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Insumo-Produto*

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# EVOLUTION OF THE ECONOMY OF THE STATE OF GOIÁS, BRAZIL, UNDER THE INPUT-OUTPUT MATRIX ANALYSIS

*Evolução da economia Estado de Goiás sob análise da Matriz Insumo-Produto*

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**Resumo:** O objetivo deste estudo é o de realizar um comparativo setorial da economia do estado brasileiro de Goiás, entre os anos 2011 e 2015, baseado na Matriz Multirregional de Insumo-Produto (MRIO) e, especificamente, observar a evolução dos indicadores de campo de influência e índices de ligações para frente e para trás de 22 setores agregados. O estudo preenche uma importante lacuna: não foram identificados na literatura outros trabalhos com o escopo do aqui proposto para Goiás, que é um importante player no agronegócio brasileiro, grande produtor e exportador de grãos e de proteína animal. Os resultados apontaram que o estado possui poucos setores-chave em sua economia, com baixo nível de encadeamento entre eles. Ainda, não houve mudança estrutural significativa no período analisado.

**Palavras-chave:** Estrutura Econômica. MIP. Ligações. Campo de Influência.

**Abstract:** *The objective of this study is to carry out a sectoral comparison of the economy of the Brazilian state of Goiás, between the years 2011 and 2015, based on the Multiregional Input-Output Matrix (MRIO). Specifically, we observe the evolution of the field of influence indicators and backward and forward linkages of 22 aggregated sectors. The study fills an important gap: there were no studies in the literature with the present scope for Goiás, which is an important Brazilian player of agribusiness, a major producer and exporter of grains and animal protein. The results showed that the state has few key sectors in its economy, with low linkages among them. So far, there was no significant structural change in the analyzed period.*

**Keywords:** *Economic Structure. IO. Linkages. Field of Influence.*

**Resumen:** *El objetivo de este estudio es realizar una comparación sectorial de la economía del estado brasileño de Goiás entre los años 2011 y 2015, con base en la Matriz Input-Output Multirregional (MRIO) y, específicamente, observar la evolución del campo de indicadores de influencia y índices de conexiones adelante y atrás de 22 sectores agregados. El estudio llena un vacío importante: no se identificaron otros estudios en la literatura con el alcance del propuesto aquí para Goiás, que es un actor importante en la agroindustria brasileña, un importante productor y exportador de granos y proteína animal. Los resultados mostraron que el estado tiene pocos sectores clave en su economía, con un bajo nivel de vinculación entre ellos. Aun así, no hubo un cambio estructural significativo en el período analizado.*

**Palabras clave:** *Estructura Económica; MIP; Conexiones; Campo de influencia.*

## INTRODUCTION

Economic studies that seek greater understanding of the relationships between different sectors of the economy are present, and growing in the literature, in order to understand the level of dependence between them, among their agents (families, government, companies), the international market, or in the demand for inputs such as in the supply of products and services, as well as their participation in the GDP, in the generation of income and employment, and also to observe the evolution of the productive structure and of the relations between the sectors over the years.

In the construction of this study is the search for greater understanding or the answer to the following question: has the productive structure of Goiás changed between 2011 and 2015? The basic hypothesis is that yes, and in a complementary way, that the sectors linked to agribusiness are the most important and have undergone major changes in this period.

The general objective of this work is to carry out a comparison by sectors of the economy of Goiás between 2011 and 2015, based on the Multiregional Input-Output Matrix (MRIO). Specifically, it aims to: calculate multipliers; intra- and inter-regional call indices; and fields of influence with an emphasis on evolution between years. The analysis will consider 22 aggregate sectors of the Goiás economy.

The contribution of this study is to fill an important gap: works with the scope of the one proposed here for the State of Goiás, which is an important player in national agribusiness, a large producer and exporter of grains and animal protein, were not observed in the literature. In Marques (2013), it is shown that the agribusiness segment represented, in 2008, more than a quarter of everything produced in the state, according to Value Added. Furthermore, the state occupies an area of 340,242,854 km<sup>2</sup> (IBGE, 2021a) equivalent to little more than Finland and little less than Germany.

Marques (2017; 2013), however, conducts a study for Goiás based on the year 2008, it is not multi-regional and does not compare different years. The study by Bellezoni et al. (2018) uses the same matrix as Marques (2013) for 2008, with the same limitations, but causing a shock in the production of sugar and alcohol.

In addition to this introduction, this work also brings the literature review in the second section followed by the methodology, then in the fourth the results and finally, in the last, the final considerations.

## 2 – LITERATURE REVIEW

Numerous studies have been conducted using the input-output matrix methodology for the Brazilian economy over the past few decades with the aim of deepening the understanding of countless economic sectors. Among some of the main ones, without the objective of exhausting the theme, we can mention: Guilhoto et al. (2010), Machado et al. (2001), Teixeira et al. (2020), Veiga et al. (2018), Marconi et al. (2016), Haddad et al. (2017), Takasago et al. (2010), Perobelli et al. (2015), Cohen et al. (2015), Borges and Montibeler (2014), Costa et al. (2006), Hilgemberg and Guilhoto (2006), Parré and Guilhoto (2001), Fagundes et al. (2016), Figueiredo et al. (2011), Toldi et al. (2017), Takasago (2017) and Suela et al. (2022). And for the state of Goiás, object of this study, we have only two works:

Bellezoni et al. (2018) and Marques (2013; 2017). Table 1 details the objectives, object of study and results obtained by the aforementioned authors.

For the state of Goiás, object of this research, three studies used the input-output matrix: Marques (2013; 2017) and Bellezoni et al. (2018). The first study (the one from 2017 is basically an adaptation of the 2013 work) was a pioneer in estimating an input-output matrix for Goiás based on the Table of Resources and Uses of Goiás/2008 (TRU) and 28 sectors of the economy were considered. The results of the work showed that the agribusiness segment represented in 2008 more than a quarter of everything produced in the state, according to the Added Value. However, it was still found that Goiás is characterized as a major importer of raw materials to produce final goods, to meet their consumption and is an exporter of primary products, concentrated in just two complexes, soybean, and meat.

The study by Bellezoni et al. (2018) analyzed, through the Input-Product Matrix, the impact on the future availability of natural resources with the recent expansion of the Goiás area, which has been used for the planting of sugarcane to produce sugar and ethanol, specifically in the Parnaíba-GO basin region. The results indicated that such expansion should have a low impact on the availability of land and water in Goiás.

The studies mentioned in Table 1 reveal that the Input-Output methodology is widely used by researchers interested in carrying out research on Brazil. Among the works listed, it is possible to classify them in different groups according to the research object.

There are works on: a) the Input-Output Matrix methodology, its details and evolution: Guilhoto (2004), Guilhoto and Sesso Filho (2010), Figueiredo et al.(2011), Marques (2013), and Haddad et al. (2017); b) on agriculture and agribusiness: Parré and Guilhoto (2001), Costa et al.(2006), Fagundes et al.(2016), Marconi et al.(2016) and Veiga et al.(2018); Marques (2013); c) about the environment: Machado et; al (2001), Hilgemberg and Guilhoto (2006), Bellezoni et al. (2018), Teixeira et al.(2019) and Perobelli et al.(2015); and d) on other topics related to the Brazilian economy: Takasago et al.(2010), Borges and Montibeler (2014) and Toldi et al.(2017). Without aiming to exhaust the literature on the subject, but it is possible to notice that there are few studies on the state of Goiás, which reveals the importance of the study proposed here.

