# Regional hierarchies in the sugarcane agribusiness:

## border movement and the centrality of São Paulo

# *Hierarquias regionais no agronegócio canavieiro:*

## movimento da fronteira e centralidade de São Paulo

Fernando Mesquita [ABCEF] *
Ricardo Castillo [ABEF] *
Ivette Luna [BCEF] *
Henrique Faria dos Santos [BC] *

*Universidade Estadual de Campinas, Campinas, SP, Brazil.

Abstract: The starting point for this paper takes the form of a discussion with studies related to the border movement of the sugar-energy sector and its influences on urban and regional development in the interior of Brazil. It is argued that, although this process has induced a major dispersion of production, new inequalities persist within this sector because the decision-making centers and the production of knowledge for the innovation process essentially remain located in the State of São Paulo. The methodology was based on qualitative and quantitative analyses. Data on the location of company headquarters and productive units were used for the study on the decision-making centers. In studying the centralization of knowledge, we undertook an historical investigation into how learning and sugarcane production techniques in São Paulo have evolved. From a theoretical viewpoint, the paper seeks to contribute to the analysis of how forces of geographical differentiation are present in the same productive sector.

Key-words: Sugar-energy Sector; Regional Development; New Regional Inequalities; Knowledge Production; Decision-making Centers.

Resumo: O artigo tem como ponto de partida um diálogo com análises que discutem o movimento da fronteira do setor sucroenergético e sua influência no desenvolvimento urbano e regional no interior do território nacional. O argumento é que, apesar da maior dispersão da atividade produtiva, novas desigualdades persistem nesse setor, devido aos centros de decisões e à produção do conhecimento útil ao processo de inovação, localizados essencialmente no Estado de São Paulo. A metodologia desenvolvida se fundamenta em análises quantitativas e qualitativas. No estudo dos centros de decisão, foram utilizados dados da localização das sedes e das unidades agroindustriais. No estudo da centralização do conhecimento, foi feito um exame histórico de como evoluíram o aprendizado e as técnicas associadas ao setor canavieiro em São Paulo. Do ponto de vista teórico, o artigo busca contribuir para o estudo de como forças de diferenciação geográfica atuam em um mesmo setor produtivo.

Palavras-chave: Setor Sucroenergético; Desenvolvimento Regional; Novas Desigualdades Regionais; Produção de Conhecimento; Centros de Decisões.

**Contribution of each author: A.** designed and conceived the theoretical concept and problematization; **B.** data search and statistical analysis; **C.** produced figures and tables; **D.** photographs; **E.** wrote the manuscript; **F.** selected all references.
**DOI:** https://doi.org/10.22296/2317-1529.2019v21n2p329

## INTRODUCTION

The participation of the sugar-energy sector in the dynamics of the agricultural border moving towards the Brazilian *Cerrado* (savanna) after the 2000s, with the incorporation of new cities and regions into its productive logic - mainly in portions of southern Goiás, the southwest of Mato Grosso do Sul, the *Triângulo Mineiro*, northern Paraná and to the west of São Paulo - has been the subject of much discussion in the specialized literature (PIETRAFESA; SAUER, 2012; SAUER; PIETRAFESA, 2012; SAMPAIO, 2014; CASTILLO, 2015; MESQUITA, 2016; BERNARDES; ARRUZZO, 2016; SANTOS, 2017). The major dispersion across the territory has been seen as one of the advantages of biofuels compared to oil production and extraction, since, according to a number of analyzes, it would stimulate job creation, income growth and regional development in a larger number of municipalities in the interior of the country, (MORAES; OLIVEIRA; DIAZ-CHAVEZ, 2015; CALDARELLI; MORAES; PASCHOALINO, 2017). However, little discussion has emerged with regard to the manner in which the expansion of the sugarcane border has accentuated hierarchies within the sugar-energy production system, and the manner in which a territorial division of labor, commanded from São Paulo, has imposed itself onto the cities and regions that have become part of this system.

The expansion cycle of the sugar-energy sector, induced by the emergence of hybrid engines (gasoline and anhydrous ethanol) in 2003, represents a moment in which the share of the State of São Paulo in the national production of sugarcane and ethanol was significantly reduced. However, despite this relative drop in the volume of production, São Paulo has nonetheless increased its importance in the sector. This condition becomes apparent in two dimensions: 1) in the political control of production, as the headquarters of large business groups, thereby centralizing much of the decision-making that directly affects the various units that make up their topologies; and 2) in the technical control of production, as a place for generating knowledge for industrial and agricultural segments (SANTOS, 2010). The political centrality is largely due to the role assumed by the state capital, São Paulo; while the technical centrality is located in the interior of the state of São Paulo, especially in the cities of Ribeirão Preto and Piracicaba.

The objective of this article is to present evidence that, despite the decrease demonstrated by the state of São Paulo in terms of production, it has gone on to qualify and strengthen its position in the territorial division of labor associated with the expansion of the sugar-energy sector in Brazil. Recognizing the centrality of São Paulo within the national territory is far from being a new issue (DINIZ, CAMPOLINA, 2007, LENCIONI, 2008). The contribution of this paper comes from discussing how this process has manifested itself in an activity such as sugarcane agribusiness. The outcome is that it affects the sector's potential in inducing urban and regional development throughout the country, especially since its most sophisticated portion has remained in São Paulo.

The article is based on quantitative and qualitative methods. In the study of the territorial expansion of the sugar-energy sector, data from the Sugarcane Industry Union (UNICADATA, 2018) were analyzed to specify the productive changes. This data was combined with information from the Sugarcane

Yearbook (PROCANA, 2016) to identify the municipalities with Sugar-energy Agroindustrial Units (referred to hereafter as UASs). Data was used from the National Register of Legal Entities (CNPJ – a tax registration number issued to companies), available at Infocana (2018), and consulted on the website of the Federal Revenue Department (MF, 2018), in order to analyze the year when the UASs were installed. The decision-making centers were analyzed using data on the location of UAS headquarters, available in the Sugarcane Yearbooks (PROCANA, 2008, 2016). In the study on knowledge generation, the article presents an analysis of the historical process that marked the creation of learning about sugarcane in several municipalities in the state of São Paulo.

The text is divided into five parts, in addition to this introduction. The first presents the theoretical reference, discussed in terms of the most complex knowledge and the strategic decisions that make up the new vectors of regional inequality across the country. In the second item, we analyze the performance of São Paulo in the production of sugarcane, sugar and ethanol between 2000 and 2016, seeking to understand the dynamics of the transformations that resulted from the adoption and diffusion of hybrid engine technology, as from 2003. The third and fourth parts respectively, address the results on the decision-making centers and knowledge generation in the sector. Lastly, we present the final considerations.

## POWER RELATIONS AND KNOWLEDGE PRODUCTION AS VECTORS OF REGIONAL INEQUALITIES

The manner in which different branches of economic activity have produced different relations with cities and regions is a well-established field of study in economic geography (WALKER; STORPER, 1991; SELINGARDI-SAMPAIO, 2009; STORPER, 1997, 2013; SPOSITO, 2015). Nevertheless, in the present case, the proposal is to make advances within a discussion on how the same productive branch - the sugar-energy sector - engenders unique geographical situations in every place in which it is employed.

For this analysis, the first step, as indicated by Santos (2008: 50), is to recognize that with globalization, "space becomes more diversified and heterogeneous, and, to the traditional division into regions, is added another, produced by the vectors of modernity and regulation".[1] From this perspective, regional inequalities are not just restricted to the distribution of productive units, they involve the manner in which intangible assets of knowledge beneficial to the innovation process (DINIZ; GONÇALVES, 2005; FERNANDES, 2016) and power relations (FURTADO, 1992; PAULILLO, 2000; BRANDÃO, 2004) are organized in the territory. Unlike production in itself, which is able to move about more easily, tacit knowledge and control mechanisms are linked to more complex urban and regional dynamics.

Considering the sugar-energy sector, the idea is that the recent expansion, especially in the Cerrado regions (SAMPAIO, 2014; CASTILLO, 2015; MESQUITA, 2016), according to Santos (1996, 2008), reflects a diffusion of technical-scientific--informational milieu (TSIM) across the whole country. The countryside and the

**1** This and all Portuguese citations hereafter have been translated by the authors.

cities of these new sugarcane regions have been transformed in order to meet the demands of a globalized agriculture (SANTOS, 2005; ELIAS, 2011, 2016), based on the production of sugar, biofuels and, more recently, electricity. These logics combine both market forces and state policies, e.g., gasoline price freezes (federal government) and changes in the rate of ICMS (state government sales and service tax) (MORAES; ZILBERMAN, 2014).

