Guilhoto and Sesso Filho (2005) and Guilhoto and Sesso Filho (2010). The matrix sectors are in Table 1.

Table 1. Sectors of the input-output matrix of the Brazilian economy in the year 2017.

Sectors	
1.	Agriculture, including support to agriculture and post-harvest
2.	Livestock, including support to livestock
3.	Forest production; fishing and aquaculture
4.	Extraction of coal and non-metallic minerals
5.	Oil and gas extraction, including support activities
6.	Iron ore extraction, including processing and agglomeration
7.	Extraction of non-ferrous metallic minerals, including processing
8.	Slaughter and meat products, including dairy and fish products
9.	Sugar manufacturing and refining
10.	Other food products
11.	Beverage manufacturing
12.	Manufacturing of tobacco products
13.	Textile manufacturing
14.	Manufacture of apparel and accessories artifacts
15.	Manufacture of footwear and leather goods
16.	Wood Products Manufacturing
17.	Manufacture of pulp, paper and paper products
18.	Printing and reproduction of recordings
19.	Oil refining and coke ovens
20.	Biofuel manufacturing
21.	Manufacture of organic and inorganic chemicals, resins and elastomers
22.	Manufacture of pesticides, disinfectants, paints and various chemicals
23.	Manufacturing of cleaning products, cosmetics/perfumery and personal care
24.	Manufacturing of pharmochemicals and pharmaceuticals
25.	Manufacture of rubber and plastic material products
26.	Manufacture of non-metallic mineral products
27.	Production of pig iron/ferroalloys, steel and seamless steel tubes
28.	Metallurgy of non-ferrous metals and metal smelting
29.	Manufacture of metal products, except machinery and equipment
30.	Manufacturing of computer equipment, electronics and optical products
31.	Manufacture of electrical machinery and equipment
32.	Manufacture of mechanical machinery and equipment
33.	Manufacture of cars, trucks and buses, except parts
34.	Manufacturing of parts and accessories for motor vehicles
35.	Manufacture of other transport equipment, except motor vehicles
36.	Manufacture of furniture and products from various industries
37.	Maintenance, repair and installation of machinery and equipment
38.	Electricity, natural gas and other utilities
39.	Water, sewage and waste management
40.	Construction
41.	Trade and repair of motor vehicles and motorcycles
42.	Wholesale and retail trade, except motor vehicles
43.	Land transport
44.	Water transport
45.	Air transport
46.	Storage, auxiliary activities of transport and mail
47.	Accommodation
48.	Food
49.	Editing and editing integrated with print

50. Television, radio, cinema and sound and image recording/editing activities
51. Telecommunications
52. Systems development and other information services
53. Financial intermediation, insurance and supplementary pension
54. Real estate activities
55. Legal, accounting, consulting and company headquarters activities
56. Architectural, engineering, technical testing/analysis and R&D services
57. Other professional, scientific and technical activities
58. Non-Real Estate Leases and Management of Intellectual Property Assets
59. Other administrative activities and complementary services
60. Surveillance, security and investigation activities
61. Public administration, defense and social security
62. Public education
63. Private education
64. Public health
65. Private health
66. Artistic, creative and entertainment activities
67. Membership organizations and other personal services

Note: IBGE (2017)

4 RESULTS AND DISCUSSION

Table 2 presents the key sectors according to the Rasmussen-Hirschman (RH) intersectoral linkages indexes. Considering that the index does not consider the size of sectors, the participation in national production in percentage terms is additional information to identify the driving sectors.

The fourteen key sectors identified with the RH index belong to mineral extraction (one sector), agribusiness (two sectors), chemical industry (four industries), metallurgy and steel (two services) and services (five sectors). The driving sectors must have links with other sectors of the economy in terms of acquisitions and sales of important inputs and relative size to impact the economy, which would be (10) Other food products, (19) Petroleum refining, (38) Electricity and (43) Land transport.

In general, the results of the RH and GHS intersectoral linkages show that the values obtained for the service sectors are lower than for the industrial sectors. Purchases of goods and services for industrial production processes are relatively higher in monetary values than for trade and services. Furthermore, the service sectors sell most of the production directly to final demand. Therefore, the use of three complementary methods for identifying key sectors contributes to a more comprehensive and assertive analysis.

Table 2. Key sectors of the Brazilian economy according to the Rasmussen-Hirschman (RH) intersectoral linkages indexes, 2017.