### **3 – METHODOLOGY AND DATA**

Numerous works, conducted by the authors listed in section two, bring a deep and detailed discussion about the methodology for the construction of the input-output matrix (IO), among them: Guilhoto and Sesso Filho (2010), Figueiredo et al. (2011), Marques (2013) and Haddad et al. (2017), in addition of course to the classic work of Miller and Blair (2009).

The IO is officially prepared and made available by the Brazilian Institute of Geography and Statistics (IBGE) and is useful, as mentioned in section two, for the analysis of various sectors of the economy. The last IO released for Brazil was in 2015 and has 68 sectors.

Input-output analysis is an analytical model developed by Wassily Leontief in the late 1930s. Its purpose is to analyze the interdependence of sectors in an economy. The concepts established by Leontief are key components of different

types of economic analysis, and input-output analysis is one of the most applied methods in economics (MILLER and BLAIR, 2009).

For this work, the aggregation conducted and proposed by Haddad et al. (2020), called Inter-regional Input-Output Matrix for the Population Arrangement of Goiânia, 2015, which follows the estimation process of the inter-regional system called IIOAS (HADDAD et al., 2017) with aggregation into 22 sectors (Annex - Table A).

The 2011 MRIO Brazil was aggregated into 22 sectors, following the proposal by Haddad et al. (2017), where Goiás and the Rest of Brazil were extracted and, therefore, there are two regions (Goiás and Rest of Brazil) aggregated into 22 sectors, as shown in Table 2, for the years 2011 and 2015.

The present work will emphasize the region of Goiás, and not the Rest of Brazil, and these data for the Rest of Brazil can be obtained by direct request from the authors.

Table 1 - Summary of work conducted for Brazil under the input-output matrix methodology

<b>Authors</b>	<b>Goals</b>	<b>Results and Conclusions</b>
Machado et al. (2001)	Assess the total impacts of international trade on energy use and CO <sub>2</sub> emissions	They suggest that Brazilian policymakers should be concerned about the extra impacts international trade policy may have on the country's energy use and carbon emissions.
Parré and Guilhoto (2001)	Study the importance of Brazilian agribusiness for the economy as a whole and for the country's five macro-regions.	The main conclusions of the work are: there was a decrease in the concentration of agribusiness between regions and their components (inputs, agricultural production, processing and distribution).
Costa et al. (2006)	Estimate the impact of an increase in Brazilian sugar and ethanol exports on production and employment levels in Brazil.	Shocks arising from increases in the final demand for sugar and alcohol may have a more significant impact on the Brazilian economy, when they occur in the North-Northeast, compared to those originating in the Center-South.
Hilgemberg and Guilhoto (2006)	Quantify CO <sub>2</sub> emissions arising from the energy use of natural gas, alcohol, and petroleum derivatives in six Brazilian regions and assess the impacts of any emission control policies.	The main contribution is to provide the policy maker with information for decision making regarding the best emission control strategy, both nationally and internationally, making it possible to identify the key sectors in emissions and the costs involved in an eventual control policy. Obviously, such results are the result of the model used, and the formulator must consider the limitations arising from the linearity of the input-output models.
Guilhoto and Sesso Filho (2010)	Evaluate the matrix estimation methodology of input-output, at basic prices, based on preliminary data from the Brazilian National Accounts.	The series of economic indicators of the estimated matrix and that provided by IBGE are not different, based on statistical analysis (correlation indices).
Takasago et al. (2010)	Dimension tourism in Brazil, and examine, in particular, the potential for generating employment and income that it has, based on the estimation of the matrix of input-output of tourism in Brazil, for the year 2006.	The tourism complex as a whole, that is, including, in addition to tourism, its related inputs, and services provided to other sectors in the production process, the importance of the performance of tourism in Brazil is growing a lot.
Figueiredo et al. (2011)	Presentation of methodological notes for the construction of the input-output matrix for Mato Grosso, accompanied by a general analysis of the productive structure of the state's economy.	They confirmed the importance of the primary sectors in terms of their trade relations with other activities, as a way of stimulating the economy to heat up. The analysis of multipliers identified the importance of several sectors related to agribusiness, regarding their capacity for direct and indirect generation of employment and income in the economy.

<b>Authors</b>	<b>Goals</b>	<b>Results and Conclusions</b>
Borges and Montibeler (2014)	Measure the direct and indirect effects of tax cuts for a limited time on production, employment, and income generation in Brazil between 2008-09.	They showed that the countercyclical economic policy adopted by Brazil achieved a positive result and fulfilled the expected objectives.
Perobelli et al. (2015)	Evaluate the impact of consumption by Brazilian families on CO <sub>2</sub> Emissions for 2003 and 2009.	The Transport sector has the greatest negative impact during the period analyzed for all household income groups. The food industry, like most other sectors, lowers its emissions and is more pronounced in the lower consumer classes. Furthermore, the service sector has the least impact. These results are in line with the arguments that consider the assessment of emissions to be important, with particular attention to household consumption.
Fagundes et al. (2016)	Analyze the composition of the product, demand, income, and sectorial interconnections of agriculture in the state of Mato Grosso do Sul.	Purchases and sales concentrated mainly in agriculture and the food and beverage sector. In terms of GDP, agriculture was ranked among the top five in terms of product. From the perspective of income, taxes and wages in agriculture reached small proportions of the economy. In terms of demand, the highlight was the share of exports destined for the rest of Brazil. These results demonstrate the importance of agriculture in the economy of Mato Grosso do Sul, providing support for decision-making by the sector and the government.
Marconi et al. (2016)	It assesses sector performance and its effects on related sectors in the downstream and upstream chains through input-output matrices.	Two main conclusions: 1) the expansion of agricultural production and mineral commodities show little capacity to promote growth, as these sectors have low linkage rates; and 2) the analysis of the Brazilian productive structure demonstrates that sectors related to manufacturing can stimulate other sectors, such as sophisticated services, due to their high linkages with other sectors.
Haddad et al. (2017)	It presents the estimation process of an inter-regional input-output system under conditions of limited information, using the IIOAS method.	It allowed us to verify that the aforementioned method is easy to implement and can be applied to any region in a country that publishes its Use and Resources Tables – TRUs and has some type of subnational information, to be used in the regionalization process.
Toldi et al. (2017)	Evolution of agriculture and agribusiness in Brazil, between 2003 and 2013, using Leontief's input-output multipliers and Hirschman's chains.	The activities did not undergo major changes in the chains in the period. A decrease in the economic impact of employment was noted, related to mechanization, and increases in wages, profits, taxes, imports, and exports. Agro-industrial activities were identified as key sectors in the Brazilian economy in 2003. In 2013 the textile sector lost competitiveness in the forward chain.
Marques (2017)	Show Goiás' economy and its intersectoral relationships, as well as its linkages and reflexes on the economy, with 2008 as the reference year for the data.	It uses a matrix whose only region is Goiás, for 2008, with an original focus on agribusiness. The key sectors were identified: extractive industry; food and drinks; Chemicals; non-ferrous metallurgy; metal; information services; and financial intermediation services.

