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**THE EQUIPMENT SUPPLY INDUSTRY TO SUGAR MILLS,
ETHANOL AND ENERGY IN BRAZIL: AN ANALYSIS BASED IN
LEADING COMPANIES AND KEY-ORGANIZATIONS OF SECTOR
AND OF LPA OF SERTÃOZINHO**

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ABSTRACT

This study aims to analyze the profile, organization, efficiency and innovation in the supply industry equipment for sugar mills, ethanol and energy in Brazil, contributing to an important discussion on the competitiveness of this industry. Therefore, the study was based on analysis of information obtained from two surveys: the first held with representative organizations and two industry-leading companies located in the cities of Sertãozinho and Piracicaba; and the second, through interviews with companies in the Local Productive Arrangement (LPA) of Sertãozinho, known as the Silicon Valley Ethanol. The results suggest that the increasing modernization of the sector will require greater efforts from equipment industry to provide plants with the necessary technological innovations and potential



efficiency gains and that the constituent companies of this industry, few invest in technology and professional training, in other words, are lacking in management training, which leads to loss of valuable opportunities, international market share is tiny, most companies turn to private sources of financing, and companies seem unaware of the real benefits of cooperation, although they appear in most companies in this industry.

Keywords: Equipment Supply Industries, Local Productive Arrangement; Sugarcane Industry

1. INTRODUCTION

Understanding the competitiveness of the sugarcane and energy industry is of fundamental importance for Brazil, not only because it is an activity that the country has dominated for centuries but also because the industry has obtained major gains in productivity and efficiency, becoming one of the most competitive agro-industrial activities in Brazil.

The industry's development has been aided by a combination of good soil and climate conditions and a series of well-defined public policies throughout the industry's history that resulted in a large increase in the number of plants in the 1970s and 1980s and strengthened suppliers of machines and equipment for the mills. As a result, in addition to agricultural competitiveness, the sugarcane industry is also highly competitive in the production of ethanol, sugar, and energy.

This industrial competitiveness has been achieved by developing both productive processes and the equipment involved in these processes. As such, the equipment supply industry has made important contributions to the sugarcane industry's competitiveness.

Both the arrangement of the equipment supply industry and its experience have been determinant factors so that its competitiveness permeated the industry as a whole. The industry is characterized as essentially national capital and is strongly concentrated in the state of São Paulo.

The sugarcane industry's leading products are sugar, ethanol, and, more recently, electric energy. It is a very traditional industrial sector in the Brazilian economy, dating back to the colonial period and has remained one of the main

industries in the country in terms of share of GDP, employment generation, and international integration (Sugarcane Industry Association - UNICA, 2010).

In recent years, the sector has expanded due to continuous growth in the production of alcohol, sugar, and sugarcane. Ethanol production jumped from 11 billion liters in 2001/2002 to 28 billion liters in 2013/2014; during the same period, sugar rose from 19 million tons to 37 million tons, and the production of sugarcane grew from 300 million tons to 653 million tons (UNICA, 2009; EPE, 2014).

However, the sector is now going through an enormous crisis, not only a conjuncture crisis, but a result from wrong choices made by political leaders in Brazil, that somehow favored the gasoline, pushing the ethanol price down and its competitiveness. However, despite the actual crisis this is the most important agricultural sector in Brazil and has invested considerably to enhance process technologies and competitiveness.

Power plants (or industrial plants) have a set of equipment for each of the stages of extraction, treatment, fermentation, and distillation, in addition to equipment for energy production, the transportation of raw materials, and the procurement of water and water treatment, among others.

Productivity in the industrial stage depends on both the development of capital goods in different stages of the production process and engineering projects to integrate different components in the plant. The industry is comprised of some companies that design the plant as a whole and a large set of companies that develop different machines, equipment, and components (Sugarcane Equipment Industry Association of Sertãozinho - CEISE, 2009).

The technology for the supply of capital goods for plants is essentially national. The sector is dominated by national companies with low level of imports and foreign capital. The industry is located primarily in the regions of Piracicaba and Sertãozinho, in the state of São Paulo, and features industrial agglomerations, particularly in the mechanical and metallurgical sectors.