Sectors	*Intersectoral linkages indexes*		*Participation in national production*
	backard	*forward*	
Mineral extractivism			
5 Oil and gas extraction, including support activities	1.0	1.1	1.3%
Agribusiness			
10 Other food products	1.2	1.0	2.6%
17 Manufacture of pulp, paper and paper products	1.1	1.1	0.8%
Chemical industry			
19 Oil refining and coke ovens	1.2	2.4	3.4%
21 Manufacture of organic and inorganic chemicals, resins and elastomers	1.1	1.8	1.4%
22 Manufacture of pesticides, disinfectants, paints and various chemicals	1.1	1.1	0.7%
25 Manufacture of rubber and plastic products	1.1	1,2	1.0%
Metallurgy and Steel			
27 Production of pig iron/ferroalloys, steel and seamless steel tubes	1.2	1.1	1.0%
29 Manufacture of metal products, except machinery and equipment	1.1	1.0	0.8%
Services			
37 Maintenance, repair and installation of machinery and equipment	1.0	1.2	0.6%
38 Electricity, natural gas and other utilities	1.1	2.0	2.7%
43 Land transport	1.1	2,3	3.3%
50 Television, radio, cinema and sound and image recording/editing activities	1.0	1.1	0.4%
57 Other professional, scientific and technical activities	1.1	1.2	0.9%

Note: Rasmussen-Hirschman (2017)

Table 3 has the key sectors identified according to the GHS intersectoral linkages indexes. Considering that the RH indexes revealed fourteen key sectors, the criterion for establishing the key sectors for the GHS indexes was to identify the fourteen sectors with the highest values of the normalized index (obtained values divided by the mean).

The results of the GHS indexes are obtained in monetary values and are Appendix. The absolute values are in billions of Reais and, after being divided by the average, they will be the normalized indexes shown in Table 3. The key sectors belong to agribusiness (three sectors), Industry (four sectors) and Trade and services (8 sectors). The driving sectors were identified as (42) Wholesale and retail trade, (53) Financial intermediation, (19) Oil refining, (1) Agriculture, (40) Construction and (43) Land transport.

The results show that the intersectoral linkages have different characteristics. The RH index is calculated from the Leontief matrix considering the forward and backward multiplier effect of production and presents important key sectors regardless of their size, therefore, even relatively smaller sectors (low participation in production) can be classified as important. On the other hand, the GHS indexes consider the multiplier effect of production (backwards and forwards) and the absolute values of purchases and sales of goods and services and, consequently, show greater prominence for sectors with greater participation in national production.

The key coincident sectors considering the two economic indicators calculated (RH and GHS) are (10) Other Food Products, (19) Petroleum Refining, (38) Electricity, Gas and (43) Land Transport. The coincident driving sectors are (19) Oil refining and (43) Land transport. The sector (40) Construction is present in the GHS indexes as the fourth most

important sector and does not appear as a key sector by the RH index. It represents 5% of the total national production with large input acquisitions and a long production chain, therefore, it is a key and driving sector. The economic activities identified as the most important that have the capacity to boost the sectors of the economy are related to the manufacture of essential inputs to feed the production process, such as food, energy and transport.

Table 3. Key sectors of the Brazilian economy ranked according to the total normalized pure GHS intersectoral linkages, 2017. Position in the ranking is the number in parentheses.

Sectors	*GHS intersectoral linkages*		*Total*
	backard	*forward*	
Agribusiness			
8 Slaughter of meat products (4)	5.1	0.5	2.8
10 Other Food Products (8)	3.9	1.2	2.7
1 Agriculture, including support to agriculture and post-harvest (9)	2.1	2.7	3.3
Industry			
40 Construction (3)	5.7	0.9	3.3
19 Oil refining and coke ovens (7)	1.8	3.5	3,4
33 Manufacture of automobiles, trucks and buses, except parts (13)	3.3	0.1	1.7
38 Electricity, natural gas and other utilities (12)	0.8	2.7	1.8
Commerce and services			
42 Wholesale and retail trade, except motor vehicles (1)	5.2	7.0	9.6
53 Financial intermediation, insurance and supplementary pension (2)	1.5	5.1	5.9
43 Land transport (5)	1.8	3.7	3.3
61 Public administration (6)	5.0	0.4	2.7
48 Food (10)	3.1	0.6	1.9
59 Other administrative activities and complementary services (11)	0.4	3.2	1.8
55 Legal, accounting, consulting and company headquarters (14)	0.2	3.1	1.6
54 Real estate activities (15)	1.0	1.4	1.2

Note: Prepared by the authors

Comparing the results of the present study for the year 2017 with the research on key sectors for the Brazilian economy between 1959 and the 2000s carried out by Guilhoto et al. (1994), Guilhoto and Sesso Filho (2005) and Guilhoto and Sesso Filho (2010), one can note the evolution of the list of key sectors with a decrease in the importance of Agriculture and an increase in the intersectoral relations of the sectors of Agribusiness, Energy (Oil refining, gas, electric energy), Construction and Transport. The sectors related to energy generation and transport services have remained key sectors since 1959 and therefore, are priority for the country's development in any period.