In spite of having a common base that combines technology, science and information in the organization and use of the territory (SANTOS, 1996; FERNANDES, 2016), the manner in which cities and regions become incorporated into the movement of the sugar-energy sector border is heterogeneous and hierarchical. Egler et al. (2011, p.32) state that "a number of cities may be hierarchized in terms of the size of their stocks (of population, of goods and services offered, etc.) and [...] the degree of interaction or interdependence between the cities may be thought of in terms of flows (of people, commerce, etc.) that exist between them". The hierarchy results from the position of centrality that certain cities present in the urban network as a whole. As our proposal is to consider the hierarchy of the cities associated with the sugar-energy productive system, centrality is associated with the determinants of technical and political control. These vectors create differentiation tendencies (SMITH, 1988) in cities and regions that are based upon the same productive branch.

In order to understand how the hierarchy process takes place in relation to technique, as a starting point, we adopt a very common discussion from economic geography: the distinction between specific and generic assets (BENKO; PECQUEUR, 2001; STORPER, 1997). Specific assets are those, which are available in a few places and are difficult to replicate in others, such as high-skilled labor, more sophisticated knowledge, teaching centers and R & D institutes. Generic assets are those, which are available in a wide range of places and are easier to replicate in others, for example, basic levels of knowledge, services and trivial techniques (SANTOS, 2008) and *commoditized*[2] technologies (STORPER, 1997; CARR, 2003).

In the sugar-energy sector, there is a tendency for cities with low demographic levels with UASs - some of which could be classified, according to Elias (2011, 2016), as "agribusiness cities" - to offer less qualified labor, services such as farm equipment repair services and agricultural machinery sales, which are essential to agricultural capital. But, these services constitute generic assets, since they are relatively simple to reproduce. These cities receive more complex knowledge, or specific assets, from other places, with a higher degree in the urban hierarchy.

The concept of innovation systems (FREEMAN, 1988; LUNDVALL, 1992) at a local level (LOPEZ; LUGONES, 1999) makes it possible to distinguish the components that enable the production of specific assets[3]. The idea of an innovation system is based on the fact that firms normally do not innovate in isolation, but rather in collaboration with public and private agents. The concept discusses the interactions between a set of agents, amongst which are firms, universities and research centers focused on production and scientific research, which drive the creation and diffusion of innovations[4]. The focus is on dynamic categories such as technological evolution and interactive learning (EDQUIST, 2006). The historical dimension is a key element, since learning is cumulative. The production of complex knowledge depends on a continuous combination of new and old skills and competences (BALLAND; RIGBY, 2017).

**2** The example used by Carr (2003) is that of information technologies in their most ordinary sense, i.e., technologies used to process, store and transport information in a digital form.

**3** There is a wide literature on local innovation systems and the production of specific assets in industrial activities. Recent examples would be the studies by Albuquerque et al. (2015) and Garcia et al. (2015). However, few have analyzed how specific assets are formed in agribusiness.

**4** In the case of the sugar-energy sector, these are incremental innovations (FURTADO; SCANDIFFIO; CORTEZ, 2011).

The adequate functioning of this system at a local level requires a certain level of urban agglomeration that enables a greater frequency in the face-to-face interactions of the agents involved in the innovation system (STORPER; VENABLES, 2004). The personal contact facilitates the transfer and mutual exchange of knowledge between researchers and producers - an essential process in the evolution of knowledge and the opening of paths not only to "reproduce what exists, but also to widen the field of what is immediately possible" (FURTADO, 2008, p 111). Diniz and Gonçalves (2005: 133) observe that "the capacity to generate knowledge and its productive application has become the most important locational factor in the current stage of economic development".

As previously mentioned, the hierarchy that accompanies the movement of the sugar-energy sector not only takes place in terms of knowledge generation, but also includes strategic decisions. Together with the territorial dispersion of the UASs, there has been an agglomeration of decision-making centers in São Paulo (FURTADO, 1992; SANTOS, 2010).

This process results from the Brazilian socio-spatial formation (SANTOS, 1977), in which the national unit is made up of an integration of "various regional productive structures above their complementarity with the command center of the country's capital accumulation (São Paulo)" (BRANDÃO, 2004, p.23). It is true that globalization has weakened the integration of the national economy, imposing a process of regional fragmentation commanded by centers outside the territory (PACHECO, 1998). At the same time, this is a moment that the metropolis of São Paulo passed through a period of economic restructuring. Administration mechanisms and the offer of services directed towards companies "reaffirms and renews the centrality of the metropolis" (LENCIONI, 2008, p.8). "The role of leadership and command of the economy exercised by the metropolis of São Paulo has been accentuated, which constitutes a privileged location for the headquarters of the large companies operating in Brazil" (LENCIONI, 2008, page 13). Globalization strengthens the function of the metropolis of São Paulo in linking the national economy to the global economy (DINIZ; CAMPOLINA, 2007; DINIZ; VIEIRA, 2016).

The urban hierarchy, associated with the political arena, is formed insofar as the interdependencies amongst the agents in the productive chain "are much more inclined towards the search for power resources than to the exclusive gains of the market, since the power resources are those that allow domination in the chain, because they grant the capacity of coordinating one or more agents" (PAULILLO, 2000, p.6). This process, in its territorial dimension, marks "the existence of an interactive force between the nodes (centers with decision-making autonomy) around which the 'satellite' spaces gravitate, with low autonomous and endogenous decision-making powers" (BRANDÃO, 2007, pp. 80)

In the sugar-energy sector, it is possible to consider power relations in two ways: through the alliance that large companies establish with the state to modify norms, regulatory mechanisms and create material conditions for the reproduction of capital (SANTOS, 1996); and, more directly, through the way that large companies interact with subsidiary firms and units that are created in other parts of the territory. The second situation - the focus of this article - enables local actions to be defined by remote agents.

The link between technical and political centrality creates new relations of

regional dependence and the subordination of certain areas to others. As Santos (2008: 101) states, "the spaces commanded by the technical-scientific milieu are the spaces that command, the others are the spaces that obey". The expansion of the border of the sugar-energy sector has reproduced this logic. The most sophisticated scientific knowledge is created in one place and applied in another. Although adaptations are required (MESQUITA, 2016), the breeding site assumes a greater degree of centrality for conducting technical direction. A similar idea applies to political power, since strategic decisions are made in one place and taken to another.

## PRODUCTION DYNAMICS AND THE GEOGRAPHIC RESTRUCTURING OF THE SUGAR-ENERGY SECTOR IN BRAZIL IN THE TWENTY-FIRST CENTURY

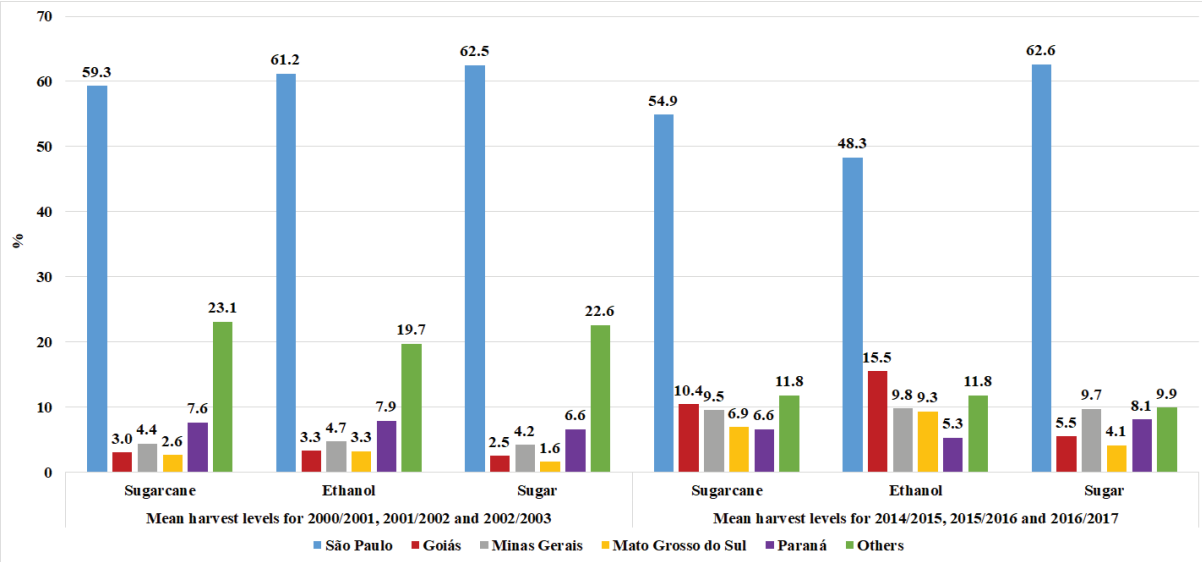
The advent of bi-fuel (gasoline-ethanol) vehicles in 2003 occasioned a number of important geo-economic transformations in the sugar-energy sector in Brazil. In response to this sudden increase in the actual and potential demand for hydrated ethanol from sugarcane, used directly as fuel for the new passenger fleet and light utility vehicles, as well as anhydrous ethanol mixed with gasoline, as Castillo (2015) demonstrated, the sector grew in Brazil much more through the incorporation of new areas (horizontal growth), jumping from around 5 million hectares in the year 2000 to close on 10 million hectares in 2016, than through productivity (vertical growth), that increased from an average yield level of 69.5 t/ha during 2000, 2001 and 2002, to an average of 73.3 t / ha in 2014, 2015 and 2016.