The industry's organization is different in each region, both in relation to the degree of integration and the size of the companies and their strategies. This type of industrial organization, in the form of local production arrangements, contributes to

greater efficiency in the sector and greater dynamism for the regions in which they are located (CEISE, 2009).

A number of questions arise in relation to the industry's performance, including: what is the equipment supply industry's ability to keep up with the demand generated by the sugarcane industry and its advances in the agronomical processes, and how does innovation occur in these industries? This study seeks to answer these questions by assessing some of the characteristics of these industrial agglomerations. In addition, we sought to characterize the constituent companies of the industry, analyzing the profile of companies, of export, innovation, financing and major challenges and opportunities encountered by the sector.

The first qualitative research was based on a set of non-structured interviews conducted in 2011 with representatives and experts from the industry: Adésio José Marques of the Sertãozinho Center for Industries (Sugarcane Equipment Industry Association of Sertãozinho – CEISE); Octávio Valseschi, Coordinator of Master Technology Administration for Sugarcane Industry – MTA at the Federal University of São Carlos (São Carlos Federal University – UFSCAR); Antônio de Pádua of the Sugarcane Industry Union (Sugarcane Industry Association – UNICA); José Luiz Olivério of Dedini¹; Luis Biagi of Renk Zanini²; and Marco Pastorelli of Unisystems³.

The second qualitative research was an online survey and was based on a semi-structured questionnaire for all companies of LPA sent by CEISE and the

¹ Dedini - Operates in the sugar and ethanol with expertise in technology for high efficiency, with own manufacturing and embedded systems, provides individual equipment or under "turnkey", from receipt, preparation, extraction and treatment of the broth to produce sugar and ethanol.

² Renk Zanini - The consolidation of its brand began in 1976 with the merger of Zanini S.A. Equipamentos Pesados from Sertãozinho (SP) and Renk AG of Germany. Its purpose has been, since then, the production and sale of special, custom-built speed reducers, power transmission elements, and the provision of machining and Heat Treatment services. Its main office today is located in the State of São Paulo.

³ Unisystems – Was established in 1995, in Miami (Florida), focused on supplying advanced technologies, engineering services and a large selection of sophisticated equipments of process for the sectors of sugar, ethanol and energy. In 1996 it was founded the Uni-Systems do Brasil hosted in Sertãozinho - São Paulo, focused on providing integrated solutions of process and engineering services for the same industrial sectors.

Department of Industry and Trade of Sertãozinho, during 2014. Altogether they were received 44 responses to the questionnaire, although some incomplete. After standardization data base 36 remaining valid replies.

The choice of method is justified by the need to get a general view of the organization and equipment of industry configuration in the alcohol sector as well as characterization of the companies of this industry. Secondary data were also used, which were acquired from databases such as the Sugarcane Industry Association (UNICA), the Brazilian Association of Machinery and Equipment Industry (ABIMAQ), the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística - IBGE), and the Annual List of Social Information (Relação Anual de Informações Sociais - RAIS). The instrument for data analysis was content analysis, which used to understand the information and systematize the knowledge acquired during the interviews.

2. LOCAL PRODUCTION ARRANGEMENTS

The debate over the issue of industrial clusters is an old one in the Brazilian economy, both for evaluating the determinants of agglomerations and verifying their impact in terms of competitiveness, the introduction and development of technological innovations, and the impact on regional development, among other aspects. The literature on local production arrangements (LPAs), defined as a geographic and sectoral concentration of small and medium enterprises that maintain a systematic relationship, spans various fields of the economy: the industrial economy, the technology economy, the regional and urban economy, and other areas that seek to analyze specific impacts from the presence of LPAs (TELLES; TONETO JR, 2007).

In his Principles of Economics, Marshall (1920) highlighted the idea that external economies that originate from the agglomeration of certain economic activities can enable efficiency gains for participants by attracting suppliers, making skilled labor easily available, or by other means. "External economies depend on the general development of the industry [...] and they can frequently be achieved through the concentration of many similar companies in certain places; or, as is often said, by the industry's location" (MARSHALL, 1996, p. 315).

Therefore, the main advantages of the geographic and sectoral concentration of companies are the presence of external economies and the possibilities for joint strategies, which may be an important source of generating competitive advantages for business clusters (IPT, 2008; MARINI; SILVA, 2012).