The results of the present research agree with the study developed by Bertussi et al. (2020), which identified the Transport and Electric Energy sectors as keys to the Brazilian economy in 2011, the same occurs for 2017. The importance of these activities lies in feeding the production process of all other sectors such as Providers.

The studies developed by Sesso Filho et al. (2009) and Brene et al. (2014) described a Brazilian economy in transformation and with an increase in the importance of services and a decrease in the participation and impact of industrial sectors. The indicator that best shows

this phenomenon is the GHS index, which identified eight service sectors among the fourteen key sectors, while the RH index indicated five trade and services activities among the fourteen most important sectors. In 2011, Bertussi et al. (2020) identified eight service sectors as key to the development of the Brazilian economy through the analysis of the HR indexes, this shows that the deindustrialization process has been underway since the 1990s. This is a stylized fact of economic development; however, it can be considered that the deindustrialization of the Brazilian economy occurred too early (Brene et al., 2014).

The joint analysis of the two intersectoral linkages allows for a better understanding of the role of each sector as a buyer and supplier of inputs within the production chains. However, there is still a gap not filled by these economic indicators, which is the identification of sectors impacted in the purchase and sale of inputs (goods and services). The field of influence approach permits a visual analysis of the productive chains of the sectors and their most important impacts on the economic system possible when there are increases in the demand or sale of inputs. The results of the field of influence are shown in Figure 1 and will be analyzed together with the indexes of intersectoral linkages.

Figure 1 illustrates the results of the field of influence of the sectors of the Brazilian economy in 2017, the graph corresponds to the input-output matrix scheme with 67 sectors and its lines and columns correspond respectively to sales and purchases of goods and services for intermediate consumption. Visual analysis shows that the points (markers) on the lines corresponding to the sectors are important linkages (transactions) in the economic system. The sector (1) Agriculture, for instance, it can be observed that the points of its sales line are all important links for the country's economic system, in its column we have that its main input suppliers are the sectors (1) Agriculture, (19) Oil refining and coke plants, (38) Electric energy, natural gas and other utilities and (42) Wholesale and retail trade. Therefore, sector (1) Agriculture is an important input supplier in the economy and a relatively minor buyer. The Rasmussen-Hirschman index for this sector is 0.92 backward and 1.85 forward, while the GHS index is 2.08 backward and 2.72 forward. The index values confirm the visual analysis of the field of influence.

The sectors that present many important linkages in their rows and columns (with markers) are considered key to the development of the economy. Thus, the key sectors are (19) Oil refining, (21) Manufacturing of organic and inorganic chemicals, (38) Electric power, natural gas and other utilities, (42) Wholesale and retail trade, (43) Land transport, (50) Television, radio, cinema and sound and image recording/editing activities and (51) Telecommunications.

It is important to note that the field of influence approach is complementary to the indexes of intersectoral linkages and its advantage is the possibility of identifying the main sectors impacted by transactions for intermediate consumption in each sector within the production chains. The key sectors identified by this method are on the list drawn up in the joint analysis of the RH and GHS indexes, with the exceptions of (50) Television, radio, cinema and sound and image recording/editing activities and (51) Telecommunications. The Rasmussen-Hirschman indexes for these sectors are 1.01 (backard) and 1.09 (forward) for sector (50) and 0.99 (backard) and 0.95 (forward) for sector (51). The GHS indexes are 0.03 (backard) and 0.67 (forward) for (50) and 1.12 (backard) and 0.87 (forward) for (51). These two sectors should be included as the most important for development because they are related to a new business environment where information flows are important for decision making in companies and marketing of products and services. However, they should not be considered drivers because they participate respectively with 0.4% and 1.5% in national production.