This horizontal growth bias has conditioned a new geographical pattern of the sector across Brazil, marked by the spatial deconcentration of agricultural and agroindustrial production, especially within the borders of the so-called Mid-Southern Region[5]. This phenomenon of the spatial deconcentration of production has led to an overspill from the core area of the large sugarcane industry in São Paulo, and crossed the state boundaries towards the states of Minas Gerais, Goiás, Paraná and Mato Grosso do Sul, which constituted what Sampaio (2014) termed the Sugarcane Macroregion of the Mid-Southern Region of Brazil (referred to as MCCSB), thereby initially aggravating the well-known environmental impacts caused by the sector (SZMRECSANYI; GONÇALVES, 2009; MENDONÇA, PITTA; XAVIER, 2012) and, consequently, increasing the territorial vulnerability of the sugarcane municipalities, especially those with low demographic levels and strongly dependent on the sector in terms of employment and income (CAMELINI, CASTILLO, 2012). It should also be pointed out that the sector, in this new phase of expansion, became the cause of structural unemployment due to the intense mechanization of sugarcane harvesting and planting, and that most of the jobs generated were poorly paid (BRINKMAN et al., 2018).

The territorial expansion of the sugar-energy sector is illustrated in Graph 1, which presents the variation in the production of sugar, ethanol and sugarcane during two periods: the mean harvest rates for 2000/2001, 2002/2003 and 2003/2004 and those for 2014/2015, 2015/2016 and 2016/2017.

**5** The term Mid-Southern Region was adopted to designate the area comprising the Southeast, South and Midwest macro-regions (defined by The Brazilian Institute of Geography and Statistics - IBGE), aiming to differentiate it from the area comprising the other sugar-producing states, located in the North and Northeast macro-regions, terms the North-Northeast Region.

**Graph 1** – Participation in the production of sugarcane, ethanol and sugar, the mean harvest rates for 2000/2001, 2001/2002, 2002/2003 and 2014/2015, 2015/2016, 2016/2017 (Selected states – major producers), Brazil




**Source:** UNICADATA (2018). **Organization:** SANTOS, Henrique F.

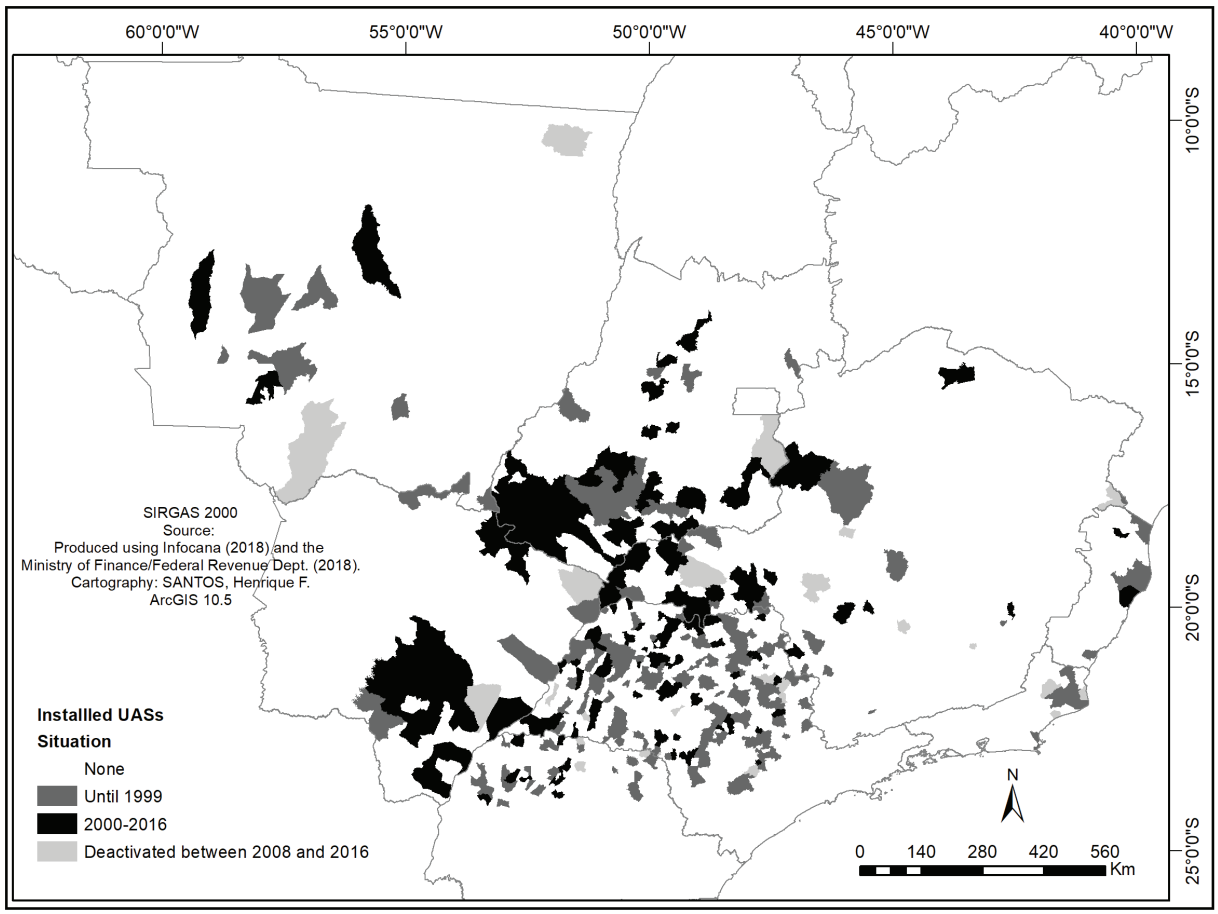
Comparing the two periods of the graph, it may be observed that the State of São Paulo lost relative participation in the total production of sugarcane in Brazil, mainly to the states of Goiás, Minas Gerais, Mato Grosso do Sul and Paraná. The geoeconomic dynamics of ethanol during the same period is similar to that of sugarcane. The participation of the State of São Paulo dropped even more abruptly in favor of Goiás, Minas Gerais, Mato Grosso do Sul and Paraná, which may also be stated with regard to all the other states in Brazil. Sugar production however, followed a different trend. In this case, São Paulo maintained its level of participation.

It should be noted that, although the production of sugarcane and ethanol in the state of São Paulo reduced in relative terms, it is increasing in absolute terms. The state of São Paulo continued to receive the most productive investments of the country. Between 2000 and 2016, 56 new UASs were implemented. The states of Goiás and Minas Gerais remained in second place, both with 26 new projects, followed by Mato Grosso do Sul, with 21 projects, and Paraná, with nine projects.

The creation of a new productive units changes the economic dynamics of the municipalities by incorporating them into an interactive network with the municipalities that were higher in the expansion hierarchy of the sugar-energy sector. Map 1 illustrates the position of the municipalities with UASs before the year 2000 in the Mid-Southern Region, as well as the position of those incorporated into the system after this date[6].

**6** The Infocana portal (2018) was used to produce this map and the Sugarcane Yearbook (PROCANA, 2016) was used to list the UAS and the municipalities in which they are located, and the portal for consultation of the National Register of Legal Entities ( CNPJ) of the Federal Revenue Department (MF, 2018), to identify the date when the company was registered.

**Map 1** – Municipalities with UASs in the Mid-Southern Region of Brazil




**Source:** Produced using Infocana (2018) and the Ministry of Finance/Federal Revenue Dept. (2018).

In Goiás, there are 34 municipalities with UASs, 27 of which have been installed since 2000. In Mato Grosso do Sul, there are 22 municipalities with UASs, 18 of which were installed after 2000. In Minas Gerais, this ratio is 32 to 18; in Paraná, 25 to 8. In São Paulo, there are 136 municipalities with units, 49 of which were implanted after the year 2000, with a good proportion located towards the western region of the State.

The data reinforce how biofuels have become a sector in which the productive activity is widely distributed across the whole country (MORAES; OLIVEIRA; DIAZ-CHAVEZ, 2015). However, this fact fails to reveal the regional inequalities and the hierarchies that persist with the movement of the sugar-energy sector border within the current context of globalization.

## THE POWER OF CONTROL: THE CENTRAL DIMENSION OF SÃO PAULO, THE STATE CAPITAL

The sugar-energy sector, unlike other branches of agribusiness - such as soy, controlled by a few multinational groups (WESZ JUNIOR, 2011) - is highly heterogeneous in regard to the agents that control the capital. Different groups coexist within this activity operating on different scales: local, regional, national and, especially after 2008, multinational groups.