<b>Authors</b>	<b>Goals</b>	<b>Results and Conclusions</b>
Bellezoni et al. (2018)	To analyze the impact of expanding the sugarcane area to produce sugar and alcohol in Goiás, specifically in the Parnaíba-GO basin region.	The results are obtained from an expanded matrix by Marques (2013) for 2008 and indicated that such expansion of this crop in the region should have a low impact on the availability of land and water in Goiás.
Veiga et al. (2018)	Assess the sustainability performance of sugarcane biofuel production in Brazil, using a multi-regional input-output matrix (MRIO) to determine multipliers of carbon emissions, primary energy use, labor, imports and economic stimulus, and its relationship with the Brazilian economic system.	They suggest that if areas that were initially used as pasture for cattle are replaced for sugarcane production, energy consumption is increased by a factor of 3.7, employment is reduced by a factor of 5.4 and emissions of GHG are reduced to just 2% for each monetary unit (R\$) produced.
Teixeira et al. (2019)	Identify these strategic economic sectors for investment to mitigate GHG emissions in Brazil.	They show the importance of paying special attention to the country's productive structure and the pressure of pollution it generates. From this approach, we identified that the forest sector is still a key investment destination for the mitigation of GHG emissions. Agriculture, transport, and industrial sectors are also relevant for investment allocation

Source: Prepared by the authors.



Table 2 – Aggregation used in the research, in 22 sectors.

<b>Id/sector</b>	<b>Description</b>	<b>Code</b>
1	Agriculture, livestock, forestry, fishing, and aquaculture	Agriculture
2	Extractive industries	Mining
3	Food products	Food_prod
4	Machines and equipment	Mach_Equip
5	Other manufacturing industries	Other_man
6	Electricity and gas	Elect_gas
7	Water, sewage, waste management, and decontamination activities	Public_serv
8	Construction	Construction
9	Business; repair of motor vehicles, and motorcycles	Bus_Trade
10	Transport, storage, and mail	Transp_Storage
11	Accommodation and food	Accomodation
12	Information and communication	Information
13	Financial, insurance and related services activities	Finan_Activ
14	Real estate activities	RealState_Activ
15	Scientific, professional, and technical activities	Scient_Activ
16	Administrative activities and complementary services	Admin_Activ
17	Public administration, defense, and social security	Public_Adm
18	Education	Education
19	Human health and social services	Heath
20	Arts, culture, sport, and recreation	Arts
21	Other service activities	Other_Services
22	Domestic services	Domestic_Serv

Source: Haddad et al. (2020).

To obtain the results, the ioanalysis package (WADE; SARMIENTO-BARBIERI, 2020) and the RStudio software (RSTUDIO TEAM, 2021) with R language were used for regional and sectorial aggregations, as well as the calculation of forward linkage rates back and forth and the field of influence.

### 3.1 THE RASMUSSEN/HIRSCHMAN INDEXES

Guilhoto (2004) details the Rasmussen/Hirschman linkage indexes where it is possible to determine which sectors of an economy have greater linkage power: backward linkage indexes reveal input supplying sectors and forward linkages with input demanding sectors. Thus, defining  $b_{ij}$  from an inverse Leontief matrix  $B$ , where  $B^*$  is the mean of the elements of  $B$ ;  $B_{*j}$  and  $B_{i*}$  are, respectively, the sum of a row and a column typical of  $B$ . Therefore, the indexes of backward (1) and forward (2) links can be expressed:

$$U_j = [B_{*j} / n] / B^* \quad (1)$$

$$U_i = [B_{i*} / n] / B^* \quad (2)$$

Obtaining values above the unit indicates sectors above the average and considered key in the economy.

### 3.2 INFLUENCE FIELD

Guilhoto (2004, p.36) also highlights that the field of influence shows the changes in the direct coefficients throughout the system, in order to visualize the sectors that have the greatest impact on it.

To obtain the indicators about the field of influence, considering  $A = |a_{ij}|$  as the representation of a matrix of direct coefficients and  $E = |\varepsilon_{ij}|$  is the matrix of incremental variations in the direct input coefficients. The respective Leontief inverse matrices are given by  $B = [I-A]^{-1} = |b_j|$  and by  $B(\varepsilon) = [I - A - \varepsilon]^{-1} = |b_{ij}(\varepsilon)|$ , for a small variation ( $\varepsilon$ ) that will only occur in a direct coefficient:

$$\varepsilon_{ij} = \begin{cases} \varepsilon & i = i_1, j = j_1 \\ 0 & i \neq i_1, \text{ ou } j \neq j_1 \end{cases} \quad (3)$$

We have the field of influence of this variation (3) by approximation by the expression:

$$F(\varepsilon_{ij}) = \frac{B(\varepsilon_{ij}) - B}{(\varepsilon_{ij})} \quad (4)$$

Where  $F(\varepsilon_{ij})$  is the matrix ( $n \times m$ ) of the field of influence of the coefficient  $a_{ij}$ .

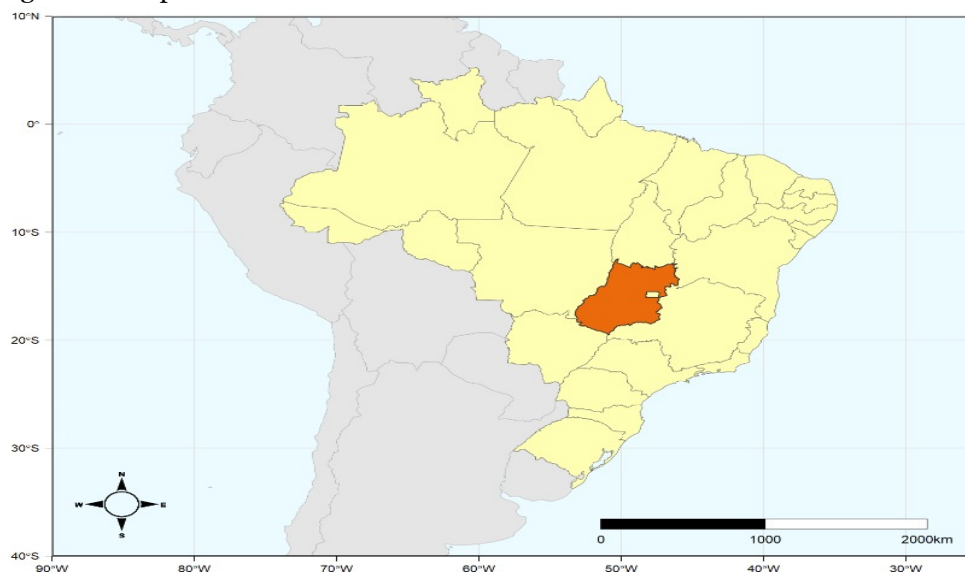
In the next section the results and their discussion are presented.

## 4 RESULTS AND DISCUSSIONS

### 4.1 THE STATE OF GOIÁS: SOCIOECONOMIC CHARACTERISTICS

The state of Goiás, object of this study, is located in the Midwest region of Brazil and borders the Federal District, where the capital, Brasília, is located (Figure 1). It occupies an area of 340,106 km<sup>2</sup>, equivalent to that of Finland. The metropolitan area of Goiânia, the state capital, has a population of 2.5 million inhabitants, out of a total of 7 million in the state, and accounts for 40% of the state's GDP. The GDP of the state in 2018 was around USD 44 billion, which represents approximately 3% of the national GDP. The state's *per capita* income is approximately USD 6.2 thousand. Electricity supply by ENEL-GO was 11 terawatt/hour (TWh) in 2019, and Brazil consumes 555 TWh annually.