The joint and complementary analysis of the methods for identifying key and driving sectors led to a list of economic activities that can stimulate the productive system of the

Brazilian economy, which should receive investments for their expansion to optimize the use of public resources and private. The sector (10) Other food products provides inputs for the chains of the agro-industrial complex and is the main link with agricultural production. Energy-related economic activities such as (19) Oil refining and (38) Electric power, gas and other utilities are important to all other sectors of the economy. Most of the products are transported by the sector (43) Land transport, making it the main link between sectors and with the final demand. (40) Construction is responsible for increasing the country's production capacity and infrastructure. The driving sectors are (19), (38) and (40), as in addition to having the greatest impacts on the production chains in which they are inserted, they also have a high share in terms of national production.

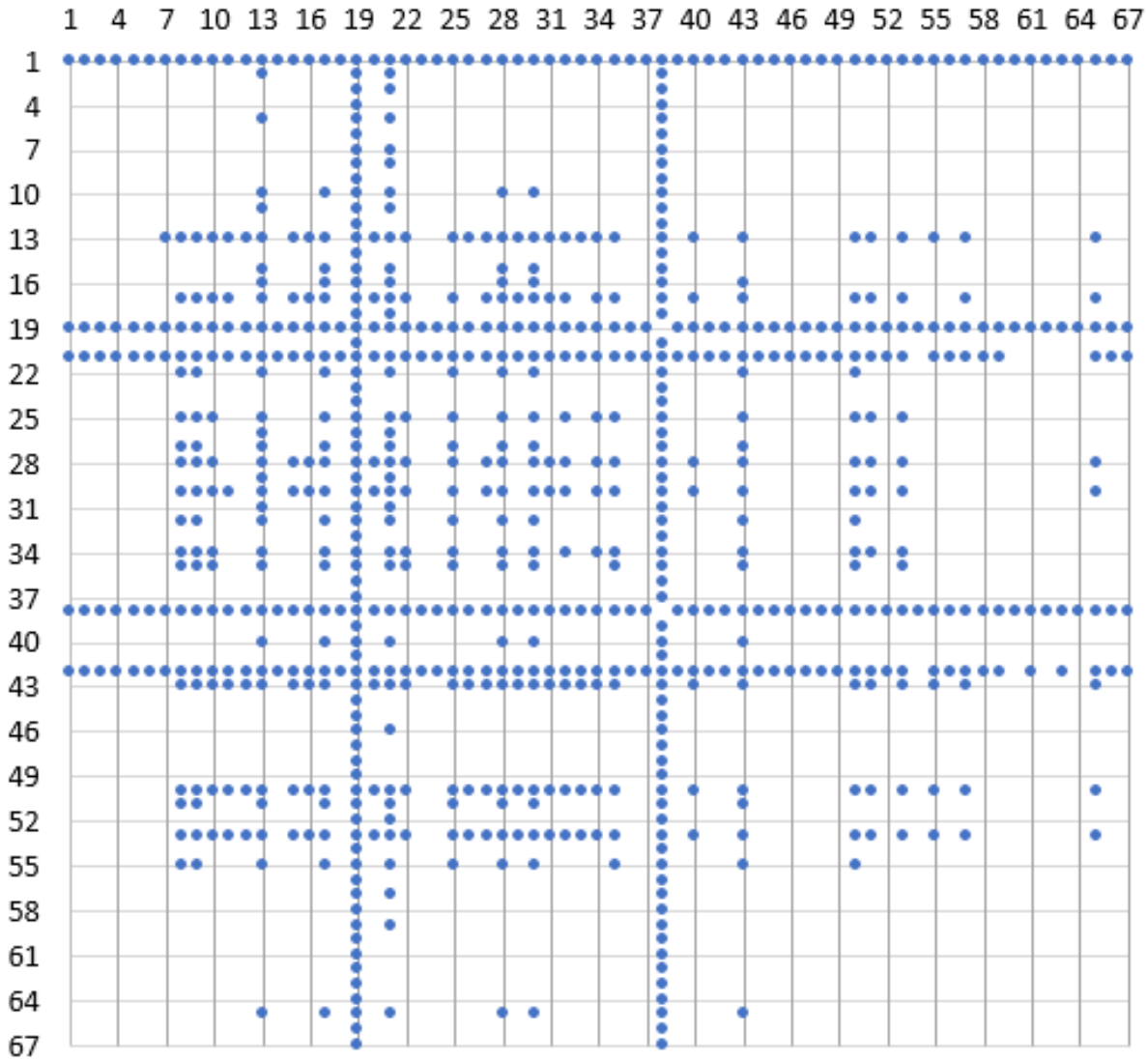

Figure 1. Field of influence of the sectors of the Brazilian economy in the year 2017.
Note: Extracted from MatLab software (2019)