The major business groups in the sector have originated from the State of São Paulo and the Northeast Region, traditional sugarcane producing areas in Brazil. In the case of São Paulo, the Ometto family groups (from which Cosan, São Martinho and the Usina São João Group originate), Biagi, Bellodi and Marchesi already owned a number of units before 1929, but grew after that period, appearing amongst the major units of the country in the 1940s, and particularly during the 1970s, benefited by the National Alcohol Program (Proálcool) (RAMOS, 2001). Outstanding in the Northeast is the growth in the state of Alagoas of Tércio Wanderley, Carlos Lyra and João Lyra, and in Pernambuco the Farias group, who, given the impossibility of growth in the northeastern Zona da Mata region, are amongst the pioneers in UAS investments in the Cerrado region (OLIVEIRA, 2009).

During the 2000s, a period of internationalization began, involving the groups that controlled the sugar-energy sector. The first group to enter this sector was Louis Dreyfus Commodities. Gradually, there was an advancement of investments from Bunge, Adecoagro, Cargill, Tereos, Evergreen, Noble, Infinity Bio-Energy and ADM (BENETTI, 2009). The years following the 2008 crisis saw the change in the sector's control groups deepen further, with the inclusion of oil companies such as Petrobras, British Petroleum (BP) and Shell, as well as Odebrecht (PIETRAFESA, PIETRAFESA, 2016), a traditional heavy civil construction company. This change took on a variety of meanings, including acquisitions, mergers and joint ventures. It is worth mentioning the cases of Raízen (a joint venture between Cosan and Shell do Brasil) and SJC Bioenergia (a joint venture between the Usina São João Group and Cargill)[7].

In order to analyze the municipalities that have taken on a greater degree of centrality in the management of the sugar-energy sector, we have used data associated with the UAS headquarters. As Moura and Werneck (2001, p. 28) demonstrated, urban centrality also "consolidates the decision-making and management system through the selective localization of public administration institutions and headquarters of large corporations, offering a clear hierarchical positioning of the centers". Data on headquarters were extracted from the Sugarcane Yearbook for the 2008/2009 and 2015/2016 harvests. The proposal was to demonstrate how this condition changed during this period. The 2008/2009 Sugarcane Yearbook presents information on a total of 406 UASs and 250 groups, while that of 2016 provides information on 401 UASs and 214 groups. Of the total data available in the 2008/2009 Yearbook, 75% of the UASs declared their headquarters, and by 2015/2016 this percentage had dropped to 74%. For the UASs that did not declare their headquarters, information was checked in the next yearbook, in the 2009/2010 yearbooks, for the undeclared headquarters in

**7** There are a number of ongoing changes in the sugar-energy sector, but this goes beyond the scope of our analysis. Infity Bio-Energy, which had gone into administration since 2009, filed for bankruptcy in 2017. But the most illustrative case is that of Bunge, one of the leaders in sugarcane processing, which in 2018 announced that it would close its commercialization of sugar and concentrate its activities in the grain sector.

the 2008/2009 yearbook, and in the 2014/2015 for the undeclared headquarters in the 2015/2016 yearbook. For the units that remained with no information, and for groups with more than one unit, we considered the headquarters as being the UAS that crushed the most sugarcane; for groups with only one unit, we considered this as the headquarters[8].

The use of data on the head offices provides an essential dimension of the sugar-energy sector's decision-making, since it is where the issues are defined, such as: investments in the industrial plant, e.g., the need to increase the crushing capacity; land control policies, both to guarantee the supply of the UAS with raw material and for speculative purposes; the management of investment funds and other financial assets; merger, acquisition and sales strategies; lobbies with the state for adopting measures that directly or indirectly benefit the sector; calculating the profitability of the sector in relation to other possible investments; logistic strategies; providing technical services to the agricultural and industrial segments.

Based on the information collected, the Socioeconomic Network Analysis (JACKSON, 2008) was used to identify the interdependencies between the UASs and the head offices for the 2015/2016[9] harvest and to present evidence that indicates the persistent centrality of localities in the State of São Paulo.

A socioeconomic network is a structure that arises from a set of nodes or agents interconnected by some type of relationship. In this case, the nodes represent the municipalities; the interaction between them is due to the control relationship between the UASs and the head offices of these municipalities. Geometrically, such networks are represented by a graph with vertices symbolizing the municipalities. Given the unilateral nature of the control relationship between a UAS and a head office, this is represented graphically with arrows leading from the municipality of a UAS towards the municipality with its head office. Thus, the greater the amount of UASs under the command of a head office, the greater the number of arrows leading towards its municipality, which, therefore, gives it a greater centrality of command within the sector.

On the other hand, a network is made up of components, which constitute the most cohesive parts of the network, in which, all the nodes are interconnected, and yet are somehow isolated from other parts of the structure, i.e., from the other components. Once these components are identified it is possible to conduct a more detailed analysis of the parts of the structure where there is greater local connectivity.

The network presented, consisting of 366 municipalities and 382 control relationships, was created using R and Pajek software. Figure 1 illustrates the two largest components of the 2015/2016 network, made up of 48% of the total municipalities considered in the survey. It should be noted that amongst the components not considered in Figure 1, most are small groups with head offices and UASs in the same place, and are made up of isolated municipalities that bring little to a more in-depth analysis of the dynamics of power relations between municipalities.

In the figure, the size of the nodes is proportional to the degree of centrality of the municipality. In the main component (a), composed of 141 municipalities and 161 control relations (respectively, 39% and 42% of the total), we highlight the centrality assumed by the municipality of São Paulo, where the head offices of groups are located that control 68 UASs, which represents 17.8% of the total productive units in the country. The importance should also be noted of centers in the Northeast,

**8** Raízen is a case that deserves greater detail, given its size and representation in the sugar-energy sector. This group appears in the Yearbooks in two headquarters: São Paulo and Piracicaba. Information from the company's website highlights four offices in the country: one in Rio de Janeiro, one in São Paulo and two in Piracicaba. It was decided to consider Piracicaba as its headquarters.

**9** The analysis was conducted for the years 2008/2009 and 2015/2016, but since no significant changes were observed between the two periods, we chose to present the results only from 2015/2016. The changes between these two periods may be observed in Graph 2 and Figure 2.

such as Maceió and Recife, which appear respectively as the second and third most relevant centers in the network. Outstanding in the interior of São Paulo, is the role of Campinas, with the head office of the Odebrecht group, and Presidente Prudente, with the head office of the Lincoln Junqueira group. The second component (b), with 33 municipalities and 44 control relations (9.5% and 11.5%, respectively), Piracicaba is outstanding, with the head office of the Raízen group[10].

**10** A third component, not represented in Figure 1, preponderates the role of Maringá, with the head offices the UASs of ten different municipalities.

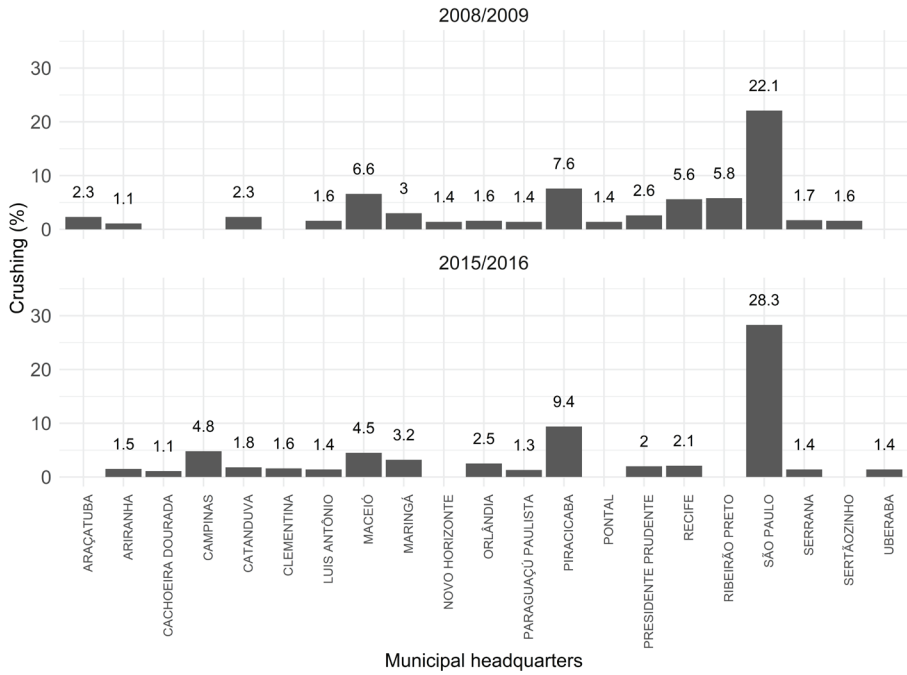
**Figure 1** – Main command centers for the sugar-energy sector in Brazil, 2016


Source: Produced by Luna, Ivette and Santos, Henrique.
Database: Procana (2016).