Figure 1 – Map of the state of Goiás



Source: Brazilian Institute of Geography and Statistics (IBGE), 2019.

The state's average Human Development Index (HDI) is 0.69, and of the capital Goiânia, 0.799. The state's Gini coefficient is 0.56. Its economy is predominantly focused on agribusiness, especially commodities such as soy, corn, and beef cattle.

The state of Goiás is notably one of the main players in the national agribusiness, with an agro-export economy whose main products are the soy and meat chains. It occupies an area of 340,242,854 km<sup>2</sup> (IBGE, 2021a) equivalent to little more than Finland and little less than Germany. The Metropolitan Region of Goiânia, the state capital, had an estimated population in 2020 of 2.5 million inhabitants, the capital being 1.5 million, out of a total of 7 million in the state and accounting for 40% of the state's GDP (IBGE, 2020; 2021a). Table 3 brings a comparison of the GDP of Goiás with that of Brazil.

Table 3 - Gross Domestic Product (2010 to 2019)

Year	Current Values (BRL million)		Growth Rates (%)	
	Goiás	Brazil	Goiás	Brazil
2010	106,770	3,885,847	-	-
2011	121,297	4,376,382	5.8	4.0
2012	138,758	4,814,760	4.5	1.9
2013	151,300	5,331,619	3.1	3.0
2014	165,015	5,778,953	1.9	0.5
2015	173,632	5,995,787	-4.3	-3.5
2016	178,948	6,266,895	-2.8	-3.5
2017	189,129	6,593,000	1.9	1.0
2018	195,681	7,004,141	0.6	1.1
2019*	200,000	7,300,000	2.5	1.1

Source: Mauro Borges Institute (2021). \* Projections.

The GDP in 2018 was about R\$196 billion, which represents about 2.8% of the national GDP (IBGE, 2021b). Its per capita income was approximately R\$27,500. The

performance of Goiás, as an economy based on the export of agribusiness products, performed better than Brazil. In the period of analysis of this study (2011-2015), the GDP of Goiás, in nominal terms, had a balance of more than 43%, while its population grew a little more than 5.7% in the same period. Exports in 2011 reached the value of US\$5.6 billion compared to US\$5.7 billion for imports; in 2015 exports were US\$5.8 billion against US\$3.3 billion for imports. The data reveal that the increase in GDP in the period was due to a favorable trade balance in 2015 and because the state is an agro-exporter, there are signs that such advance may not be linked to a structural change, but to the increase in exports of agribusiness in Goiás.

The analysis of Tables 4 and 5 (inverse Leontief matrix or matrix of direct and indirect effects, summarized here only for the 22 sectors analyzed) indicates that agriculture (sector 1) has a greater impact on the food (3) and machinery sectors (4), which in turn impacts the construction (8) more significantly in 2011.

In any case, the literature indicates that the best way to analyze these effects considers the indexes of forward and backward sector linkages, discussed in the next section.

Table 4 – Leontief Inverse Matrix of Goiás 2011

Sectors	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	1.03	0.00	0.16	0.04	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	1.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.02	0.00	1.07	0.01	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00
4	0.03	0.03	0.02	1.06	0.04	0.01	0.02	0.06	0.01	0.01	0.06	0.01	0.01	0.00	0.01	0.01	0.00	0.03	0.01	0.02	0.00
5	0.00	0.00	0.00	0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.03	0.03	0.02	0.02	0.01	1.23	0.05	0.00	0.02	0.01	0.02	0.01	0.01	0.00	0.01	0.02	0.01	0.01	0.01	0.02	0.02
7	0.00	0.00	0.00	0.01	0.00	0.00	1.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.01
8	0.00	0.01	0.00	0.00	0.00	0.00	0.06	1.09	0.00	0.00	0.01	0.02	0.01	0.00	0.01	0.01	0.02	0.00	0.01	0.01	0.01
9	0.04	0.04	0.10	0.07	0.09	0.02	0.03	0.05	1.03	0.05	0.07	0.04	0.01	0.00	0.02	0.02	0.01	0.02	0.05	0.02	0.03
10	0.02	0.04	0.06	0.04	0.04	0.01	0.01	0.01	0.03	1.09	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.04
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.07
12	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	1.08	0.03	0.00	0.07	0.01	0.01	0.01	0.01	0.01	0.00
13	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	1.05	0.02	0.01	0.01	0.02	0.00	0.01	0.01	0.01	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.02	0.01	0.01	1.00	0.01	0.01	0.00	0.01	0.01	0.07	0.02
15	0.00	0.02	0.02	0.02	0.03	0.01	0.02	0.01	0.02	0.02	0.01	0.03	0.03	0.00	1.04	0.01	0.01	0.01	0.01	0.03	0.02
16	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.05	0.05	0.00	0.01	1.02	0.03	0.03	0.03	0.02	0.03
17	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.01	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	1.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	1.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

Source: research results.

Table 5 – Leontief Inverse Matrix of Goiás 2015

Sectors	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	1,018	0,002	0,128	0,002	0,029	0,001	0,001	0,003	0,003	0,001	0,016	0,001	0,000	0,000	0,001	0,001	0,001	0,002	0,001	0,003	0,000
2	0,001	1,022	0,000	0,000	0,003	0,002	0,001	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
3	0,014	0,002	1,065	0,001	0,011	0,000	0,001	0,001	0,002	0,001	0,049	0,001	0,001	0,000	0,001	0,003	0,004	0,005	0,001	0,006	0,000
4	0,000	0,007	0,001	1,022	0,002	0,003	0,001	0,003	0,001	0,003	0,000	0,001	0,000	0,000	0,001	0,001	0,000	0,000	0,001	0,001	0,000
5	0,047	0,050	0,035	0,045	1,093	0,017	0,024	0,073	0,016	0,022	0,063	0,018	0,008	0,004	0,016	0,014	0,007	0,007	0,040	0,024	0,022
6	0,021	0,024	0,010	0,005	0,012	1,244	0,018	0,002	0,009	0,004	0,009	0,005	0,003	0,001	0,003	0,007	0,005	0,005	0,004	0,012	0,010
7	0,000	0,004	0,002	0,001	0,004	0,001	1,009	0,001	0,004	0,003	0,006	0,002	0,002	0,001	0,002	0,012	0,012	0,004	0,008	0,003	0,010
8	0,001	0,015	0,001	0,002	0,001	0,000	0,040	1,079	0,002	0,004	0,003	0,015	0,004	0,003	0,004	0,008	0,015	0,004	0,003	0,004	0,003
9	0,049	0,051	0,083	0,089	0,074	0,017	0,021	0,053	1,025	0,048	0,061	0,034	0,010	0,004	0,022	0,015	0,010	0,013	0,057	0,019	0,026
10	0,018	0,054	0,062	0,039	0,047	0,017	0,007	0,015	0,037	1,092	0,022	0,014	0,016	0,002	0,012	0,007	0,010	0,011	0,010	0,012	0,043
11	0,000	0,002	0,001	0,002	0,002	0,002	0,001	0,002	0,002	0,002	1,001	0,005	0,006	0,000	0,004	0,004	0,010	0,004	0,013	0,004	0,058
12	0,001	0,003	0,005	0,007	0,006	0,003	0,003	0,003	0,008	0,006	0,004	1,084	0,024	0,002	0,066	0,006	0,009	0,007	0,005	0,010	0,010
13	0,010	0,018	0,016	0,014	0,016	0,014	0,010	0,013	0,018	0,021	0,013	0,027	1,095	0,031	0,016	0,015	0,049	0,005	0,017	0,020	0,014
14	0,001	0,002	0,003	0,003	0,003	0,002	0,002	0,002	0,017	0,005	0,013	0,010	0,007	1,002	0,011	0,007	0,003	0,005	0,006	0,053	0,011
15	0,005	0,022	0,025	0,030	0,033	0,014	0,018	0,017	0,027	0,024	0,012	0,049	0,038	0,005	1,051	0,017	0,013	0,011	0,013	0,044	0,022
16	0,002	0,006	0,005	0,008	0,008	0,005	0,005	0,005	0,015	0,013	0,009	0,046	0,032	0,003	0,013	1,014	0,022	0,020	0,014	0,019	0,022
17	0,001	0,003	0,004	0,004	0,004	0,003	0,002	0,001	0,003	0,003	0,002	0,005	0,004	0,001	0,005	0,002	1,002	0,002	0,002	0,006	0,005
18	0,000	0,001	0,001	0,001	0,001	0,000	0,000	0,001	0,002	0,000	0,001	0,003	0,000	0,006	0,004	0,001	1,001	0,001	0,001	0,002	0,000
19	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	1,058	0,000	0,000
20	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,008	0,001	0,000	0,001	0,000	0,001	0,000	0,000	1,014	0,006
21	0,000	0,002	0,001	0,002	0,002	0,000	0,000	0,002	0,003	0,001	0,010	0,003	0,000	0,002	0,003	0,001	0,001	0,001	0,007	0,001	1,002
22	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	1,000