These joint strategies depend on local agents (companies and institutions) that are able to stimulate their competitive abilities through cooperative actions such as professional training, the creation of export consortia, contracting specialized services, and establishing collective technological centers. The union of incidental external economies with those obtained through deliberate joint actions results in a "collective efficiency", which determines the competitive capacity of the local companies (SCHMITZ; NADVI, 1999 cited in MARINI; SILVA, 2012).

A priori, the advantages of geographic and sectoral concentration result from the installation of supplier companies in the region, the provision of collective goods, specialization of local skilled labor, tacit knowledge that is created from the sector, and knowledge about what each firm is producing. Furthermore, as mentioned previously, the advantages of the companies' geographic and sectoral concentration can be enhanced by the companies' proactive behavior in organizing themselves, thereby creating power in negotiations with suppliers, making room for joint investments in research, developing strategies for access to foreign markets, and encouraging close relationships with universities, public bodies, etc. These arrangements can elevate the competitive condition of firms by obtaining efficiency gains from acting as a group (TELLES; TONETO JR, 2007).

LPAs are important for the development organizations, and they can influence economic and social development both regionally and nationally (VICARI, 2009; JAUHAR, 2008). The challenges of economic growth and the need for more equitable socioeconomic development between regions have led the Brazilian federal government and state governments to encourage the organization of LPAs in various regions of the country. The organization of local industries through LPAs is part of the industrial policy guidelines set by the Brazilian Ministry of Development, Industry, and Foreign Trade (TELLES; TONETO JR, 2007; GTPAPL, 2012).

LPAs can be described as a cluster of firms in a certain production chain in the same territory or region. More specifically, an LPA is a type of local production

system with a geographic and sectoral concentration, generally of small- and medium-sized enterprises, that maintain a systematic relationship. The cluster can consist of companies that manufacture traditional, low-technology products or technology-based companies (SUZIGAN, et al., 2003).

For Cassiolato and Lastres (2003, p. 3, 4), LPAs are local clusters that focus on activities in a specific economic segment and rely on the involvement of economic, political, and social actors. The companies within the clusters have ties to each other, even if they are recent. These local clusters demonstrate participation and interaction between companies that produce capital goods, provide services, supply inputs, and market the cluster's products. They are also related to public and private organizations that support the cluster's activities, such as financial companies, political entities, marketing companies, research and development organizations, universities, and other entities for obtaining and training qualified labor.

LPAs have some degree of specialization in one or more of the links on the chain, such as improving production processes, developing new products, differentiating the design, managing storage logistics, and developing efficient distribution channels. All of the agents involved in the productive and commercial process benefit from these differentials, which are the result of maintaining a healthy, permanent interaction between the economic and social actors (PLONSKY; SERRA; ZENHA, 2005).

Cooperation, regardless of the type of LPA, allows individual companies to operate at levels of efficiency and productivity that would not otherwise be achievable. Through interaction networks that are retro-feeding, the physical proximity between companies and institutions in an LPA fosters, facilitates, and increases the exchange of tangible assets – final and intermediate goods and services – and the diffusion of intangible assets such as relevant knowledge for the business (PLONSKY; SERRA; ZENHA, 2005).

Telles and Toneto Jr. (2007) note that cooperation between firms can play a fundamental role in the process of innovation by increasing competitive capacity, mainly when small firms are competing with large firms, thereby creating greater capacity for investment and greater diffusion of knowledge. LPAs can thus

encourage the emergence of regional systems of innovation in places they are located.

LPAAs can be classified according to their degree of organization: (i) informal, (ii) organized, and (iii) innovative. This classification is based on the market structure, degree of technological development, level of articulation, and the size of the companies (MYTELKA; FARINELLI, 2005 cited in PLONSKY; SERRA; ZENHA, 2005).

Plonsky, Serra and Zenha (2005) argue that the companies in an informal LPA produce homogeneous or slightly differentiated goods, developed with widely available technology. These companies require low levels of investment and show reduced barriers to entry and exit. They also show nascent expertise in management, a reduced level of technological development, and little cooperation between the companies in the cluster and with local actors such as clients.