5 CONCLUSIONS

The methods for identifying key sectors for development based on the input-output matrix have different characteristics. The Rasmussen-Hirschman indexes of intersectoral linkages are estimated considering the forward and backward multiplier effect of production and indicates important key sectors regardless of their size. The GHS indexes consider the multiplier effect of production (forward and backward) and the absolute values of purchases and sales of goods and services for intermediate consumption; therefore, the tendency is to indicate key sectors with greater participation in national production. The field of influence is based on visual and qualitative analysis, but it has the advantage of identifying the most important intersectoral relationships within each production chain.

The joint and complementary analysis of the methods for identifying key and driving sectors led to a list of economic activities that can stimulate the productive system, which should receive investments for their expansion to optimize the use of public and private resources. The sector (10) Other food products provides inputs for the chains of the agro-industrial complex and is the main link with agricultural production. Energy-related economic activities such as (19) Oil refining and (38) Electric power, gas and other utilities are important to all other sectors of the economy. Most of the products are transported by the sector (43) Land transport, making it the main link between sectors and with the final demand. (40) Construction is responsible for increasing the country's production capacity and infrastructure. The driving sectors are (19), (38) and (40), as in addition to having the greatest impacts on the production chains in which they are inserted, they also have a high share in terms of national production.

New research can develop new economic indicators that measure linkages across sectors. In addition, the size of the country increases the importance of a regional economy approach with the identification of key sectors for macro-regions and states and the measurement of the economic impacts of the flows of goods and services between regions.

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Appendix. Economic indicators based on the 2017 input-output matrix of Brazil.

Sector	*Billions of Reais*			*Normalized values*			*Indexes of Rasmussen-Hirschman*		*Participation in production*	*Classification Total GHS*
	GHS backard	*GHS forward*	*GHS total*	*GHS backard*	*GHS forward*	*GHS total*	*RH backard*	*RH forward*		
1	122.17	159.08	281.25	2.08	2.72	2.40	0.92	1.85	3.2%	9
2	36.34	95.99	132.33	0.62	1.64	1.13	1.00	0.88	1.3%	17
3	6.30	14.12	20.42	0.11	0.24	0.17	0.75	0.73	0.3%	61
4	1.35	17.22	18.56	0.02	0.29	0.16	1.04	0.69	0.2%	64
5	47.36	84.41	131.76	0.81	1.44	1.12	1.05	1.15	1.3%	18
6	39.65	13.39	53.04	0.68	0.23	0.45	0.95	0.70	0.6%	46
7	8.35	7.66	16.00	0.14	0.13	0.14	1.13	0.70	0.2%	66
8	298.50	31.46	329.96	5.09	0.54	2.82	1.34	0.75	2.5%	4
9	54.41	18.24	72.64	0.93	0.31	0.62	1.26	0.68	0.6%	37
10	228.78	70.83	299.61	3.90	1.21	2.56	1.25	0.98	2.6%	8
11	45.74	27.62	73.37	0.78	0.47	0.63	1.19	0.70	0.7%	36
12	16.40	0.05	16.45	0.28	0.00	0.14	1.19	0.57	0.1%	65
13	15.92	27.34	43.26	0.27	0.47	0.37	1.11	0.93	0.5%	50
14	46.94	4.22	51.16	0.80	0.07	0.44	1.01	0.60	0.6%	47
15	33.24	0.83	34.07	0.57	0.01	0.29	1.09	0.62	0.4%	56
16	7.13	18.85	25.99	0.12	0.32	0.22	1.06	0.73	0.3%	58
17	33.16	45.44	78.60	0.57	0.78	0.67	1.12	1.07	0.8%	32
18	0.20	18.57	18.77	0.00	0.32	0.16	1.01	0.74	0.2%	63
19	102.38	206.37	308.74	1.75	3.53	2.64	1.24	2.41	3.4%	7
20	34.73	20.64	55.37	0.59	0.35	0.47	1.27	0.70	0.4%	43
21	18.99	120.55	139.55	0.32	2.06	1.19	1.09	1.81	1.4%	16
22	8.35	67.13	75.48	0.14	1.15	0.64	1.11	1.15	0.7%	34
23	39.04	8.68	47.72	0.67	0.15	0.41	1.16	0.63	0.4%	49
24	31.91	16.17	48.08	0.54	0.28	0.41	0.96	0.64	0.6%	48
25	19.79	80.73	100.52	0.34	1.38	0.86	1.12	1.20	1.0%	25
26	6.97	69.10	76.07	0.12	1.18	0.65	1.15	0.84	0.7%	33
27	42.92	66.14	109.05	0.73	1.13	0.93	1.20	1.14	1.0%	21