Source: research results.

## 4.2 2011 AND 2015 LINK RATES

Looking at the sector linkage indexes, the key sectors are identified as those with  $U_i$  (forward link) and  $U_j$  (backward link) indexes greater than 1 (Table 6). The main sectors will be those with values greater than 1 in both directions (that is, with FL and BL indications in the same year).

It is noted that among the sectors considered key in the economy of Goiás, the construction sector stopped being in 2015, probably due to the economic slowdown, where the civil construction sector is one of the most sensitive to declines in economic activity. And there is an inversion between the Machinery and Equipment sectors (key in 2011) and Other Industries (key in 2015). There were six key sectors in 2011 and in 2015 there were five, that is, there was a drop in the level of linkage of the Goiás economy, while GDP (Table 2) increased in the same period.

Figures 2 to 3 depict the connection rates for the state of Goiás in 2011 and 2015, respectively. The main sectors will be in the upper right quadrant, denoting indexes greater than 1 in both directions.

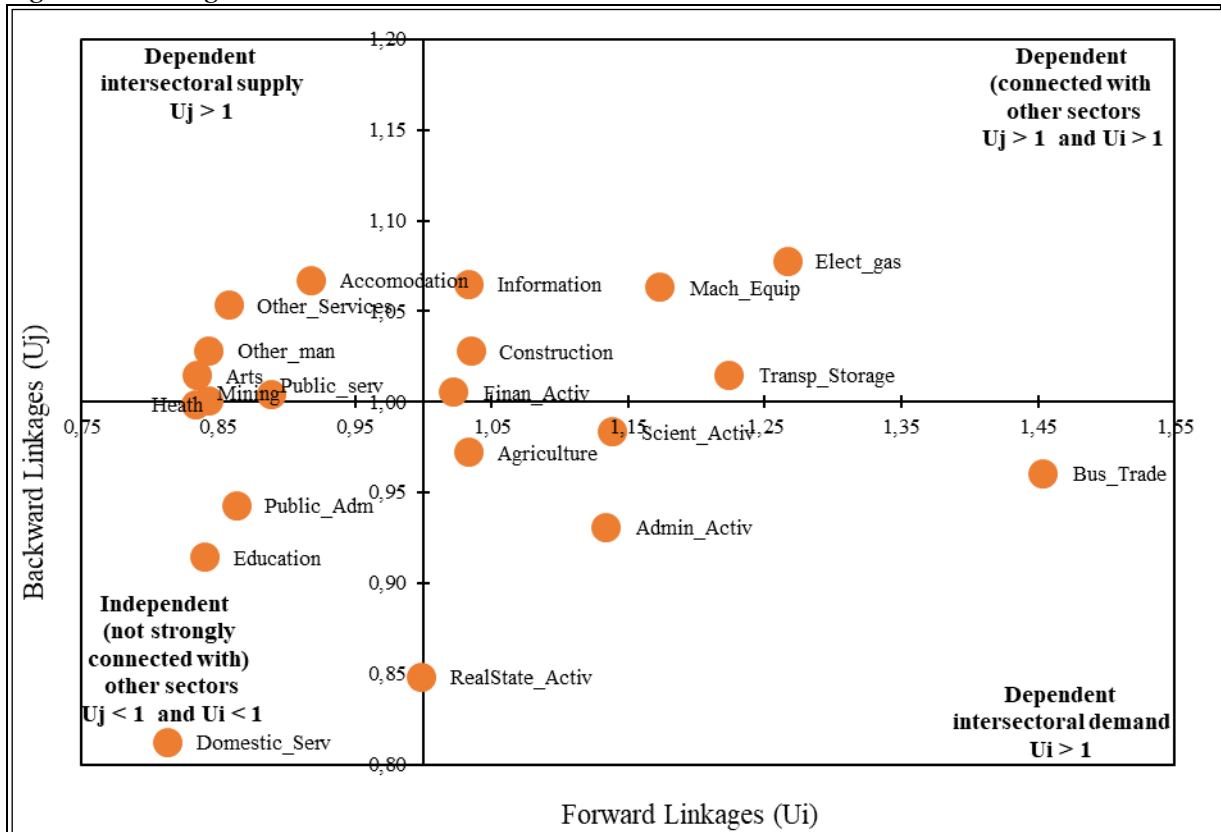
Table 6 - Forward and backward link rates for Goiás 2011 and 2015

Sector	2011		Key		2015		Key	
	$U_i$ (Forwards)	$U_j$ (Backwards)	Forwards	Backwards	$U_i$ (Forwards)	$U_j$ (Backwards)	Forwards	Backwards
Agriculture	1.033	0.972	FL	-	0.984	0.963	-	-
Mining	0.842	1.001	-	BL	0.836	1.044	-	BL
Food_prod	0.963	1.209	-	BL	0.946	1.172	-	BL
Mach_Equip	1.173	1.063	<b>FL</b>	<b>BL</b>	0.850	1.035	-	BL
Other_man	0.842	1.029	-	BL	1.333	1.095	<b>FL</b>	<b>BL</b>
Elect_gas	1.266	1.078	<b>FL</b>	<b>BL</b>	1.143	1.091	<b>FL</b>	<b>BL</b>
Public_serv	0.889	1.005	-	BL	0.882	0.942	-	-
Construction	1.035	1.028	<b>FL</b>	<b>BL</b>	0.982	1.034	-	BL
Bus_Trade	1.454	0.961	FL	-	1.442	0.966	FL	-
Transp_Storage	1.223	1.015	<b>FL</b>	<b>BL</b>	1.252	1.017	<b>FL</b>	<b>BL</b>
Accommodation	0.918	1.067	-	BL	0.911	1.040	-	BL
Information	1.033	1.065	<b>FL</b>	<b>BL</b>	1.031	1.082	<b>FL</b>	<b>BL</b>
Finan_Activ	1.022	1.006	<b>FL</b>	<b>BL</b>	1.174	1.018	<b>FL</b>	<b>BL</b>
RealState_Activ	0.998	0.848	-	-	0.947	0.858	-	-
Scient_Activ	1.138	0.984	FL	-	1.205	1.000	FL	-
Admin_Activ	1.133	0.931	FL	-	1.041	0.920	FL	-
Public_Adm	0.863	0.943	-	-	0.859	0.950	-	-
Education	0.840	0.915	-	-	0.831	0.895	-	-
Heath	0.833	0.999	-	-	0.857	1.025	-	BL
Arts	0.834	1.015	-	BL	0.837	1.010	-	BL
Other_Services	0.857	1.054	-	BL	0.847	1.034	-	BL
Domestic_Serv	0.813	0.813	-	-	0.809	0.809	-	-

Source: by the authors with research data. Note: Sectors denoted by FL and BL simultaneously are the key sectors.