These companies adopt survival strategies for the markets in which they operate. In an organized LPA, the companies are more heterogeneous in terms of size, organizational structure, and strategic capacity. They also tend to be more specialized, producing differentiated or slightly differentiated goods. Their level of industrial investment is more robust, creating stronger barriers to entry. In addition, they employ more sophisticated management strategies and use relatively modern, but accessible, equipment and technology.

They show some level of cooperation. In the innovative LPA, there are small, medium, and large businesses organized hierarchically. The small and medium enterprises gravitate around the large firms, which act as suppliers. They generally have a higher level of managerial, financial, and commercial expertise, in addition to skilled professionals. In this type of LPA, the capacity to innovate is strategic and cooperation is intense.

Definitions and typologies of LPAs are widely studied in the national and international literature. The literature is vast and, in some cases, contradictory (SUZIGAN, et al., 2003). Many studies focus on defining an LPA and differentiating it from other arrangements.

In the present study, the term LPA is used in accordance with Cassiolato and Lastres (2004), who believe that these arrangements do not show significant links

between agents (nascent cooperation) and that they therefore cannot be characterized as systems (CASSIOLATO; LASTRES, 2004). The authors use the term Local Productive and Innovative Systems (Sistemas Produtivos e Inovativos Locais - SPILs) to define “arrangements where interdependence, links, and consistent ties result in interaction, cooperation, and learning, with the potential to generate increased endogenous innovative capacity, competitiveness, and local development”.

Thus, machine and equipment industry clusters for the sugarcane sector are considered LPAs and deserve note for their capacity and potential to generate competitiveness and innovation.

3. RESULTS

3.1. The Equipment Industry for the Sugarcane Sector

The capital goods sector in Brazil is responsible for the production of a complex set of machines and equipment used in the production of other goods. It thereby maintains a direct relationship with other sectors in addition to playing an important role in the diffusion and generation of new technologies (State of Minas Gerais Federation of Metalworkers - FEM, 2014).

The sector is considered strategic for the country's development, influencing increase in the average total productivity of the economy and technological diffusion. The dynamics and competitiveness of industry as a whole depends on the degree of development of the capital goods industry, which acts as a technical progress diffuser (National Confederation of Metalworkers – CNM, 2012: pp.3).

This sector consists of the following groups, according to the National Classification of Economic Activities: machines and equipment; motor vehicles, trailers and car bodies; other transportation equipment, which includes the aeronautical segment; machinery, appliances, and electrical equipment; communications equipment; medical equipment and instruments, precision instruments, and equipment for industrial automation; and office machines and information equipment (Brazilian Institute of Geography and Statistics - IBGE, 2015).

The most important segment in the capital goods industry, the industry of machines and equipment, is located mainly in the state of São Paulo. Brazil has an industrial park for producing machines and equipment that is strongly tied to the sugarcane agro-industry. The machines and equipment industry allowed the

expansion and improvement of the production of sugar and ethanol (Brazilian Association of Machinery and Equipment Industry - ABIMAQ, 2010; CRUZ et al, 2013).

The industry of machines and equipment, tied to the sugarcane industry, is well developed in the country and is very important to the sugarcane sector's competitiveness. The sugarcane sector is also located mainly in the state of São Paulo, which contains a strong concentration of plants in the central-south region and the country's main industrial park, resulting in a concentration of sectors with high technological intensity, major research centers, and skilled-labor training.

The expansion of sugarcane cultivation in Brazil, during the last decade, created strong incentives for the machines and equipment industries related to the sector. In addition to the demand associated with new plants, there was also a significant growth in demand to replace old equipment with more modern equipment. This replacement of equipment enabled the expansion of productivity and energy efficiency and allowed for the sale of surpluses.

The expansion of the sugarcane industry and the consequent increase in demand in the machines and equipment industries resulted in the entry of new actors in the sector, including foreign capital in a sector traditionally dominated by national capital (CEISE, 2009; EXAME, 2013).

In the state of São Paulo, where most of the equipment industries for this sector is located, there are two regional production hubs: Piracicaba and Sertãozinho. These hubs historically developed with the presence of family businesses, which grew and stimulated the development of suppliers and competitors in the region.

