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ATTRACTIVENESS AND ECONOMIC DIMENSION OF SUGARCANE AGRO-INDUSTRY: THE CASE OF SOUTHEASTERN BRAZIL

ATRATIVIDADE E DIMENSÃO ECONÔMICA DA AGROINDÚSTRIA CANAVIEIRA: O CASO DO SUDESTE DO BRASIL

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Abstract

This paper analyzes the attractiveness of the Southeast region of Brazil in the sugar-alcohol sector and establishes a comparison between the growth level and rate and the innovation intensity in this sector. For such, four indicators were used: the coefficient of attraction, the growth level indicator, the growth rate indicator and the innovation intensity index. The results confirmed the state of São Paulo is a significant attraction pole for sugarcane agro-industries in terms of employment. However, the innovation intensity in this State was lower than in most other States of the Southeast, as well as the growth level. On the other hand, Rio de Janeiro showed the lowest indicators, with the exception of the growth rate.

Keywords: Regional economy. Sugar-alcohol sector. Attraction coefficient. Investment. Economic growth.

Resumo

Este artigo analisa a atratividade da Região Sudeste do Brasil no setor sucroalcooleiro e estabelece uma comparação entre o nível e o ritmo de crescimento e a intensidade de inovação neste setor. Para tanto, utilizou-se quatro indicadores, a saber: o coeficiente de atração, o indicador do nível de crescimento, o indicador do ritmo de crescimento e o índice de intensidade de inovação. Os resultados confirmaram que o Estado de São Paulo é um polo de atração significativo para as agroindústrias canavieiras em termos de emprego. Porém, a intensidade de inovação neste Estado foi menor do que na maioria dos demais Estados do Sudeste, assim como o nível de crescimento. Por outro lado, Rio de Janeiro apresentou os menores indicadores, com exceção do ritmo de crescimento.

Palavras-chave: Economia regional. Setor sucroalcooleiro. Coeficiente de atração. Investimento. Crescimento econômico.

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Introduction

The origin of sugarcane culture in Brazil dates back colonization times (16th century). The sugarcane transformation process was the first secondary activity of the Brazilian economy. Over time, the production of sugarcane and the manufacture of sugar and its derivatives has gained international importance, ensuring Brazilian competitiveness in this field. And ethanol, previously considered as a by-product of sugar production, began to gain importance after the oil crises and with the growing environmental concern, from the 1970s.

Since then, the international economic situation behind such crises enabled the organization of various activities in order to strengthen ethanol production in Brazil. This organization resulted in an arrangement of interests involving the automotive industries, capital goods industries, research centers, the Government and consumers, in addition to the mills and distilleries (SHIKIDA, 2010; NASCIMENTO; OLIVEIRA NETO; FIGUEIREDO, 2011; PEREIRA; PAULA, 2017).

Such arrangement, along with the subsidies provided from the Sugar and Alcohol Institute (IAA), provided the creation of the National Alcohol Program (PROÁLCOOL) and the leverage of production in the sugar-alcohol sector (SHIKIDA, 2010).[3] The South-Central region of Brazil started gaining importance in the national context and the Southeast Region stood out due, among other factors, to São Paulo concentrating the largest centers of agricultural and sugarcane research [such as the Sugarcane Research Center (CTC)], which develop more productive cultivars and more efficient technologies.

Currently, Brazil is the largest sugarcane and sugar producer – with a production of 642.7 million tons and 29.9 million tons, respectively. In the 2019/2020 harvest, Brazil produced the equivalent of approximately 39.2% and 16.0% of the world's sugarcane and sugar production, respectively. Brazil is also the second in ethanol production – with a production of 35.3 billion liters in the same harvest, equivalent to 31.0% of world production. The United States had their ethanol production in the range of 59.7 billion liters or 52.4% of world production. In addition, the sugar-alcohol sector employed more than one million direct and indirect formal workers in the 2019/2020 harvest (NATIONAL CENTER OF SUCROENERGY AND BIOFUELS SECTOR INDUSTRIES - CEISE, 2019; UNITED STATES DEPARTMENT OF AGRICULTURE - USDA, 2020; WORLD DATA ATLAS, 2020; BRAZILIAN SUGARCANE INDUSTRY ASSOCIATION – UNICA, 2020).

In this productive scenario, Southeast region concentrates more than 64% of the sugar-alcohol sector, with São Paulo accounting for about 83% of regional production and more than 53% of national production. There are around 46% of sugar-alcohol sector jobs in the Southeast, and São Paulo holds approximately 23% of the national employment of this sector, which corresponds to 58% in the Southeast Region (GENERAL REGISTER OF EMPLOYED AND UNEMPLOYED – CAGED, 2020; UNICA, 2020). The state of São Paulo has become the largest producer in Brazilian sugar-alcohol sector.