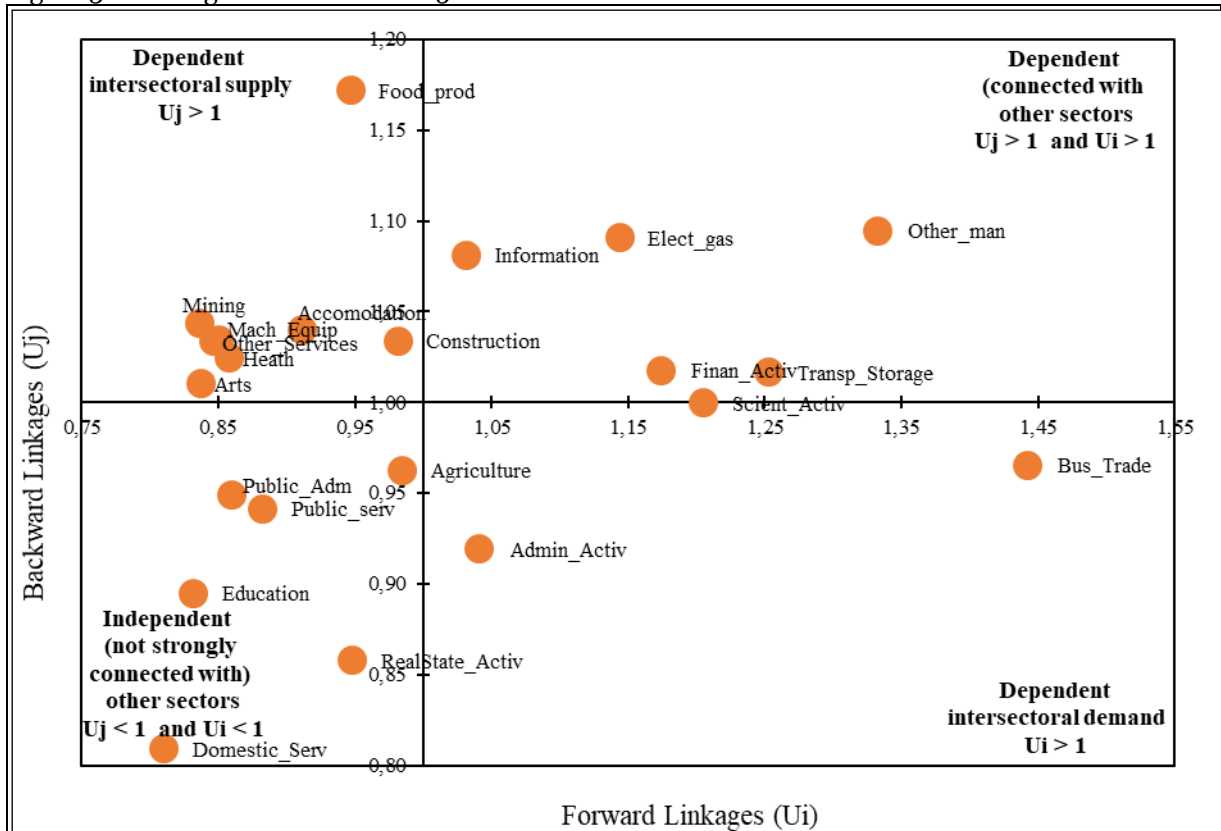
There is linkage in the sectors in the two years: Electricity (6), Information (12), Transportation (10), and Financial Activities (13). The Machines (4) and Construction (8) sectors are key only in 2011. Figure 2, Goiás 2015, brings with strong linkage, not observed in the previous period, the sector of Other Industries (5) and the sector of Construction (8) falls. In other words, in a preliminary analysis, the structural change would be small.

Figure 2 - Linking indexes Goiás 2011



Source: research results.

Figure 3 - Linking indexes Goiás 2015



Source: research results.

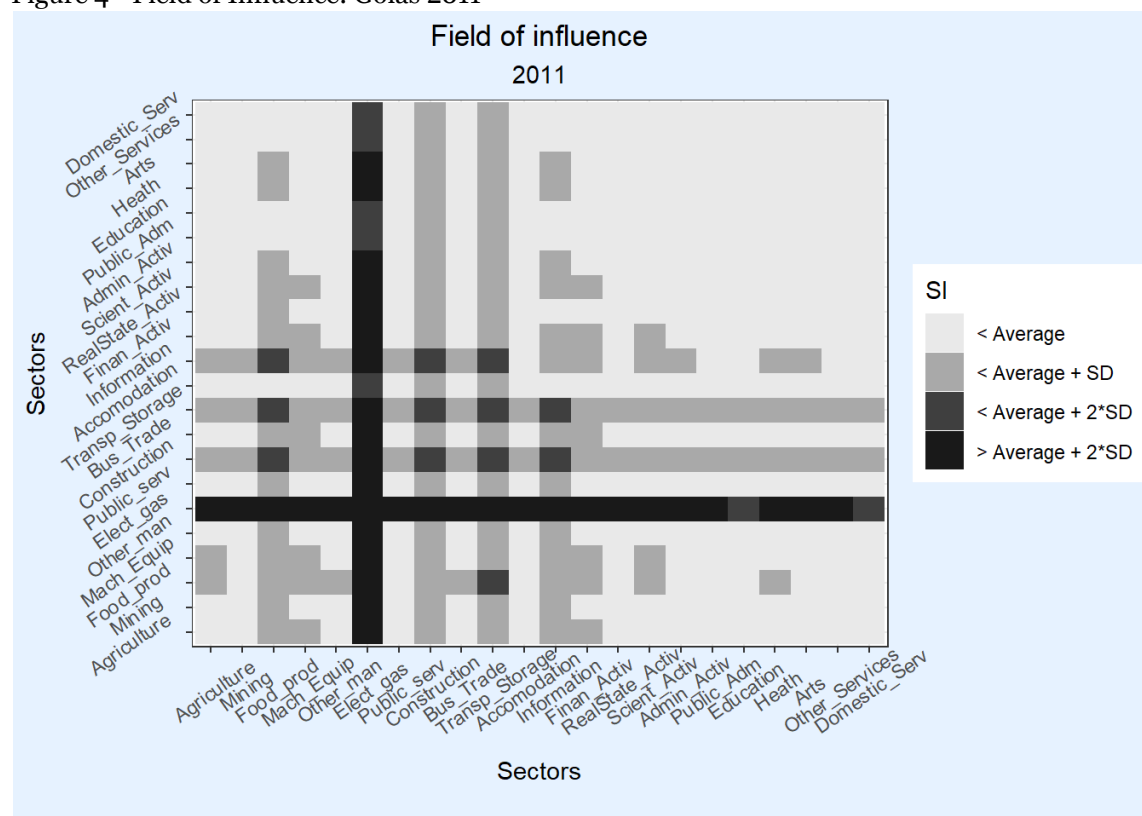
## 4.2 – 2011 AND 2015 INFLUENCE FIELDS

Sonis and Hewings (1989, 1995) describe the concept of field of influence as a non-dissociated and complementary analysis to the linkage indexes and describe how the changes in direct coefficients are distributed in the economic system. The advantage of this type of analysis lies in the possibility of determining the relationships between the sectors that would be most important in the production process.