The equipment industry in these cities is focused on the mechanical and metallurgical sectors. In Sertãozinho, the industry is strongly related to the sugarcane sector, with the predominant production of boilers and general-purpose machinery. In Piracicaba, the industry is much more diverse.

Since 1940, two major metallurgical enterprises have specialized in manufacturing machinery and plants, and they stand out in this sector: Dedini, in Piracicaba, SP, and Zanini, in Sertãozinho, SP. These enterprises experienced a major expansion during the National Alcohol Program - Pro-alcohol. The main

Brazilian suppliers produced approximately 200 independent distilleries (and 200 corresponding co-generation plants).

The two biggest manufacturers (Dedini and Zanini) produced, considering the production peaks, 96 million suits in one year, 81 distilleries in one year, and an average of 63 boilers per year between 1973 and 1982 (MACEDO; NOGUEIRA, 2004). The best phase for this sector was during Pro-alcohol, when these companies engaged a significant amount of employees and operated virtually full time.

Dedini S.A. Basic Industries, the main company in the sector, is the result of the consolidation of the activities of Dedini, Zanini, Badoni, and Codistil (according to DEDINI, 2007). The company has a market share in the sugarcane industry above 50% and has factories in Piracicaba, Sertãozinho, Recife, and Maceió. In addition to the sugarcane industry, it acts in other diverse sectors, including beer, biodiesel, and hydroelectric plants, among others.

Dedini's focus, however, is the sugarcane industry, where it produces technology for the production of sugar and hydrated and anhydrous alcohol and brandy, as well as machinery for sugar refineries, cogeneration plants, plants for tanks, and breweries, among others. Dedini also licenses technology for use in breweries, filtration systems, small central hydroelectric, and the biodiesel industry, among others. In addition, the company develops products with technology provided by customers in the fields of pulp and paper, steel, chemicals, mining, and the automotive industry.

Dedini has a high vertical integration and is involved in virtually all the stages of construction for a plant/distillery in the sugarcane industry: engineering design, viability study, equipment manufacturing, and plant construction. With approximately 4,000 employees, Dedini develops most of the products for plant installations internally. It provides engineering services, assembly design, and viability studies, in addition to producing the equipment, construction and installation, and maintenance services.

The company invests in technological development, such as the current project Dedini Rapid Hydrolysis (DHR – Dedini Hidrólise Rápida), which relies on the support of the Foundation for Research Support of the State of São Paulo (Fundação de Amparo à Pesquisa do Estado de São Paulo – FAPESP) and seeks to

develop acid hydrolysis to produce ethanol from the cellulose materials of bagasse cane.

Zanini, a manufacturer of industrial equipment for the sugar and alcohol sector, was also one of the pillars in forming the current industry for plant equipment and machinery. During the Pro-alcohol program, it grew to 7,000 employees and operated 24 hours a day in Sertãozinho. With the end of the Pro-alcohol program, some companies had trouble and there was restructuring in the sector, including mergers and closings. Zanini teamed up with Renk AG from Germany to form the current Renk Zanini. Today, in Sertãozinho, several companies excel in providing specific solutions for the industry.

An important aspect to be considered is the size of the companies in the two cities. There is greater employment in smaller-sized companies in Sertãozinho compared to Piracicaba, particularly in the mechanical sector. In Sertãozinho, 23% of workers are employed in companies with less than 49 employees, while in Piracicaba, this share is 16%.

Furthermore, in Piracicaba, 38% of employees in the mechanical sector are employed in companies with more than 1,000 employees, while in Sertãozinho this share is 24% (IBGE, 2010; Annual List of Social Information - RAIS, 2010). These facts demonstrate that in Piracicaba, the supply of capital goods for the cane alcohol and energy sector gravitates around one large company, Dedini, which has a strong degree of vertical integration. In comparison, in Sertãozinho, there are large companies with a lower degree of integration, leading to the emergence of a large number of small suppliers.

The city of Sertãozinho has one of the largest clusters in the country of suppliers and service providers for the sugarcane-alcohol sector, in addition to the presence of several units from the sugarcane agribusiness. The city has seven plants producing sugar and alcohol and 500 companies in four industrial districts, 90% of which are focused on the sugar-alcohol industry (CEISE, 2010).