In terms of production control, the representativeness of the city of São Paulo is more prominent. For this analysis, the data regarding the head offices were combined with those of crushing. We searched through two yearbooks for all the UASs that acknowledged the total crushed. For those that did not provide this data, this was estimated by the average crushing of the UASs of the business group. When this calculation was not possible, we used the data from the following yearbooks, i.e., from 2009/2010 for the case of 2008/2009 and from 2014/2015 for the case of 2015/2016.

This manner of searching in other yearbooks is justified, since, in general, there is never a sudden change from one year to the other. As a result, the UASs that did not provide accurate information or that did not allow estimates were excluded from the analysis. Therefore, it is important to note that the percentage value presented does not refer to the total crushing in Brazil, but to the total crushing data encountered in the yearbooks, based on the analysis method described. Graph 2 presents the percentage of municipalities with head offices with a relative share of over 1% for 2008/2009 and 2015/2016, respectively.

**Graph 2 –** Crushing control according to municipalities with the highest number of head offices, the 2008/2009 and 2015/2016 harvest, Brazil

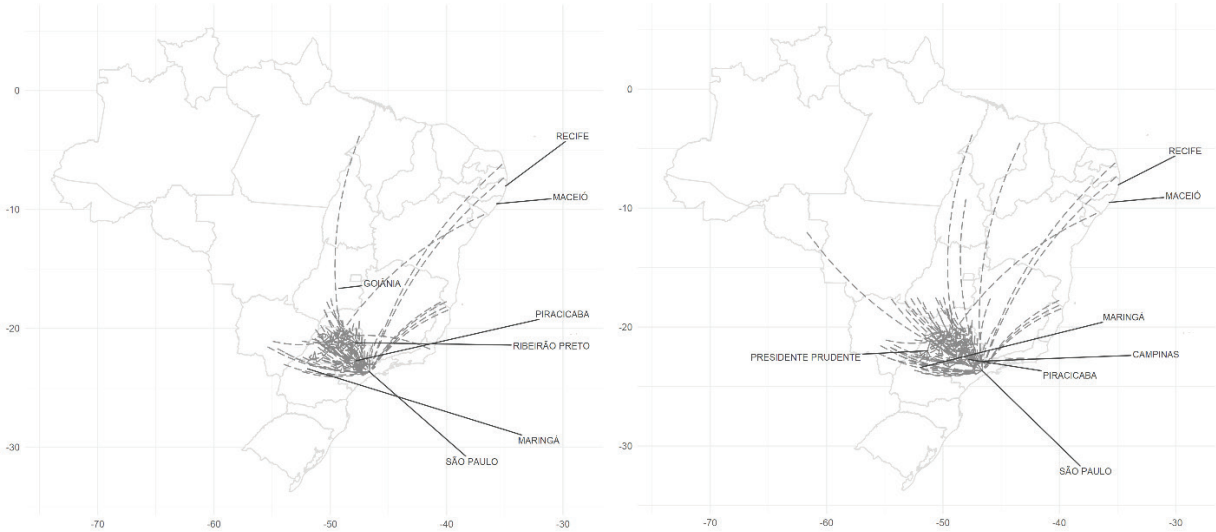



Source: Produced by Luna, Ivette and Santos, Henrique.
Database: Procana (2008, 2016).

These data reinforce the centrality of the state capital - São Paulo. In 2008/2009, groups located in the city of São Paulo accounted for 22.1% of sugarcane processing in Brazil, rising to 28.3% of the total in 2015/2016. The municipalities of Piracicaba and Campinas also demonstrate gains. In addition, the State of São Paulo controls a number of UASs, which accounted for 69.1% in 2008/2009 and 73.2% in 2015/2016. In turn, the main municipalities of the Northeast, Maceió and Recife, presented a drop in their participation - from 6.6% to 4.5% and 5.6% to 2.1%, respectively.

The head offices located in São Paulo control a major part of the UASs in Brazil, as may be observed in Figure 2.

**Figure 2 –** Locations of the UASs controlled by the head offices in São Paulo, 2008/2009 and 2015/2016 harvests




(2008/2009) (2015/2016)

Source: Produced by Luna, Ivette and Santos, Henrique.
Database: Procana (2008, 2016).

Comparing the two periods, an increase may be observed in the UAS networks based in São Paulo leading towards the north of Paraná, the southwest of Mato Grosso do Sul, the *Triângulo Mineiro* and, mainly, the south of Goiás. The cases of the states that presented higher growth rates in the production of ethanol and sugarcane - as discussed in the previous item - are precisely those in which the São Paulo networks have advanced with greater intensity. The expansion of the sugar-energy sector frontier, therefore marks a new scale of territorial performance of the groups in São Paulo, mainly expressed in the increased power of control of the state capital - São Paulo.

## THE CENTRALIZATION OF KNOWLEDGE: THE SPECIFICITY OF THE INTERIOR OF SÃO PAULO

The origins of scientific agriculture in São Paulo date from the end of the nineteenth century, when the Agronomic Institute of Campinas (IAC) was inaugurated. Research into sugarcane was one of the institute's first, beginning in 1892, with trials involving variety testing and changes in the ways of cultivation. Mosaic disease in the 1920s, which affected sugarcane plantations, stimulated major investments into genetic improvement programs. The first program by IAC aimed at this purpose was implemented in 1934, in Piracicaba (HASEGAWA, 2005).

This city was already home to the Luiz de Queiroz School of Agriculture (ESALQ), founded in 1899, with the goal of developing professional agricultural education in the State of São Paulo. In summary, the university's proposal was: i) to train professionals capable of rationally exploiting rural properties; ii) to produce studies on adapting plants to the particular natural conditions of São Paulo; iii) to

complement the activities carried out by IAC, responsible for research, while ESALQ took charge of agricultural education (ALBUQUERQUE; ORTEGA; REYDON, 1986).

After the 1950s, ESALQ underwent a modernization phase, by beginning postgraduate education and strengthening the research program. Although sugarcane was never the only research activity at ESALQ, the expansion of agriculture created an environment that was conducive to placing emphasis on this particular crop, as employment opportunities expanded. The ESALQ then became a professional training center for work in agronomy at production units and research centers.

Piracicaba was also the location for the Brazilian main capital goods industry associated with the sugar cane industry. Dedini, created in 1920 as a repairs and maintenance workshop, grew with the sugarcane expansion in São Paulo, thereby broadening knowledge on the production and maintenance of equipment. Gradually, the industry acquired the capacity to build complete plants for the production of sugar, ethanol and cogeneration of energy (NEGRI, 2000). The production of technologies for the sector therefore ceased to only be associated with the agricultural segment and now turned to the industrial system as well.

Towards the end of the 1960s, Piracicaba received investments in the area of technology from Copersucar - an institution founded in 1959 through two regional cooperatives: Coopira and Coopereste. During this period, considering that the 1960s was a moment when investments were withdrawn from agricultural research, which particularly affected IAC and Copersucar, as Belik (1985, p. 112) revealed, it was decided to create a

> research center, where, in a centralized manner, the study of new varieties and new production processes could be developed. Prior to this, the company maintained a technical assistance scheme aimed at assisting associates while conducting research in the plants in isolation.

Therefore, even before Brazil became aware of the vigorous investment in agricultural research in the 1970s, when the Brazilian Agricultural Research Corporation (Embrapa) was founded, São Paulo was already building central components of the sugarcane innovation system, especially with the role played by Campinas and Piracicaba.

In the 1970s, a number of partnerships were created in this system. "In 1972, an agreement was signed between Copersucar and IAC for the introduction of plant substance types, enabling until 1983, the introduction of 678 genotypes from several countries" (HASEGAWA, 2005, p.52) - a fact that induced interactive learning through partnerships between research centers.

In the early 1980s, Copersucar launched sugarcane varieties that were more adapted to the natural conditions of São Paulo, allowing "greater resistance to nematodes, rapid maturation (early) with a high sugar content and higher productivity" (BELIK, 1985, p. 114). This process enabled the evolution of learning in the area of genetic improvement in the São Paulo research centers.

Once again, as from 1994, IAC played a leading role in research on the cultivation of sugarcane, with the creation of Procana. This program aimed to "create new and improved sugarcane varieties, adapted to their production environment and

accompanied by a list of instructions on management, cultivation techniques, diseases, fertilizers, etc." (HASEGAWA, 2005, 61). The manner with which to accompany the use of varieties, according to Hasegawa (2005), was the main contribution of IAC. One example was the Ambicana project, a spinoff of Procana, which worked on training technicians for the transference of knowledge regarding the environments of sugarcane production[11] (HASEGAWA, 2005, p. 110).

The change at IAC also marked its spatial dynamics, with the sugarcane research center being moved to Ribeirão Preto (SP). This was where the main IAC meetings, such as the Phytotechnic group assemblies, were held, and the seed germination stage was housed, and the redistribution of the clones to the national network was also defined (HASEGAWA, 2005; MESQUITA, 2015). The Ribeirão Preto center coordinated the Procana experimental stations in the cities of Piracicaba, Jaú, Mococa, Pindorama, Adamantina and Assis, in the state of São Paulo; Goianésia, in Goiás; Serra Grande, in Bahia; and Ponta Porã, near Bunge in Mato Grosso do Sul. In 2005, from amongst the 37 UASs associated with IAC, 30 were in São Paulo (HASEGAWA, 2005, p.70). Ten years later, the institute had 130 associated UASs, 82 of which were in São Paulo (MESQUITA, 2015).