This said, this article analyzes the attractiveness of the Southeast in Brazilian sugar and alcohol industry and establishes a comparison between the growth level and rate and the innovation intensity in this sector. It is important to highlight that cane fields, mills and distilleries are considered as components of the sugar-alcohol sector, that is, agro-industries.

Locational factors of the sugar-alcohol sector in Southeastern Brazil

Southeast is the Brazilian region that stood out in the sugar-alcohol sector production in the 2019/2020 crop, accounting for 64.67% of the national production, being 64.68% of the sugarcane national production, 73.75% of the sugar national production and 57.00% of the ethanol national production. Among Southeast states, São Paulo had the highest production share both in the Region (82.75%) and in the country (53.51%), followed by Minas Gerais, Espírito Santo and Rio de Janeiro. Table 01 shows the state production share of sugarcane, sugar and ethanol in the regional and national total.

[3]Production was distinguished in two regions, the North-Northeast and the South-Central. The agro-industries of the former using the subsidy paradigm in production, that is, depended on government subsidies to operate, while the agro-industries of the later used the technological paradigm, that is, they invested in research and development to produce cultivars and technologies capable of increasing productivity, reducing dependence on subsidies. For more details, see Shikida (1998).

Table 01: Brazil: state production share of sugarcane, sugar and ethanol for the Southeast states in the regional and national total (%) - 2020

States	Southeast				Brazil			
	Sugarcane	Sugar	Ethanol	Sector total	Sugarcane	Sugar	Ethanol	Sector total
Espírito Santo	0.69	0.63	0.59	0.69	0.45	0.47	0.33	0.44
Minas Gerais	16.41	14.55	17.58	16.37	10.61	10.73	10.02	10.59
Rio de Janeiro	0.20	0.02	0.28	0.20	0.13	0.01	0.16	0.13
São Paulo	82.70	84.80	81.55	82.75	53.49	62.54	46.48	53.51
Southeast					64.68	73.75	57.00	64.67

Source: UNICA (2020).

In relation to the national production, São Paulo is the largest producer of sugarcane, sugar and ethanol; Minas Gerais is the second largest producer of sugar and the third largest producer of sugarcane and ethanol; Espírito Santo is the tenth national producer of sugar, 11th in sugarcane and 14th in ethanol production; and Rio de Janeiro is the 17th in ethanol and 18th in sugarcane and sugar production. Even though Espírito Santo and Rio de Janeiro are not very representative, the Southeast region is of paramount importance for the sector, especially since São Paulo alone conceives more than half of the national production.

Another factor that highlights the Southeast region is the concentration of large research centers, associations, universities, research groups, etc. directly or indirectly involving the sugar-alcohol sector, such as the Sugarcane Research Center (CTC); the Federal University of Viçosa (UFV), with the Sugarcane Genetic Improvement Program (PMGCA); the Luiz de Queiroz College of Agriculture (ESALQ); the University of Campinas (UNICAMP); the Agronomic Institute of Campinas (IAC), with the Cana Program (PRÓCANA); the Sugarcane Industry Association (UNICA); the Union of Bioenergy Producers (UDOP); the Organization of Sugarcane Planters in South-Central Region of Brazil (ORPLANA); among others.

It should be noted that Southeast also concentrates most of the production units, appropriating most of the investments in sugar-alcohol sector. Table 02 shows some relevant information from these production units in the Southeast and in Brazil for the 2019/2020 harvest.

Table 02: Characteristics of sugar and alcohol mills in São Paulo, Southeast and Brazil: harvest 2019/2020

	ES	MG	RJ	SP	SE	BR
Percentage of manual harvesting (%)	17.8	4.8	78.5	2.8	1.7	8.2
Percentage of mechanical harvesting (%)	82.2	95.2	21.5	97.2	98.3	91.6
Number of mills with attached distilleries	3	22	1	131	157	258
Number of (only) distilleries	3	10	2	25	40	97
Number of (only) mills	-	2	-	4	6	12
Total number of production units	6	34	3	160	203	367
Number of direct jobs in production units	1.144	982	1,292	14.769	19.567	84.718
Sugarcane grinding capacity used (%)	69.47	82.50	45.87	85.40	85.50	81.47
Sugar production capacity used (%)	56.17	50.45	-	30.60	33.04	36.53
Ethanol production capacity used (%)	63.42	48.98	38.84	42.70	44.31	47.89
Percentage of sugarcane already owned by the production units (%)	61.83	62.39	19.50	60.76	60.91	66.26
Percentage of sugarcane purchased from third parties (%)	38.17	37.61	80.50	39.24	39.09	33.74
Grinding hours in the crop per production unit	2.854	4.323	2.244	5.001	4.783	4.457
Activity days in the crop per production unit	146	229	118	240	234	223
Average distance from cane field to mill (Km)	28.35	25.51	23.24	26.78	26.59	25.11

Source: Elaborated from CAGED (2020) and National Supply Company (CONAB, 2020) data.