In the period 2008-2012, 81 plant projects have been developed in the country. To meet this demand, the Sertãozinho industry expanded significantly. The number of companies has grown from 500 to 700. More than 3,000 workers were

required by the city that, at its peak, managed to employ about 47,000 workers (EXAME, 2013).

This arrangement is the result of a crisis in the sector in the 1990s, with numerous mergers and company closings, which drew skilled labor to the city, and a number of small companies were created to serve the sugar-alcohol sector. The city's industrial capacity is strong: in addition to having one of the largest industrial parks in the state of São Paulo, the city historically developed an *arrangement* of companies focused on meeting the industrial demand of the sugar industry.

The industrial capacity of this LPA allows the companies to develop all the necessary equipment for the installation of a complete plant. Despite advances in the processes and an increased number of products, it is important to note that few companies in the city invest in technology and professional training. The companies essentially respond to the demand of the integrating companies.

A large number of the entrepreneurs who own these companies have only technical training from the old Zanini, which was at the forefront of producing and selling to other companies. However, these entrepreneurs are lacking in managerial education, which often results in the loss of valuable opportunities. These entrepreneurs need to invest and change the competitive pattern of their industries.

The proximity of these companies in the informal LPA is one of the main elements of the industry's competitiveness. The fact that the companies are located in the same physical region benefits buyers because they can purchase all the equipment they need in only one visit. Moreover, these companies have developed a way of working together in partnerships, which is very important. They collaborate on sales and develop cooperative projects. Thus, they have a greater competitive advantage compared to the few companies that are not located in the city of Sertãozinho.

3.2. Efficiency and Innovation

The equipment industry for the plants was largely responsible for the success of the Brazilian alcohol program because it facilitated processes that enabled significant increases in the conversion rate and thus expanded the potential use of sugarcane.

Throughout these years, efficiency gains were incorporated into different stages of the productive process: extraction, the processing of the liquid, fermentation, and distillation. The efficiency standards that were achieved, namely the high maturity of the processes used, made incremental gains difficult for the production of sugar and alcohol in the industrial stage. A study from Copersucar⁴ on plants in the central-south region showed the following indicators for conversion efficiency (Table 1).

Table 1: Indicators for conversion efficiency and agricultural productivity.

Efficiency	Average	Maximum
Extraction - %	96.2	97.5
Treatment - %	99.2	99.8
Fermentation - %	91.1	93.0
Distillation - %	99.6	99.6

Source: Macedo and Nogueira (2004, p. 12 and 14).

The major changes in industrial efficiency occurred with new technologies (full use of the cane and the development of the hydrolysis process) and the reduction of input consumption (energy and water), particularly in regard to the exchange of equipment that can extend the co-generation of energy. It is important to note that the efficiencies achieved by these companies enabled them to operate in other industries: beverages, paper and cellulose, energy, mining, and oil. Most of these companies are exporters for both sugar and ethanol plants abroad and for other industrial branches.

The companies providing equipment advanced towards turnkey solutions for supplying plants, distilleries, and co-generation systems. The plant is delivered in full working condition and, in some cases, with insurance and performance guarantees. Dedini had already developed plants that integrated biodiesel with ethanol and bioelectricity (three-bio plant). The turnkey packages can be obtained from the companies mentioned above or from engineering companies and contract suppliers that develop the projects. The suppliers have different levels of integration, with

⁴ Copersucar SA is the biggest trader of Brazilian sugar and ethanol production and integrated to Brazil's biggest exporter of these products, with operations in the main markets worldwide.

some companies that develop almost the entire package and others that contract a larger amount of input from suppliers.

The installation of a complete plant involves the following steps (Table 2).

Table 2: Industrial capacity.

Industrial Capacity	Industrial Focus
Design and develop solutions	Technology Process engineering
Define and specify solutions	Basic engineering Equipment engineering
Execute solutions	Produce Install Assemble
Commission and guarantee solutions	Monitoring Control and performance Technical assistance

Source: CEISE, 2009.