Copersucar also underwent a reconfiguration process during the 2000s. The technology center was privatized in 2005, due to the problems it had faced in the early 1990s, and became known as the Sugarcane Technology Center (CTC) (FURTADO; SCANDIFFIO; CORTEZ, 2011). The CTC, of which Raízen was a partner, worked on projects to develop more productive varieties of sugarcane, and has recently introduced research on transgenic varieties and cellulosic ethanol.

Considering this, the growth of the sugarcane activity in São Paulo, at least since the beginning of the twentieth century, especially after the 1970s, was not only in terms of production but also of learning. Piracicaba and Ribeirão Preto, using the term set by Ramos (2001, p. 28), reinforced one another as "radiating poles" with regards to technology and science.

In addition to Piracicaba and Ribeirão Preto, it is important to highlight the role of Campinas, with the State University of Campinas (Unicamp) - a training ground for skilled labor and research into the area of sugarcane, sugar and ethanol - and the National Bioethanol Science and Technology Laboratory (CTBE), inaugurated in 2010, together with the National Center for Research in Energy and Materials (CNPEM). The CTBE has conducted studies on the row-spacing of sugarcane, the use of straw and sustainability of ethanol. The city of Araras should also be mentioned because there is a campus of the Federal University of São Carlos (UFSCar), headquartered in São Paulo, of the Inter-University Network for the Development of the Sugarcane Sector (Ridesa). Although the priority area of action of this program, deployed from Planalsucar (FURTADO; SCANDIFFIO; CORTEZ, 2011), is not in São Paulo, the Ridesa center, linked to UFSCar, plays a prominent role in research and management supervision with the UASs in São Paulo.

Thus, a sectorial innovation system (FURTADO; SCANDIFFIO; CORTEZ, 2011) was consolidated in São Paulo, aimed at the sugar-energy sector, to support the technological development in the three main production areas: agricultural (management, genetic improvements and the use of machines and equipment), industrial (efficiency of sugar and ethanol production) and new products (green

**11** Sugarcane production environments refer to a classification that takes into consideration the interaction between variety, climate and soil. This definition is made to distinguish favorable and unfavorable environments for agriculture (MESQUITA, 2016). Each UAS presents a particular production environment, requiring a specific treatment so as to define the best management techniques and the adoption of specific varieties.

chemistry and energy cogeneration, for example) (SPÍNDOLA, LIMA; FERNANDES, 2015). Focusing on the components of this innovation system, Table 1 summarizes the main research centers, universities and industries in this sector.

**Table 1** – Components of the innovation system of the sugar-energy sector in São Paulo

| Agent | Type | Function | Location in the state of São Paulo |
|---|---|---|---|
| ESALQ | University | Preparing human resources and training for research execution | Piracicaba |
| Dedini | Industry | Production of goods and research in the area of industrial processing | Piracicaba |
| IAC | Research Center | Formation of scientific knowledge in agricultural management and genetic improvement | Ribeirão Preto |
| Ridesa | Research Center | Formation of scientific knowledge in agricultural management and genetic improvement | Araras |
| CTC | Research Center | Formation of scientific knowledge in agricultural management, industrial processing and genetic improvement | Piracicaba |
| CTBE | Research Center | Formation of scientific knowledge in agricultural management and industrial processing | Campinas |

Source: Produced by MESQUITA, Fernando from Furtado, Scandiffio e Cortez (2011).

Thus, through the individual work of each component within this innovation system, the collaboration amongst them and, above all, the interaction with the UASs in São Paulo, during the twentieth century, a set of sophisticated knowledge was created regarding sugarcane, which is constituted in the specific assets of certain poles in the interior of São Paulo. The expansion of sugarcane to the states of Goiás, Mato Grosso do Sul, Minas Gerais and Paraná, at the beginning of the twenty-first century, marked the territorial broadening of the performance of these components of the São Paulo innovation system that began to interact with UASs in other states. This interaction has been hierarchical, since it is the relationship between municipalities that produce specific assets and other producers of generic assets.

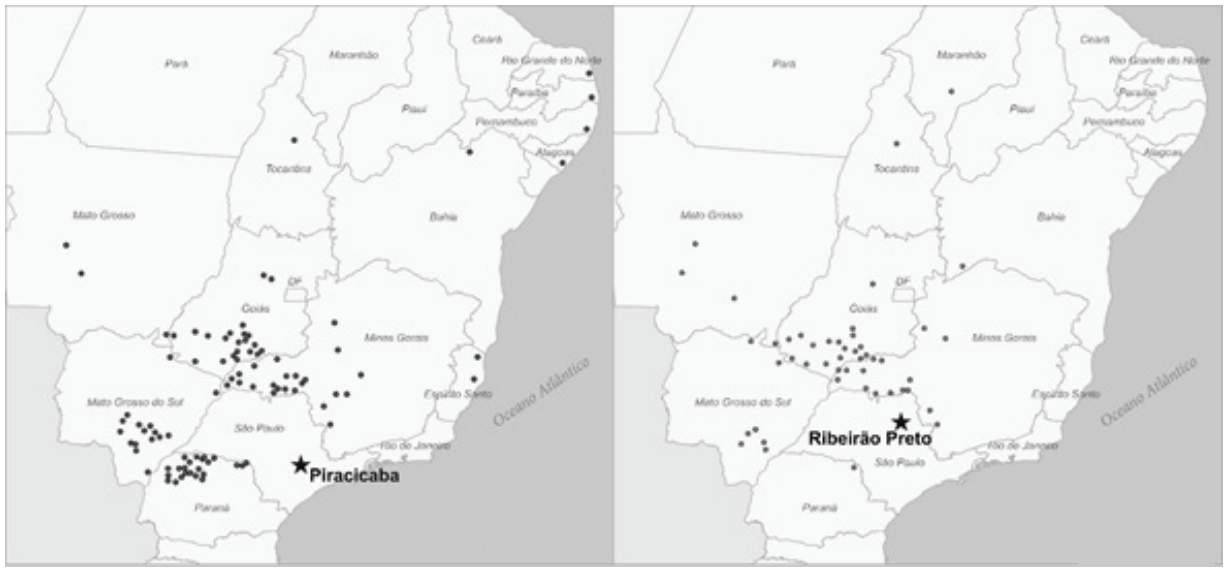
Reproducing complex knowledge in other parts of the country requires time and establishing the sector in the new parts of the Mid-South. This may be explained by the fact that both agricultural and industrial knowledge have a strong tacit dimension. In agriculture, this dimension is associated with the ability of researchers to recognize deficiencies in management and diseases, to know the development potential of varieties under different soil and climatic conditions, to identify the effects of inputs in production and to adapt equipment to their demands. The capital goods industry, as seen by Varrichio (2012), is, in turn, a highly complex activity and its segments are difficult to master.

Therefore, on the one hand, the new municipalities that receive UASs are part of this innovation system - but only as recipients of more sophisticated services and knowledge. On the other however, technical changes occurring in Piracicaba and Ribeirão Preto have the capacity to change the productive system in the group of sugarcane municipalities.

In the industrial activity, it is easy to verify the centrality of São Paulo, because

the process of productive deconcentration practically does not reach the branch of capital goods, which remains mainly in Piracicaba; in agriculture, this centrality is evident in the partnerships created between, on the one hand, the CTC and IAC and, on the other, the UASs in Goiás, Paraná and Mato Grosso do Sul, as presented in Figure 3, produced for 2015.

**Figure 3** – Partnerships between the CTC and the IAC and the UASs outside the state of São Paulo (2015), Brazil




**Partnerships between the CTC and the UASs** **Partnerships between the IAC and the UASs**

Source: Produced by Vitor Vencovsky.

Database: Mesquita (2015).