Table 02 shows the Southeast region approaches the national average in some indicators: in the percentage of mechanical harvesting, the Southeast has an average below the Brazilian one, but São Paulo and Minas Gerais, the largest national producers, have an average above the national one. Sugarcane milling capacity, sugar production and ethanol production are examples of other indicators in which the Southeast approaches the national average. It is noteworthy that the sugar production capacity used in all Southeast states exceeded the Brazilian average. On the other hand, factors related to logistics still lack improvements, such as the indicator of the average distance from cane field to mill, in which only in Minas Gerais is below the national average.

Indicators of attractiveness and economic dimension

Attraction is a natural characteristic of the center-periphery relations from which the poles arise and strengthen. These relations exist due to physical and geographic factors and by the location of productive activities. Economically, attraction arises as a result of the interaction between these variables: size, location, population density and productive activities. The population density represents the labor force location and the space attractiveness to human settlements, as a function of both the available natural resources and the conditions of employment and income. On the other hand, physical and geographical factors represent the appropriate conditions for *habitat* and production activities (FERRERA DE LIMA, 2012; 2018). In both cases, attractiveness represents an adequate set of production factors, whose productive use increasingly makes the location representative for capital efficiency. Factors such as transaction, logistics and labor costs also determine the setting of a given activity in a region (FERREIRA, 1989).

Given the definition of attractiveness, an analogy can be made: in the Southeast region, the logistic cost of sugar-alcohol sector is lower than in other regions and the sector is the most technologically modern, that is, labor use is minimal, both in crop and in mill, which reduces the cost of labor force densification in productive activities. In addition, the major research centers involving this sector and the most important ports for foreign trade are located in this Region (MILANEZ *et al*., 2010; PECEGE, 2012; ALVES and FERRERA DE LIMA, 2018).

Thus, the indicators used were adapted for the analysis of the sugar-alcohol sector according to the aim of this study. These indicators are defined below:

A) Coefficient of attraction (CA)

The CA measures the attraction of the sugar-alcohol sector in southeastern Brazil. It is estimated by:

$$CA_i = \left(\frac{AE_i}{\sum_i^r AE_i}\right) \Big/ \left(\frac{P_i}{\sum_i^r P_i}\right) \qquad (01)$$

In which: AE_i represents the agro-industries total employment in each Southeast State; $\sum_i^r A_i$ represents agro-industries total employment in the Southeast; P_i represents the population of each Southeast State; $\sum_i^r P_i$ and represents the population of the Southeast; being $i = ES, MG, RJ, SP$. We considered the number of employees registered in the General Register of Employed and Unemployed (CAGED). The used population was that available at the Brazilian Institute of Geography and Statistics (IBGE).

The CA does not have an established interval; but between 0 and 100 the attraction is considered weak; between 100 and 200, the attraction is average; and above 200 the attraction is considered strong or significant. In this case, it is worth analyzing the behavior of the indicator over time and inferring about the region attractiveness profile.

The attraction of sugarcane agro-industries contributes to explain the importance of the sector in the economy of Brazilian Southeast as a hub of attractiveness. If this sector has medium or strong attraction, it will support its importance as a job generator. Otherwise, Southeast condition as an attraction center will be put into perspective, considering the sugarcane agro-industries. That is, these agro-industries will prove to be less attractive than other economic activities in the Region.

It is noteworthy that, in its original form, the CA considers the value of purchases as the stock to be analyzed, which, however, can be replaced by taxes collected, such as the Tax on Circulation of Goods and Services (ICMS), or by employment, as used in this study. Using taxes collected represents an increase in the commercial flow, since the more goods and services circulate in the

economy, the higher the tax collection from them. And regarding employment, economic expansion tends to absorb more labor and stimulate demand, thus causing economic growth (FERRERA DE LIMA, 2012).

It is worth mentioning that the attractiveness of a pole tends to grow due to investment in research, development and innovation. Therefore, it is necessary to analyze the attractiveness of sugarcane agro-industry by a complementary indicator: the Index of research, development and innovation, which in this study was adapted to Innovation Intensity Index.