28	22.54	30.75	53.29	0.38	0.53	0.46	1.18	0.95	0.5%	45
29	21.81	65.50	87.31	0.37	1.12	0.75	1.13	1.04	0.8%	29
30	39.37	15.05	54.43	0.67	0.26	0.46	0.99	0.78	0.8%	44
31	35.69	30.62	66.31	0.61	0.52	0.57	1.16	0.82	0.6%	39
32	64.61	27.68	92.30	1.10	0.47	0.79	1.09	0.94	1.0%	28
33	190.54	2.82	193.35	3.25	0.05	1.65	1.27	0.60	1.5%	13
34	16.09	69.73	85.82	0.27	1.19	0.73	1.16	0.95	0.8%	31
35	23.65	3.59	27.25	0.40	0.06	0.23	1.03	0.67	0.4%	57
36	43.53	15.85	59.38	0.74	0.27	0.51	1.02	0.65	0.6%	42
37	9.91	58.57	68.47	0.17	1.00	0.58	1.02	1.22	0.6%	38
38	44.52	159.97	204.48	0.76	2.74	1.75	1.08	2.04	2.7%	12
39	17.56	42.64	60.20	0.30	0.73	0.51	0.87	0.82	0.7%	41
40	335.92	50.71	386.63	5.73	0.87	3.30	1.04	0.92	5.0%	3
41	62.38	46.52	108.90	1.06	0.80	0.93	0.89	0.88	1.5%	22
42	306.31	410.80	717.11	5.22	7.03	6.12	0.86	3.75	9.5%	1
43	103.67	217.76	321.44	1.77	3.72	2.74	1.09	2.26	3.3%	5
44	5.94	13.42	19.35	0.10	0.23	0.17	0.98	0.69	0.2%	62
45	13.79	24.65	38.44	0.24	0.42	0.33	1.04	0.70	0.4%	55
46	20.12	84.80	104.91	0.34	1.45	0.90	0.88	1.26	1.1%	24
47	8.27	13.64	21.91	0.14	0.23	0.19	0.95	0.63	0.2%	60
48	182.43	37.48	219.90	3.11	0.64	1.88	1.01	0.72	2.3%	10
49	7.62	7.75	15.37	0.13	0.13	0.13	0.98	0.60	0.2%	67
50	1.72	39.21	40.93	0.03	0.67	0.35	1.01	1.09	0.4%	53
51	65.83	51.11	116.94	1.12	0.87	1.00	0.99	0.95	1.5%	19
52	25.80	69.13	94.92	0.44	1.18	0.81	0.79	1.01	1.4%	26
53	89.09	299.67	388.76	1.52	5.13	3.32	0.80	2.33	5.9%	2
54	58.16	83.16	141.32	0.99	1.42	1.21	0.62	1.06	5.5%	15
55	10.11	181.74	191.85	0.17	3.11	1.64	0.80	1.97	1.9%	14
56	13.62	28.40	42.03	0.23	0.49	0.36	0.84	0.75	0.5%	51
57	3.81	90.75	94.56	0.06	1.55	0.81	1.11	1.20	0.9%	27
58	3.46	35.72	39.17	0.06	0.61	0.33	0.82	0.85	0.4%	54
59	20.99	186.47	207.45	0.36	3.19	1.77	0.80	1.54	2.2%	11
60	0.12	41.24	41.36	0.00	0.71	0.35	0.69	0.77	0.4%	52

61	294.68	21.30	315.98	5.02	0.36	2.70	0.76	0.72	7.4%	6
62	73.76	1.62	75.37	1.26	0.03	0.64	0.68	0.57	3.1%	35
63	47.74	14.49	62.23	0.81	0.25	0.53	0.78	0.66	1.2%	40
64	86.34	0.37	86.71	1.47	0.01	0.74	0.80	0.56	1.8%	30
65	109.47	0.46	109.94	1.87	0.01	0.94	0.88	0.62	2.4%	20
66	19.14	6.51	25.65	0.33	0.11	0.22	0.89	0.64	0.4%	59
67	83.36	24.51	107.87	1.42	0.42	0.92	0.92	0.72	1.4%	23