In these cases, especially in the Cerrado regions, the transition to a natural environment, where the sugarcane production technique until then was little known (MESQUITA, 2016), stimulated the UASs to invest in scientific research (SPÍNDOLA; LIMA; FERNANDES, 2015)whose objective was to better understand the interactions of firms with universities and/or technical consulting organizations that have promoted some innovation in the sector. Additionally, it was tested the hypothesis, through the case study, that the segment above preserved traces of its history that left the impression of a sector less innovative and dependent on government protection. The paper, based on a case study, has shown that companies have a R&D continuum in the agricultural area, although sugar mills and small producers relegate efforts in R&D, transferring this role to institutions such as RIDESA and CETENE. The focus of local mills is on the foreign market of sugar since they have a comparative advantage in logistics and also a big competition from other Brazilian producers. The exports of sugar have been made in bulk, implying that producers have passed on an important part of adding value to the product, leaving the procedures related to the importers and, by consequence, losing opportunities to innovate with differentiated products. The supply of labor seems likely to lead to future scarcity, causing the mills to move toward mechanization of part of the production. The foreign capital seems uninterested in the sector, considering a smaller automation of cane harvesting in the state, hence the technological dynamics does not suffer major

**Fernando Mesquita** is a geographer, and holds a Master's and Doctorate degree in Geography at Unicamp. He completed a Postdoc in the Department of Political Science and Technology at Unicamp. He has a PNPD scholarship from the Coordination for the Improvement of Higher EducationPersonnel(CAPES).
**E-mail:** fcmesquita@ige.unicamp.br
**ORCID:** https://orcid.org/0000-0002-8192-2263

**Ricardo Castillo** is a geographer, and holds a Master's and Doctorate degree in Human Geography at the Universidade de São Paulo. He is a full professor in the Department of Geography at the Universidade Estadual de Campinas.
**E-mail:** castillo@unicamp.br
**ORCID:** 0000-0002-7056-3197

**Ivette Luna** is a full professor at the Instituto de Economia at Unicamp, graduated in mechatronic engineering, and holds a Master's and Doctorate degree in electrical engineering at the Universidade Estadual de Campinas, and has completed a Postdoc at the *Scuola superiore di studi universitari e di perfezionamento S. Anna di Pisa*.
**E-mail:** iluna@unicamp.br
**ORCID:** https://orcid.org/0000-0002-5304-5523

**Henrique Faria dos Santos** is a geographer, and holds a Master's degree at the Universidade Estadual de Campinas and is currently completing a doctorate degree at the same institution. He has a scholarship from the Fundação de Amparo à Pesquisa de São Paulo.
**E-mail:** livehenriquefarias-antos@hotmail.com.
**ORCID:** https://orcid.org/0000-0002-5376-3429

This article was received on April 6, 2018 and approved for publication on February 13, 2019.



changes that could result from the arrival of these companies, in principle, more keen on investments in R&D and stronger interaction with research institutions.",

The institutes of São Paulo have therefore begun to direct studies and projects on these conditions, developing varieties and technological packages, which are being implanted in the new regions.

## FINAL CONSIDERATIONS

The ideas presented in the article have sought to help identify the expansion of the sugarcane border in the Brazil as a geographically heterogeneous and hierarchical process. While the State of São Paulo has reduced its participation in terms of sugarcane and ethanol production, it has however grown in terms of knowledge generation and as a decision-making center. From the perspective of São Paulo, this represents an increase in its positioning in the territorial division of labor, since it has begun to expand its technical centrality, both in political terms and in the production of specific assets. However, for the new expansion areas of the sector (the *Triângulo Mineiro*, south and the mid-northern region of Goiás, north-west Paraná and the southwest of Mato Grosso do Sul), this situation may represent a limiting factor for urban and regional development, since central services linked to improving the techniques and strategic decisions for the sector have become external.

The hierarchy that forms within the cities associated with the sugar-energy productive system benefits the urban centers of the interior of the state of São Paulo in relation to the technical command, particularly Piracicaba, Ribeirão Preto, Campinas and, to a lesser extent, Araras. In relation to the political command, this hierarchy is of particular benefit to the state capital of São Paulo, followed by Campinas and Presidente Prudente. However, it is important to note that this link between the technical and political command in São Paulo is associated with the sugar-energy sector. Other agribusiness activities, such as soybeans, corn and cotton, for example, will have different spatial dynamics

The analysis demonstrates that the globalization of the economy does not lead to homogeneity; on the contrary, it stimulates the differentiation of regional spaces and creates new urban hierarchies or accentuates existing ones. Differentiation forces act on factors that surpass the productive dimension, defining, within the scope of the technical command and the political command, different growth potentialities for the sugarcane cities.

## REFERENCES

ALBUQUERQUE, R. H. DE; ORTEGA, A. C.; REYDON, B. P. O setor público de pesquisa agrícola no Estado de São Paulo. *Cadernos de Difusão de Tecnologia*, v. 3, n. 2, p. 243–296, jan./abr. 1986.

ALBUQUERQUE, E.; SUZIGAN, W.; KRUSS, G.; LEE, K. *Developing National Systems of Innovation:* University-Industry Interactions in the Global South. Cheltenham, UK, Northampton, MA, USA: Edward Elgar Publishing, 2015.

BALLAND, P. A.; RIGBY, D. The Geography of Complex Knowledge. *Economic Geography*, v. 93, n. 1, p. 1–23, jul. 2017.

BELIK, W. A tecnologia em um setor controlado: o caso da agroindústria canavieira em São Paulo. *Cadernos de Difusão de Tecnologia*, jan./abr. 1985.

BENETTI, M. D. A internacionalização recente da indústria de etanol brasileira. *Indicadores Econômicos FEE*, v. 36, n. 4, p. 1–12, s.d. 2009.

BENKO, G.; PECQUEUR, B. Os recursos de territórios e os territórios de recursos. *Geosul*, v. 16, n. 32, p. 31–50, jul./dez. 2001.

BERNARDES, J. A.; ARRUZZO, R. C. Expansão do setor sucroenergético e a história dos lugares: a questão territorial dos Guarani e Kaiowá em Mato Grosso do Sul. *Revista da Anpege*, p.5-33, V.12, n.17, jan./jul.2016

BRANDÃO, C. A. O processo de subdesenvolvimento, as desigualdades espaciais e o "Jogo das Escalas". *Superintendência de Estudos Econômicos e Sociais da Bahia*, p. 9–37, 2004.

BRANDÃO, C. A. *Território e Desenvolvimento*: as múltiplas escalas entre o local e o globa**l**. Campinas: Editora da Unicamp, 2007.

BRINKMAN, L. J. M.; CUNHA, M. P.; HEIJNEN, S.; WICKE, B.; GUILHOTO, J. J. M.; WALTER, A.; FAAIJ, A.; HILS. Interregional assessment of socio-economic effects of sugarcane ethanol production in Brazil. *Renewable and sustainable energy reviews*, n. 88, p. 347-362, 2018.

CALDARELLI, C. E.; MORAES, M. A. F. D.; PASCHOALINO, P. A. Sugarcane industry effects on the GDP per capita in the Center-South region of Brazil. *Revista de Economia e Agronegócio - REA*, v. 15, n. 2, p. 183–200, Set. 2017.

CAMELINI, J. H.; CASTILLO, R. Etanol e uso corporativo do território. *Mercator*, v. 11, n. 25, p.7-18, mai./ago. 2012.

CARR, N. IT Doesn't Matter. *Harvard Business Review*, Mai. 2003.

CASTILLO, R. Dinâmicas recentes do setor sucroenergético no Brasil: Competitividade regional e expansão para o bioma Cerrado. *GEOgraphia*, v. 17, n. 35, p. 95–119, s.d. 2015.

DINIZ, C. C.; CAMPOLINA, B. A região metropolitana de São Paulo: Reestruturação, re-espacialização e novas funções. *Eure*, v. 33, n. 98, p. 27–43, 2007.

DINIZ, C. C.; GONÇALVES, E. Economia do conhecimento e desenvolvimento regional no Brasil. In: DINIZ, C. C.; LEMOS, M. B. *Economia e território.* Belo Horizonte: Editora da UFMG, 2005. p. 131–170.

DINIZ, C. C.; VIEIRA, D. J. Brazil: accelerated metropolization and urban crisis. *Area Development and Policy*, v. 1, n. 2, p. 155–177, jun. 2016.

EGLER, C. A. G.; MENDES, C. C.; FURTADO, B. A.; PEREIRA, R. H. M. Bases conceituais da rede urbana brasileira: análise dos estudos de referência. In: PEREIRA, R. H. M.; FURTADO, B. A. *Dinâmica urbano-regional*: rede urbana e suas interfaces. Brasília: IPEA, 2011.

ELIAS, D. Agronegócio e novas regionalizações no Brasil. *Revista Brasileira de Estudos Urbanos e Regionais*, v. 13, n. 2, p. 153–167, mai. 2011.

ELIAS, D. A cidade e o campo: ambiente e sociedade. In: SPOSITO, E. S. (Coord.). *A diversidade da geografia brasileira*: escalas e dimensões da análise e da ação. Rio de Janeiro: Consequência, 2016. p. 211–232.

FERNANDES, A. C. Sistema territorial de inovação ou uma dimensão de análise na Geografia contemporânea. In: SPOSITO, E. S. (Coord.). *A diversidade da geografia brasileira*: escalas e dimensões da análise e da ação. Rio de Janeiro: Consequência, 2016. p. 113–142.

FREEMAN, C. Japan: A New National System of Innovation. In: DOSI, G. (Coord.). *Technical change and economic theory*. London: Pinter Publishers, 1988. p. 330–347.

FURTADO, A. T.; SCANDIFFIO, M. I. G.; CORTEZ, L. A. B. The Brazilian sugarcane innovation system. *Energy Policy*, v. 39, n. 1, p. 156–166, jan. 2011.