B) Innovation Intensity Index (III)

The III measures the innovation intensity and potential for the sugar-alcohol sector in the Southeast. Its calculation should be made as follows:

$$III = \left(\frac{Inv_i}{\sum Inv_{ij}}\right) \Big/ \left(\frac{Invt_i}{\sum Invt_{ij}}\right) \qquad (02)$$

In which: Inv_i represents the investment in the sugarcane agro-industries innovation for each state of the Southeast; $\sum Inv_{ij}$ represents the total Southeast investment in innovation; $Invt_i$ represents the total agro-industries investment for each Southeast state; and $\sum Invt_{ij}$ represents the total Southeast investment. The *proxies* of these variables were collected at the Statistical Yearbook of Rural Credit, available at the Central Bank of Brazil, regarding as investment in innovation the credits that consider investments in agriculture, processing and industrialization. And the total investments add the costing and commercialization credits.

In the case of sugarcane agro-industry, investments in cane fields can be made both in the form of costing and in the form of direct investment; it depends on the producer's objective. In mills and distilleries, investments are generally applied in the acquisition of machinery and equipment that improve product quality and/or increase productivity. Investments in research are related to the genetic improvement of sugarcane in order to increase the content of Total Recoverable Sugar (TRS), fundamental for sugar and ethanol production.

The III uses acuity in research, development and innovation (FERRERA DE LIMA, 2012). However, in Brazil, these data are not available in a disaggregated way and those that are available do not satisfy the sector, the period and the region analyzed, so we chose to adapt it.

Considering that growth also depends on Gross Domestic Product (GDP), it is necessary to analyze two other complementary indicators, *i.e.*: the Growth Level Indicator and the Growth Rate Indicator. Such indicators will portray the Southeast economic dimension. The exposed equations were extracted from Ferrera de Lima *et al.* (2014).

C) Growth level indicator (GLI)

The GLI measures the growth level of sugarcane agro-industry in the Southeast through the Gross Value of Production (GVP) by agro-industry. This indicator is calculated as follows:

$$GLI = \frac{GVP_{ai}}{GVP_{aa}} \qquad (03)$$

In which: GVP_a represents the GVP by agro-industry of each Southeast state; and GVP_{aa} represents the average GVP by agroindustry in the Southeast. The sugarcane agro-industry GVP was obtained from the database of the Institute for Applied Economic Research (IPEA).

Originally, GDP *per capita* is used to represent economic growth. However, this work uses the GVP by agro-industry, since this can be a *proxy* for GDP *per capita* due to agro-industries not having GDP.

It is possible to fix a value as the ideal for growth level. Below the fixed value, the region (in this case, the agro-industries of each Southeast state) will be growing less than the country (in this case, the Southeast agro-industries as a whole) (BOISIER, 1989; FERRERA DE LIMA *et al.*, 2014). Analogically, we can make inferences to values above the fixed one. In this case, we will consider the agro-industries of the state will be growing more than those of the Region if the GLI exceeds 0.5.

D) Growth rate indicator (GRI)

The GRI measures the growth rate of the Southeast sugarcane agro-industry, calculated as follows:

$$GRI = \frac{\left[\left(\frac{GVP_{ait1}}{GVP_{ait0}}\right)-1\right]}{\left[\left(\frac{GVP_{aat1}}{GVP_{aat0}}\right)-1\right]} * 100 \qquad (04)$$

In which: GVP_{ait1} represents the GVP by agro-industry of each Southeast state in time t_1; GVP_{ait0} represents the GVP by agro-industry of each state in time t_0; GVP_{aat1} represents the average GVP by agro-industry in the Southeast in time t_1; and GVP_{aat0} represents the average GVP by agro-industry in the Southeast in time t_0.