During the Pro-alcohol program, the national equipment industry supplied 200 complete distilleries in 10 years. For reference, the historical installed capacity is 5 plants/trimester and 20 per year, with energy co-generation. The capacity for providing installed industry today differs according the order of magnitude of new projects (Table 3).

Table 3: Installed supply capacity

Plants by order of magnitude	
Typical Solution 1	Typical Solution 2
80,000,000 liters/year of alcohol	180,000,000 liters/year of alcohol
1,000,000 tons of cane/harvest	2,160,000 tons of cane/harvest
40 turn-key plants/year	24 turn-key plants/year
Lead time 2 years	Lead time 2 years

Source: CEISE, 2011

In terms of co-generation, the supply capacity is 40 plants of 30 MW + 1.2 GW/year (CEISE, 2011). It is noteworthy that the time between the investment decision and the time when a plant can begin operating is approximately five years. The main determinant for this term is the agricultural phase: the establishment of nurseries for sugarcane and the cane field.

Thus, once the investment decision is made, industrial equipment is not the first phase of investment. The construction and installation of a plant is performed during the establishment of the agricultural phase. Thus, no restrictions for equipment suppliers to meet planned investments are observed because the equipment has already been contracted with the supplier. Suppliers already have projects to be delivered over the next decade.

Much of the technology involved in the sector is in the public domain. The industry's competitiveness is based mainly on scale (number of people in demand and the size of the production park for sugar and alcohol) and the proximity to consumer markets, which facilitates technical assistance and equipment maintenance.

The specificity of the raw material (sugarcane), which has a defined period for harvesting and a specific interval between the collection and extraction of the juice to prevent a loss of quality, requires the equipment companies to develop an efficient assistance system to attend to the plants in the case of equipment failure. Thus, the proximity of the consumer market is determined, in large part, by the concentration of the equipment sector in Piracicaba and Sertãozinho.

Regarding the productive and technological characteristics of the equipment supply industry, a typology for the companies, which differs according to both the products and the manner in which they work, can be generated (Figure 1):

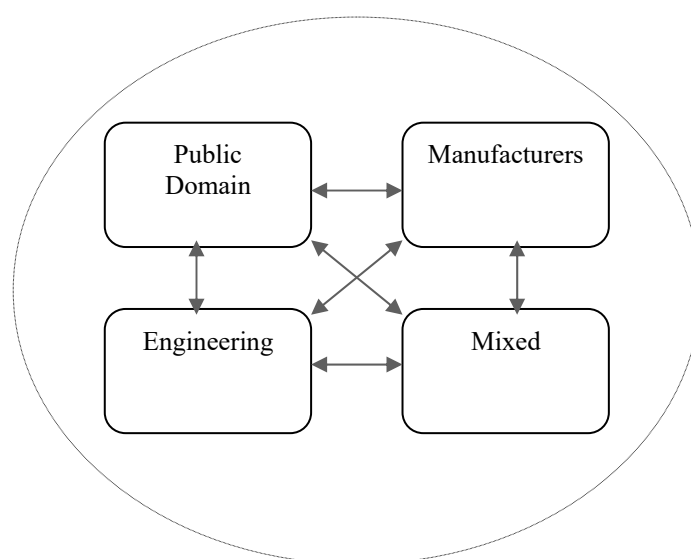


Figure 1: Typology of equipment industries in the sugar-alcohol sector.

Source: Author's elaboration.

The companies in the public domain are the companies that produce low-technology equipment such as tanks, pipes, and chains. These companies acquire the know-how for equipment and production and do not perform research and development; they are small businesses that are outsourced by the larger companies.

The manufacturers are the companies that manufacture equipment that involves more aggregated technology, but they do not have integrated engineering. These companies manufacture the equipment necessary for the implementation of a plant, but they follow the guidelines of an engineering company that develops the projects and the technology necessary for the equipment and the processes. The engineering companies are responsible for research and development in the areas of production and processing technology.

These companies sell their projects, acting in partnership with manufacturing companies. The mixed companies manufacture equipment with higher aggregated technology and have an internal research and development center. These companies are responsible for their own projects and invest in production and processing technology. Generally, mixed companies are focused on producing certain products such as industrial automation.