Figures 4 and 5, respectively for 2011 and 2015, illustrate the results of the fields of influence of the Goiás economy. The highlights of the analysis are in a darker color, which shows that the changes that have taken place in the Energy and Other Industries (year 2011) and Machinery and Equipment and in Other Industries (2015) sectors have a greater impact on the economy. That is, because they have a higher level of linkage (Table 6 and Figures 2 and 3), their influence on other sectors of the economy is also greater.

Goiás in the last decade has been going through a strong energy crisis, with great difficulty in increasing the supply of electric energy. Even after the privatization of Celg-D, the distributor is still among the worst in Brazil. Given the importance of the energy sector for the growth and development of the state and the high level of linkage of this to the economy of Goiás, the low level of growth in the supply of electric energy becomes a strong obstacle to the growth of Goiás.

Figure 4 - Field of Influence: Goiás 2011

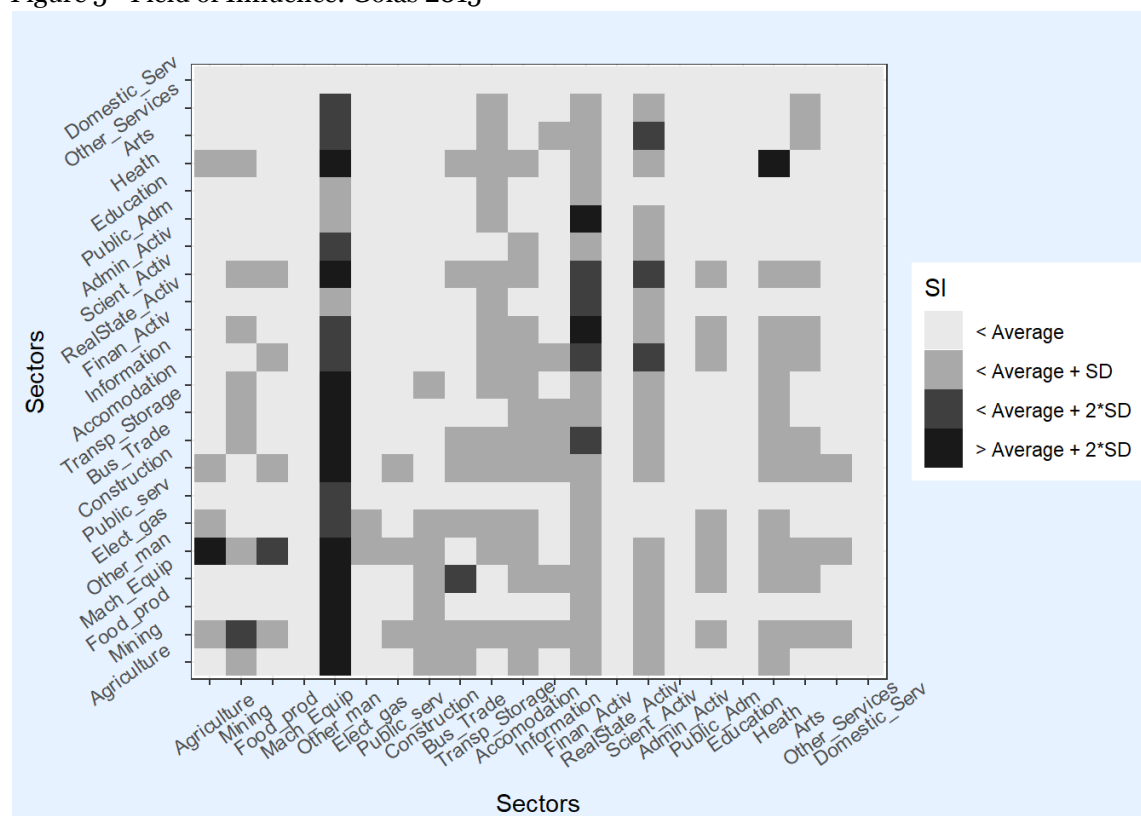


Source: Research results.

Under the strong influence of the Machinery and Equipment sector, the state is recognized as a strong Brazilian player in agribusiness, and this sector is fundamental for the growth of this activity, which generates a trade surplus, employment and income.



Figure 5 - Field of Influence: Goiás 2015



Source: Research results.

The joint analysis of the results (Table 6 and Figures 2 to 5) shows that Goiás has an economic structure, as aggregation into twenty-two sectors and for the period analyzed, with few key sectors. Greater investment is needed in sectors that have higher Connection Indices (and above unity) and a long-term policy, especially, to promote sectors linked to services, which have very low indices, whose results will take much longer. According to Marconi, Rocha and Magacho (2016), sectors linked to services on average have forward indexes greater than 1 in Brazil.

## FINAL CONSIDERATIONS

This work is important as it fills a gap in the literature for a better understanding of the economic structure of Goiás. The analysis complements that done by Marques (2013), who carried out his focused study for agribusiness, and sheds more light as he progresses significantly and produces an analysis for the entire economy of Goiás for two periods.

The economy of Goiás has few sectors considered key, which are those that, in the face of economic growth, cooperate for the expansion of other sectors, precisely because it has a strong connection with them, whether in the need for the supply of inputs, or in the availability of products for the sectors ahead. This shows that there must be policies to promote sectors that have rates of connection closer to the unit, as a way to foster the impact on sectors dependent on them. And also, attention to sectors related to services, which by nature, generate employment. Still, there was no change in the structure of Goiás in the period analyzed.

Future research can be conducted in the construction of the Input-Output Matrix for the state of Goiás for the year 2015 and thus allow comparison with

previous MRIOs and observe in a less aggregated way the structure of the economy and its evolution over the years.