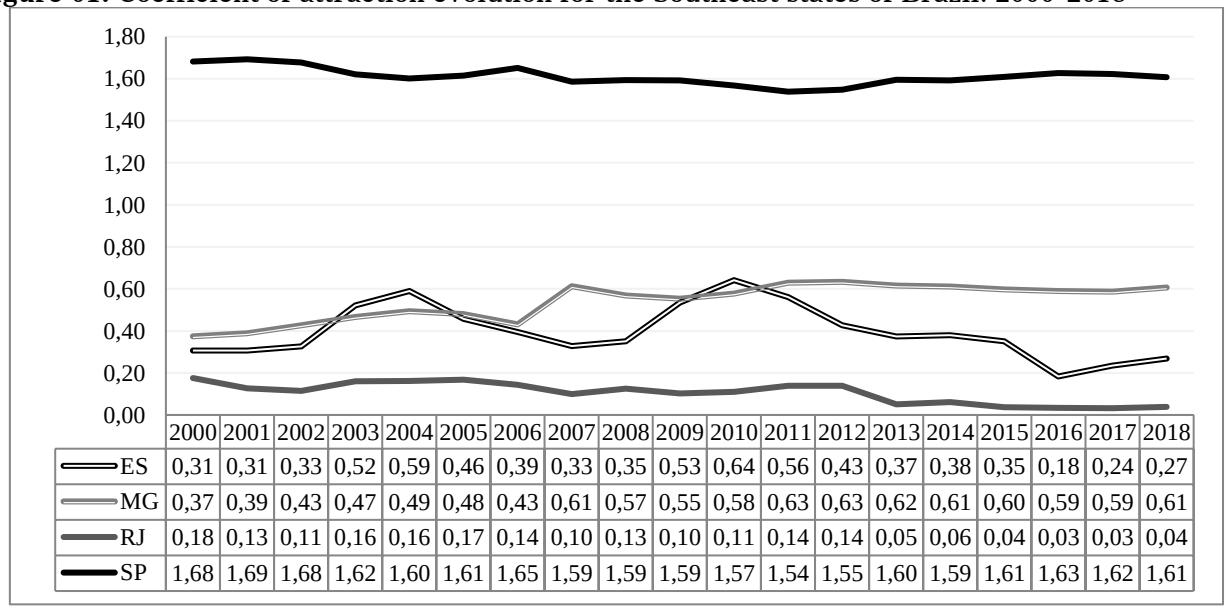
The growth rate importance in regional development occurs when the economic weight of the most significant regions increases and stimulates the less significant regions (BOISIER, 1989; FERRERA DE LIMA *et al.*, 2014). In this case, the economic weight of Southeast agro-industries should increase in the period to confirm its acuity, as promoters of regional development.

It is known the entrepreneur opts for a composition of labor, capital and technology to generate production. From the combination of these production factors he finds the balance point of production that allows profits maximization. The results of the indicators here proposed will point to, in Southeast case, whether the combination of supplies has led to a greater technological content and or the densification of the workforce.

Analysis of the indicators

For better comparison and in order to analyze behavior over time, we estimated the indicators between 2000 and 2018 for each state. Figure 01 shows the Coefficient of Attraction evolution for each Southeast state.

Figure 01: Coefficient of attraction evolution for the Southeast states of Brazil: 2000-2018



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
ES	0,31	0,31	0,33	0,52	0,59	0,46	0,39	0,33	0,35	0,53	0,64	0,56	0,43	0,37	0,38	0,35	0,18	0,24	0,27
MG	0,37	0,39	0,43	0,47	0,49	0,48	0,43	0,61	0,57	0,55	0,58	0,63	0,63	0,62	0,61	0,60	0,59	0,59	0,61
RJ	0,18	0,13	0,11	0,16	0,16	0,17	0,14	0,10	0,13	0,10	0,11	0,14	0,14	0,05	0,06	0,04	0,03	0,03	0,04
SP	1,68	1,69	1,68	1,62	1,60	1,61	1,65	1,59	1,59	1,59	1,57	1,54	1,55	1,60	1,59	1,61	1,63	1,62	1,61

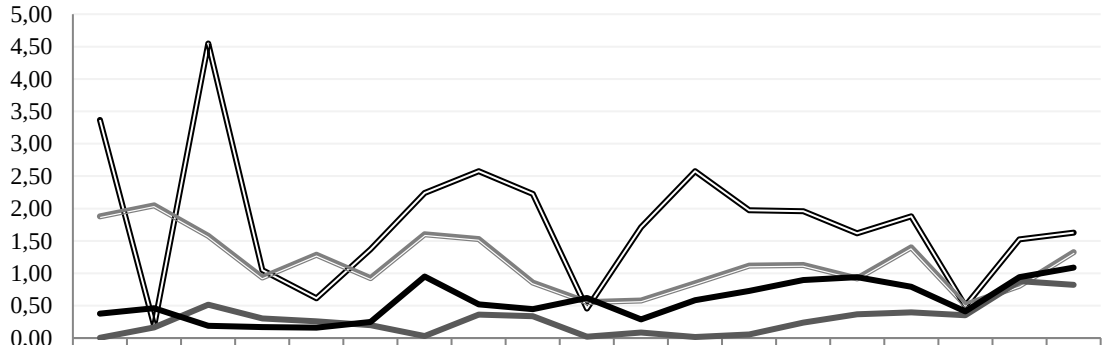
Source: Search results from the data of CAGED (2020) and IBGE (2020).

The Coefficient of Attraction results showed that São Paulo was more attractive than the other Southeast states for employment in the sugarcane agro-industry, during all the years between 2000 and 2018 (Figure 01). However, its attractiveness was reduced in this period. The explanation for this trend comes from two possibilities: firstly, mainly due to the modernization of the sector, which requires less labor, whether in cane fields or in mills and distilleries; secondly, due to the period of economic growth in the Brazilian economy at the beginning of the 21st Century, other branches of the economy had a job supply, competing with supply generated in the sugar-alcohol sector.