FURTADO, C. Criatividade e dependência na civilização industrial. Rio de Janeiro: Companhia das Letras, 2008.

FURTADO, C. *Brasil*: a construção interrompida. Rio de Janeiro: Paz e Terra, 1992.

GARCIA, R.; DIEGUES, A. C.; ROSELINO, J. E.; COSTO, A. R. Desenvolvimento local e desconcentração industrial: uma análise da dinâmica do sistema local de empresas de eletrônica de Santa Rita do Sapucaí e suas implicações de políticas. *Nova Economia*, v. 25, n. 1, p. 105–122, jan./abr. 2015.

HASEGAWA, M. *Avaliação das capacitações e dos spinoffs gerados por programas de P&D*: O programa cana do IAC. 118 f. Dissertação (Mestrado em Política Científica e Tecnológica) - Instituto de Geociências, Unicamp, Campinas, 2005.

INFOCANA. *Usinas/Grupos*. Disponível em: <https://www.infocana.com.br/>. Acesso em: 1 abr. 2018.

JACKSON, M. O. *Social and economic networks.* Princenton, Oxford: Princeton University Press, 2008.

LENCIONI, S. Concentração e centralização das atividades urbanas: uma perspectiva multiescalar. Reflexões a partir do caso de São Paulo. *Revista de geografia Norte Grande*. n. 1, v. 20, p. 7–20, mai. 2008.

LOPEZ, A.; LUGONES, G. Los sistemas locales en el escenario de la globalización. In: CASSIOLATO, J. E.; LASTRES, H. M. M. *Globalização e Inovação Localizada*: Experiências De Sistemas Locais No Mercosul. São Paulo: IBIC, 1999, p. 72-109.

LUNDVALL, B.-A. *National Systems of Innovation*: Toward a Theory of Innovation and Interactive Learning. London: Anthem Press, 1992.

MENDONÇA, M. L.; PITTA, F. T.; XAVIER, C.V. A agroindústria canavieira e a crise econômica mundial. *Relatório da Rede Social de Justiça e Direitos Humanos*. São Paulo: Outras Expressões, 2012

MESQUITA, F. C. *Evolução da agricultura e transformações da técnica e das relações territoriais no cerrado goiano*: a dimensão endógena da expansão da agroindústria canavieira. 257 f. Tese (Doutorado em Geografia) - Instituto de Geociências, Unicamp, Campinas, 2015.

MESQUITA, F. C. Evolução do aprendizado na expansão da cana-de-açúcar para Goiás: o papel dos centros de pesquisa. *Campo e Território*: Revista de Geografia Agrária, v. 22, 2016.

MF. (Ministério da Fazenda) *Emissão de Comprovante de Inscrição e de Situação Cadastral.* Disponível em <https://goo.gl/AeWC41>. Acesso em: 1 abr. 2018.

MORAES, M. A. F.; OLIVEIRA, F. C. R.; DIAZ-CHAVEZ, R. A. Socio-economic impacts of Brazilian sugarcane industry. *Environmental Development*, v. 16, p. 31–43, dez. 2015.

MOURA, R.; WERNECK, D. Z. Rede, hierarquia e região de influência das cidades: um foco sobre a região Sul. *Revista Paranaense de Desenvolvimento*, n. 100, p. 27-57, 2001.

NEGRI, B. *Estudo de caso da indústria nacional de equipamentos*: Análise do Grupo Dedini (1920-1975). Piracicaba, SP: Instituto histórico e geográfico de Piracicaba, 2000.

OLIVEIRA, A. M. S. *Reordenamento territorial e produtivo do agronegócio canavieiro no Brasil e os desdobramentos para o trabalho*. 597 f. Tese (Doutorado em Geografia) - Faculdade de Ciência e Tecnologia, UNESP, Presidente Prudente, 2009.

PACHECO, C. A. *Fragmentação da Nação.* Campinas: Editora da Unicamp, 1998.

PAULILLO, L. F. *Redes de Poder e Territórios Produtivos*. São Carlos: Ed. UFSCAr, 2000.

PIETRAFESA, J. P.; PIETRAFESA, P. A. International Capital and New Frontiers of Biofuel Production in Brazilian Midwest. *Ateliê Geográfico*, v. 10, n. 1, p. 7–27, abr. 2016.

PIETRAFESA, J. P.; SAUER, S. A nova dinâmica na velha fronteira. Terceira marcha da ocupação no Cerrado. *Revista FUNADESP*, v. 5, n. 5, p. 139–160, s.d. 2012.

PROCANA. *Anuário da Cana***.** Ribeirão Preto: Procana, 2008.

PROCANA. *Anuário da Cana.* Ribeirão Preto: Procana, 2016.

RAMOS, P. A evolução da agroindústria canavieira paulista no período 1946-1980: expansionismo agrário e características da estrutura de produção. *Informações Econômicas*, v. 31, n. 8, p. 14–32, ago. 2001.

SAMPAIO, M. DE A. P. *360°* - O périplo do açúcar em direção à macrorregião canavieira do Centro-Sul do Brasil. 881 f. Tese (Doutorado em Geografia Humana) - FFLCH, USP, São Paulo, 2014.

SANTOS, H. F. *Competitividade regional do setor sucroenergético na mesorregião Triângulo Mineiro/Alto Paranaíba*: agricultura científica globalizada e implicações socioambientais no município de Uberaba. 286 f. Dissertação (Mestrado em Geografia) - Instituto de Geociências, Unicamp, Campinas, 2017.

SANTOS, M. Sociedade e espaço: a formação social como teoria e como método. *Boletim Paulista de Geografia*, v. 1, n. 9, p. 81–100, jun. 1977.

SANTOS, M. *A natureza do espaço*: técnica e tempo, razão e emoção. São Paulo: Hucitec, 1996.

SANTOS, M. *A urbanização brasileira*. São Paulo: EdUSP, 2005.

SANTOS, M. *Técnica, espaço, tempo*: globalização e meio técnico-científico informacional. São Paulo: Editora da EdUSP, 2008.

SANTOS, M. *Por Uma Outra Globalização*. Rio de Janeiro: Record, 2010.

SAUER, S.; PIETRAFESA, J. P. Cana-de-açúcar, financiamento público e produção de alimentos no Cerrado. *Campo-Território: Revista de Geografia Agrária,* v. 7, n. 14, p. 1–29, ago. 2012.

SELINGARDI-SAMPAIO, S. *Indústria e território em São Paulo:* a estruturação do multicomplexo industrial paulista. Campinas: Alínea, 2009.

SZMRECSANYI, T; GONÇALVES, D. B. Efeitos socioeconômicos e ambientais da expansão da lavoura canavieira no Brasil. In: LASA 2009 XXVIII International Congress of the Latin American Studies Association, 28, 2009, Rio de Janeiro. *Anais…* Rio de Janeiro: LASA, 2009.

SMITH, N. *Desenvolvimento desigual*: natureza, capital e produção do espaço. Rio de Janeiro: Bertrand, 1988.

SPÍNDOLA, F. D.; LIMA, J. P. R.; FERNANDES, A. C. Interação Universidade-Empresa: o caso do setor sucroalcooleiro de Pernambuco. *Economia e Sociedade*, v. 1, n. 53, p. 121–149, abr. 2015.

SPOSITO, E. S. *O novo mapa da indústria no início do século XXI:* diferentes paradigmas para a leitura das dinâmicas territoriais do Estado de São Paulo. São Paulo: Editora da UNESP, 2015.

STORPER, M. *The Regional World:* Territorial Development in a Global Economy. Nova Iorque e Londres: Guilford Press, 1997.

STORPER, M. *Keys to the City*: How Economics, Institutions, Social Interaction, and Politics Shape Development. Princeton e Oxford: Princeton University Press, 2013.

STORPER, M.; VENABLES, A. J. Buzz: Face-to-face contact and the urban economy. *Journal of Economic Geography*, v. 4, n. 4, p. 351–370, Ago. 2004.

VARRICHIO, P. C. *Uma análise dos condicionantes e oportunidades em cadeias produtivas baseadas em recursos naturais*: o caso do setor sucroalcooleiro no Brasil. 271 f. Tese (Doutorado em Política Científica e Tecnológica) Instituto de Geociências, Unicamp, Campinas, 2012.

WALKER, R.; STORPER, M. *The Capitalist Imperative*: Territory, Technology and Industrial Growth. Orxford: Basil Blackwel, 1991.

WESZ JUNIOR, V. J. *Dinâmicas e estratégias das agroindústrias de soja no Brasil*. Rio de Janeiro: e-papers, 2011.

UNICA (União da Indústria de Cana-de-açúcar). *Histórico de produção e moagem por produto*. Disponível em <https://goo.gl/X2CjV0>. Acesso em: 23 de março de 2017.

UDOP (União dos produtores e bioenergia). *Relatórios diversos*. Disponível em <http://www.udop.com.br/index.php>. Acesso em: 05 de abril de 2017.