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## ATTACHMENTS

Table A – Aggregation into 22 sectors proposed by Haddad et al. (2020):

#	Id	Descrição	Agregação	Id	Descrição
1	S1	Agricultura, inclusive o apoio à agricultura e a pós-colheita	1	1	Agricultura, pecuária, produção florestal, pesca e aquíicultura
2	S2	Pecuária, inclusive o apoio à pecuária	1	2	Indústrias extrativas
3	S3	Produção florestal; pesca e aquíicultura	1	3	Produtos alimentares
4	S4	Extração de carvão mineral e de minerais não-metálicos	2	4	Máquinas e equipamentos
5	S5	Extração de petróleo e gás, inclusive as atividades de apoio	2	5	Outras indústrias de manufatura
6	S6	Extração de minério de ferro, inclusive beneficiamentos e a aglomeração	2	6	Eleticidade e gás
7	S7	Extração de minerais metálicos não-ferrosos, inclusive beneficiamentos	2	7	Água, esgoto, atividades de gestão de resíduos e descontaminação
8	S8	Abate e produtos de carne, inclusive os produtos do laticínio e da pesca	3	8	Construção
9	S9	Fabricação e refino de açúcar	3	9	Comércio; reparação de veículos automotores e motocicletas
10	S10	Outros produtos alimentares	3	10	Transporte, armazenagem e correio
11	S11	Fabricação de bebidas	5	11	Alojamento e alimentação
12	S12	Fabricação de produtos do fumo	5	12	Informação e comunicação
13	S13	Fabricação de produtos têxteis	5	13	Atividades financeiras, de seguros e serviços relacionados
14	S14	Confecção de artefatos do vestuário e acessórios	5	14	Atividades imobiliárias
15	S15	Fabricação de calçados e de artefatos de couro	5	15	Atividades científicas, profissionais e técnicas
16	S16	Fabricação de produtos da madeira	5	16	Atividades administrativas e serviços complementares
17	S17	Fabricação de celulose, papel e produtos de papel	5	17	Administração pública, defesa e seguridade social
18	S18	Impressão e reprodução de gravações	5	18	Educação
19	S19	Refino de petróleo e coqueiras	5	19	Saúde humana e serviços sociais
20	S20	Fabricação de biocombustíveis	5	20	Artes, cultura, esporte e recreação
21	S21	Fabricação de químicos orgânicos e inorgânicos, resinas e elastômeros	5	21	Outras atividades de serviços
22	S22	Fabricação de defensivos, desinfestantes, tintas e químicos diversos	5	22	Serviços domésticos
23	S23	Fabricação de produtos de limpeza, cosméticos/perfumaria e higiene pessoal	5		
24	S24	Fabricação de produtos farmoquímicos e farmacêuticos	5		
25	S25	Fabricação de produtos de borracha e de material plástico	5		
26	S26	Fabricação de produtos de minerais não-metálicos	5		
27	S27	Produção de ferro-gusa/ferroligas, siderurgia e tubos de aço sem costura	5		
28	S28	Metalurgia de metais não-ferrosos e a fundição de metais	5		
29	S29	Fabricação de produtos de metal, exceto máquinas e equipamentos	5		
30	S30	Fabricação de equipamentos de informática, produtos eletrônicos e ópticos	4		
31	S31	Fabricação de máquinas e equipamentos elétricos	4		
32	S32	Fabricação de máquinas e equipamentos mecânicos	4		
33	S33	Fabricação de automóveis, caminhões e ônibus, exceto peças	4		
34	S34	Fabricação de peças e acessórios para veículos automotores	4		
35	S35	Fabricação de outros equipamentos de transporte, exceto veículos automotores	4		
36	S36	Fabricação de móveis e de produtos de indústrias diversas	5		
37	S37	Manutenção, reparação e instalação de máquinas e equipamentos	5		
38	S38	Energia elétrica, gás natural e outras utilidades	6		
39	S39	Água, esgoto e gestão de resíduos	7		
40	S40	Construção	8		
41	S41	Comércio por atacado e a varejo	9		
42	S42	Transporte terrestre	10		
43	S43	Transporte aquaviário	10		
44	S44	Transporte aéreo	10		
45	S45	Armazenamento, atividades auxiliares dos transportes e correio	10		
46	S46	Alojamento	11		
47	S47	Alimentação	11		
48	S48	Edição e edição integrada à impressão	12		
49	S49	Atividades de televisão, rádio, cinema e gravação/edição de som e imagem	12		
50	S50	Telecomunicações	12		
51	S51	Desenvolvimento de sistemas e outros serviços de informação	12		
52	S52	Intermediação financeira, seguros e previdência complementar	13		
53	S53	Atividades imobiliárias	14		
54	S54	Atividades jurídicas, contábeis, consultoria e sedes de empresas	15		
55	S55	Serviços de arquitetura, engenharia, testes/análises técnicas e P & D	15		
56	S56	Outras atividades profissionais, científicas e técnicas	15		
57	S57	Aluguéis não-imobiliários e gestão de ativos de propriedade intelectual	15		
58	S58	Outras atividades administrativas e serviços complementares	16		
59	S59	Atividades de vigilância, segurança e investigação	16		
60	S60	Administração pública, defesa e seguridade social	17		
61	S61	Educação pública	18		
62	S62	Educação privada	18		
63	S63	Saúde pública	19		
64	S64	Saúde privada	19		
65	S65	Atividades artísticas, criativas e de espetáculos	20		
66	S66	Organizações associativas e outros serviços pessoais	21		
67	S67	Serviços domésticos	22		

Source: Haddad et al. (2020)

Note: In the matrix above there are 67 sectors, unlike the Brazilian which has 68. We believe it was just a typo by the authors. In what we added to this study, we included in Sector 9 the segment “Trade and repair of motor vehicles”.

### Id Description Aggregation

Agriculture, including the support to agriculture and post-harvest

Livestock, including the support to livestock

Forest production; fishing and aquaculture.

Extraction of coal and non-metallic minerals

Oil and gas extraction, including support activities

Iron ore extraction, including processing and agglomeration

Extraction of non-ferrous metallic minerals, including processing

Slaughter and meat products, including dairy and fish products

Sugar manufacturing and refining

Other food products

beverage manufacturing  
Manufacturing of tobacco products  
Textile manufacturing  
Manufacture of apparel and accessories artifacts  
Footwear and leather goods manufacturing  
Manufacture of wood products  
Manufacture of pulp, paper, and paper products  
Printing and reproduction of recordings  
Oil refining and coke ovens  
Biofuel manufacturing  
Manufacture of organic and inorganic chemicals, resins, and elastomers  
Manufacture of pesticides, disinfectants, paints, and various chemicals  
Manufacturing of cleaning, cosmetics/perforation, and personal care products  
Manufacturing of pharmochemicals and pharmaceuticals  
Manufacture of rubber and plastic material products  
Manufacture of non-metallic mineral products  
Production of iron / pig iron / ferroalloys, steel, and seamless steel tubes  
Metallurgy of non-ferrous metals and metal smelting  
Manufacture of metal products, except machinery and equipment  
Manufacturing of computer equipment, electronics, and optical products  
Manufacture of electrical machinery and equipment  
Manufacture of mechanical machinery and equipment  
Manufacture of cars, trucks, and buses, except parts  
Manufacturing of parts and accessories for motor vehicles  
Manufacture of other transport equipment, except motor vehicles  
Manufacture of furniture and products from various industries  
Maintenance, repair and installation of machinery and equipment  
Electricity, natural gas, and other utilities  
Water, sewage, and waste management  
Construction  
Wholesale and retail trade  
Ground transportation  
Water transportation  
Air Transport  
Storage, auxiliary activities of transport and mail  
Accommodation  
Food  
Editing and editing integrated with print  
Television, radio, cinema and sound and image recording/editing activities  
Telecommunications  
Systems development and other information services  
Financial intermediation, insurance, and supplementary pension  
Real estate activities  
Legal, accounting, consulting, and company headquarters activities  
Architectural, engineering, technical testing/analysis, and R&D services  
Other professional, scientific, and technical activities  
Non-Real Estate Leases and Management of Intellectual Property Assets  
Other administrative activities and complementary services  
Surveillance, security, and investigation activities  
Public administration, defense, and social security  
Public education  
Private education  
Public health  
Private health  
Artistic, creative and entertainment activities  
Membership organizations and other personal services  
Domestic services