However, São Paulo results did not imply a greater or lesser attraction of the other states. In Rio de Janeiro, for example, the coefficient of attraction also showed a reduction. On the other hand, the coefficient of attraction of Minas Gerais increased. In the period, Minas Gerais had a greater capacity to expand jobs and attract more employees to the sugarcane agro-industry than before. Even so, it continues to attract less than São Paulo. Thus, we can affirm São Paulo represents an employment attraction pole of such agro-industry. In Espírito Santo, there was some instability until 2010, when the coefficient evolution shows a pattern of increase and reduction, reaching its peak in 2010 and, later, showing a downward trend. A possible explanation for this scenario is the instability in the number increase of mills and distilleries in Espírito Santo, which peaked in 2010 and subsequently started to reduce.

On the other hand, the III showed that investments made in sugarcane agro-industry have been expanding over the years. Figure 02 shows the evolution of this index for the Southeast states, between 2000 and 2018.

Figure 02: Evolution of the Innovation Intensity Index for the Southeast states of Brazil: 2000-2018



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
ES	3,37	0,19	4,55	1,05	0,61	1,37	2,24	2,57	2,23	0,45	1,71	2,58	1,98	1,96	1,62	1,88	0,49	1,52	1,63
MG	1,88	2,05	1,58	0,94	1,29	0,92	1,60	1,53	0,85	0,55	0,58	0,84	1,12	1,13	0,92	1,40	0,51	0,81	1,33
RJ	0.00	0,16	0,51	0,30	0,26	0,20	0,03	0,36	0,34	0,02	0,09	0,02	0,06	0,24	0,37	0,40	0,35	0,88	0,82
SP	0,38	0,46	0,19	0,17	0,16	0,25	0,95	0,52	0,44	0,62	0,29	0,59	0,73	0,89	0,94	0,79	0,41	0,94	1,09

Source: Search results from the data of the Central Bank of Brazil (2014; 2020)

The decrease in III value, from 2000 to 2018, in Espírito Santo and Minas Gerais, shows that, from the total investments made in the sugarcane agro-industry, innovation investments are losing representativeness. The other types of investments – such as crop costing or machinery maintenance and even for commercialization – were more representative than investments in innovation, that is, in farming, processing and industrialization.

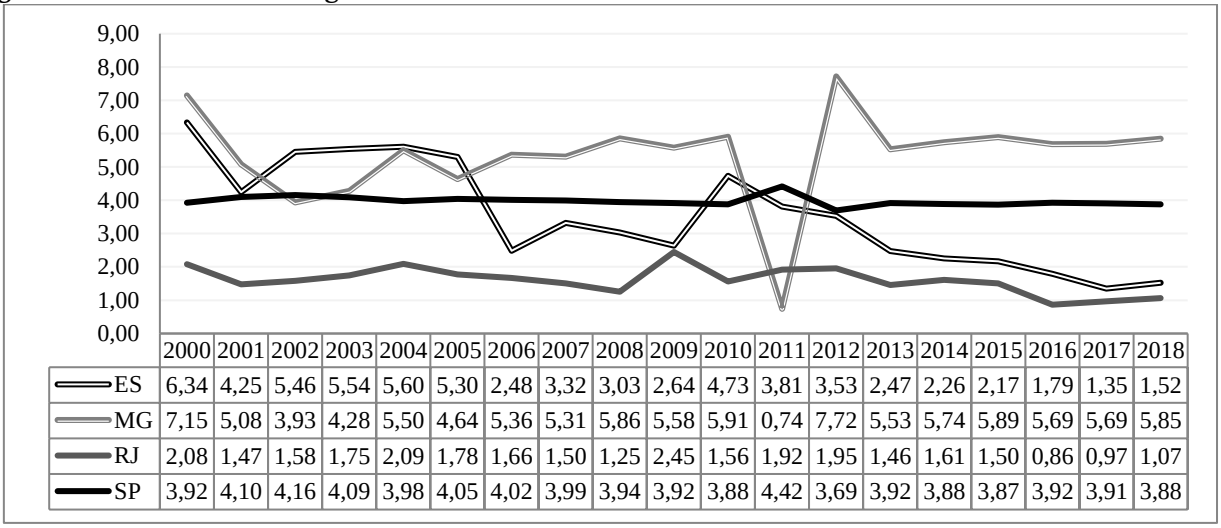
It is noteworthy that investments in sugarcane agro-industries in Espírito Santo and Rio de Janeiro are few, since these states hold few units and a their production is not focused on sugarcane. Minas Gerais has stood out as the second largest producer of sugar and the third largest producer of sugarcane and ethanol, although its agricultural *expertise* is coffee. However, we observe that innovation investments have been reducing their participation in the total investment available for sugarcane agro-industry. An explanation for this fact, according to Goebel *et al*. (2020), is a large increase in judicial reorganization requests by sugarcane agro-industries.

The sugarcane agro-industries in Rio de Janeiro, although contemplated with little resources volume for investments, showed that most of these are destined to innovation. In parallel, this same inference can be made regarding investments in São Paulo agro-industries, although these are contemplated with a large volume of resources.

Such an investment in São Paulo had so positive results that helped making this state the largest sugarcane, sugar and ethanol producer in the country. It also explains the fact that São Paulo has enough sugar-alcohol tech to attract less labor than before, without losing the attraction pole status.

Regarding the growth level indicator, it showed that agro-industries showed a growth level decrease when the extremes were analyzed, although the state of Minas Gerais showed an increase trend. Figure 03 shows the evolution of this indicator for the Southeast states, between 2000 and 2018.

Figure 03: Evolution of the growth level indicator for the Southeast states of Brazil: 2000-2018



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
ES	6,34	4,25	5,46	5,54	5,60	5,30	2,48	3,32	3,03	2,64	4,73	3,81	3,53	2,47	2,26	2,17	1,79	1,35	1,52
MG	7,15	5,08	3,93	4,28	5,50	4,64	5,36	5,31	5,86	5,58	5,91	0,74	7,72	5,53	5,74	5,89	5,69	5,69	5,85
RJ	2,08	1,47	1,58	1,75	2,09	1,78	1,66	1,50	1,25	2,45	1,56	1,92	1,95	1,46	1,61	1,50	0,86	0,97	1,07
SP	3,92	4,10	4,16	4,09	3,98	4,05	4,02	3,99	3,94	3,92	3,88	4,42	3,69	3,92	3,88	3,87	3,92	3,91	3,88

Source: Search result from Institute for Applied Economic Research (Ipea, 2020) data.

The growth level indicator showed that agro-industries, in general, reduced their growth level, although São Paulo, Rio de Janeiro and Minas Gerais showed moments of increase.

Minas Gerais was the only state that, when analyzed the extreme years, showed a reduction in the growth level, but with an increase trend. It should be noted that this state showed a GLI sharp drop in 2011. This phenomenon is due to the fact that Minas Gerais GVP by agro-industry was lower than the average GVP by agro-industry. In addition, Minas Gerais was the state showing the highest GLI since 2012, which is consistent with its productive expansion.

The decrease portrayed by Espírito Santo and Rio de Janeiro GLI should be carefully analyzed, since these states have few production units and are not major producers in the sector. Therefore, any small increase represents, relatively, major changes.

It is noteworthy that, even in São Paulo, the largest producing state in the sector, the agro-industries are growing less, and at the same time their GVP corresponded in 2018 to approximately 83% of Southeast and about 60% of the national GVP. In 2000 these values were 90% and 63%, respectively. These data corroborate the result of the growth level indicator. Another factor that explains the lower growth of agro-industries in São Paulo is portrayed in the previous paragraph. São Paulo had 99% of sugarcane agro-industries in 2018, that is, almost 25,000 agro-industries. Therefore, for the increase to be representative, it will have to be at least representative.

Moreover, the complementary analysis of the Southeast states GLI should be portrayed by the growth rate indicator, analyzed between 2000 and 2018, as Table 3 shows.

Table 3: Evolution of the growth level indicator for the Southeast states of Brazil: 2000-2018

State	Growth rate indicator (2000-2018)
Espírito Santo	21.89
Minas Gerais	81.37
Rio de Janeiro	49.86
São Paulo	98.81

Source: Search result from Ipea data (2020).

The GRI showed there was an increase in the agro-industries growth rate in all Southeast states. We highlight that, in these states, the agro-industries number increased from 2000 to 2018, with Rio de Janeiro holding the smallest increase, which went from 205 in 2000 to 259 in 2007, returning to 162 in 2018. Regarding GVP, there was an increase in all states.

Espírito Santo showed a low growth rate, consistent with its growth level and the state's position in the national production of sugarcane (11th), sugar (10th) and ethanol (14th). The same reasoning can be used to explain the low growth rate in Rio de Janeiro. Its national position in sugarcane, sugar and ethanol production is 18th for the first two and 17th for ethanol. On the other hand, Minas Gerais showed a high growth rate, consistent its representativeness in the sector.

As for São Paulo, we can say that, although its agro-industries have shown a small growth level, their rate is still accelerated. The fact that São Paulo represents more than half of national and more than 80% of Southeast production makes public and private incentives, as well as large research centers, turn to the improvement of this state's agro-industries, either in terms of sugarcane genetic improvement, or in terms of more efficient techniques of sugar and/or ethanol production. This enables a higher growth rate in relation to sugarcane other states agro-industries.

Summarizing, Table 4 shows the indicators average, together with GRI for each state.

Table 4: Southeast Region: indicators average and growth rate indicator

	CA	III	GLI	GRI
Espírito Santo	0.40	1.79	3.56	21.89
Minas Gerais	0.54	1.15	5.34	81.37
Rio de Janeiro	0.11	0.28	1.61	49.86
São Paulo	1.61	0.57	3.98	98.81

Source: Search results from data of the Central Bank of Brazil (2014; 2020), (CAGED, 2020), (IBGE, 2020) and (Ipea, 2020).

We can infer the Southeast attraction for employment in the sugarcane agro-industry is weak. For all analyzed years, the coefficient of attraction was below 1 for the states, except for São Paulo. For this state, the coefficient of attraction was above 1, but below 2, that is, São Paulo is more attractive than the other states, but its attraction is still weak.

As for the innovation intensity in sugarcane agro-industries, it is high in Espírito Santo and Minas Gerais, for most years, since much of the investments made was destined to innovation. We see the opposite in Rio de Janeiro and São Paulo, whose investments allocation for innovation is getting smaller.

The growth level and rate did not show a pattern, since Espírito Santo, with the third highest growth level, has the lowest growth rate. On the other hand, this fact may imply that the state is specializing more in other activities and not in those of the sugar-alcohol sector. Unlike São Paulo, which holds the second highest growth level and the highest growth rate.

Conclusion

This article analyzes the attractiveness of the Southeast region of Brazil in the sugar-alcohol sector and establishes a comparison between the growth level and rate and the innovation intensity in this sector. For such, four indicators were used: the coefficient of attraction, the innovation intensity index, the growth level indicator and the growth rate indicator.

We can infer the innovation intensity in sugarcane agro-industries in Espírito Santo was high, since it was above 1 (1.79). This fact may be related to the high growth level (3.56) indicated by agro-industries, although their growth rate was low (21.89). It is worth mentioning that this state, besides having few agro-industries, is also not very attractive for jobs in the sector. This was confirmed by the mean of the coefficient of attraction (0.40), and may result in more innovation investments allocation and, therefore, increased production, which, consequently, will lead to an increase in the GVP. On the other hand, Espírito Santo concentrates its productive activities in other agriculture sectors, not sugar and alcohol. Thus, we already expected the growth rate of the agro-industries from this state to be low.

In Minas Gerais, the innovation intensity in sugarcane agro-industries was also above 1 (1,15). As in Espírito Santo, this fact is related to the high growth level (5.34) pointed out by agro-industries and their growth rate, which was high (81.37). It is worth mentioning that Minas Gerais is among the three largest of the country in the sugar-alcohol sector, oscillating between the second and third position with Goiás, depending on the product and the year. Even so, Minas Gerais has few agro-industries in relation to São Paulo (the largest national and regional producer) and was not very attractive for jobs in agro-industries, which can be verified by the mean of the coefficient of attraction (0.54). On the other hand, as already pointed out, Minas Gerais concentrates its agricultural productive activities in coffee, and still is one of the three most representative states of sugar-alcohol sector.

In Rio de Janeiro, the innovation intensity in sugarcane agro-industries was low, since it was below 1 (0.28). This fact may be related to the medium growth level (1.61) indicated by agro-industries and their growth rate (49.86). It is noteworthy that, as Espírito Santo, this state has few

agro-industries and was not regarded as attractive for jobs in the sector, which we can verify by the mean of the coefficient of attraction (0.11).

São Paulo, in turn, showed low innovation intensity in sugarcane agro-industries, since III was below 1 (0.57). This fact is related to the great development of the sector, which does not require as much investment as it did before and as the agro-industries of the other states still do. Moreover, the moderate growth level (3.98) indicated by agro-industries may be another explanatory factor, although the growth rate of these agro-industries was regarded as high (98.81). It is noteworthy that this state has 99% of the Southeast sugarcane agro-industries and was more attractive for jobs than the others, which can be verified by the mean of the coefficient of attraction (1.61), and may result in more innovation investments allocation and, therefore, increased production, which, consequently, will lead to an increase in the GVP.

We should also say that this analysis has some limitations, such as not considering the investments made by the Brazilian Agricultural Research Corporation (EMBRAPA), by the Sugarcane Research Center (CTC) and by other public and private agencies, in sugar-alcohol sector research. In addition, for future studies we suggest a deeper analysis of these indicators, differentiating the periods related to the phases of the National Alcohol Program (PROALCOOL).

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