The companies in this sector, particularly in Sertãozinho, are mostly public domain or manufacturing companies, with fewer mixed companies and engineering companies, which shows that the development of research and technology in these companies is less intense because only a small proportion of the companies falls into this typology. It is noteworthy that despite the low technological intensity, the public domain and manufacturing companies are responsible for diverse incremental innovations in processing and production.

When considering the competitiveness and longevity of this industry, it is important to understand how the profile of public domain and manufacturing companies can be transformed into a profile of companies that invest in research and development. It is not only necessary to characterize the types of companies but also to understand their equipment. There is specific equipment, with varying degrees of technology in development, for each step in the industrial process for the production of sugar, ethanol, and energy (Table 4).

Table 4: Equipment for steps in the production process and potential productivity gains.

Process	Steps	Equipment per Step	General Equipment	Potential Productivity Gains
Extraction	MP, weighing, washing, preparation, grinding	Reducer Grinder or diffuser Food table Turbine Chippers Shredders	Tanks Pumps Automator Dunnage Pipes Engines Valves Currents Reducers Cranes Winches Sensors Actuators Controllers	Food table Chippers Shredders Millers Tracks Evaporators Distillation columns Boilers Automation (sensors, actuators, controllers)

Source: Author's elaboration.

Table 4 shows that the equipment manufactured for the industrial process in plants, both for the steps in the production process and for the general equipment, constitutes simple equipment with low technological intensity. Nevertheless, there is still the potential for innovation that will increase productivity gains through equipment or processes.

In general, the equipment industry for the sugarcane sector, which focuses predominantly on metallurgy and mechanics, has low technological intensity. Therefore, there is low investment in research to develop more elaborate technologies.

However, this equipment industry has innovated throughout its history. Incremental innovations for production and processing have brought greater efficiency to the production of sugarcane derivatives. One example is the adaptation of steam turbines in the industrial process for energy efficiency and, later, the sale of surplus electricity.

This innovation was a major gain for the sector. Other examples, such as increased capacity for boilers and greater efficiency for tracks, show that there are innovations in the industry, but with low technological intensity. However, there are companies that do develop more elaborate technologies, such as in the industrial

automation industry, in which companies have created more efficient technologies for management and processing control within plants.

What is clear is that the industry will have to incorporate investments in research and development so that there is a technological upgrade corresponding to new processes that are designed, as is the case with hydrolysis. The industry will need to stop being reactive because the production of second-generation alcohol will bring a new technological frontier with new characteristics of raw materials, requiring new processes.

3.3. Features of LPA sugarcane companies from of Sertãozinho

After the analysis of the leading companies and some key organizations in the sector, the study, in order to deepen understanding of the dynamics and the profile of the machinery and equipment industry to sugar mills, ethanol and energy in Brazil, also analyzed the companies that make up the Local Productive Arrangement (LPA) of Sertãozinho. Sertãozinho is a town from the countryside of the state of Sao Paulo that presents one of the largest clusters of suppliers and service providers for the sugarcane sector.

The industrial capacity of this LPA allows industries to develop the necessary equipment for turnkey industry plants. The city has seven mills producing sugar and alcohol and 500 companies divided into four industrial districts, 90% of which focused on the sugar and alcohol sector (CEISE, 2010). This model resulted from the own sector crisis in the years 90, with the mergers and closing a business, which resulted in a labor-skilled workers in the city and a number of small companies were created to serve this sector. Despite the proximity, cooperation to the structuring of the formal arrangement is not yet a fact.

This section characterizes Sertãozinho LPA through online survey during 2014. It was designed a structured questionnaire for all companies of LPA sent by Center of Sertãozinho Industries (CEISE) and the Department of Industry and Trade of Sertãozinho county. Altogether they were received 44 responses to the questionnaire, although some incomplete. After standardization data base 36 remaining valid replies.

The variables addressed were: Profile of organizations, levels of export, innovation, financing activities, key challenges and opportunities encountered by the sector.

Of the 36 companies responding, it is possible to identify the oldest companies, founded in 1964 to start-ups in 2014. The median was 2000, which means that half of the sample is made up of companies with founding date from the 2000s. As for the gross sales, 49% of respondents had a value of more than 2.4 million in 2013.

It was also asked for companies to identify three main products or services on the market. The groups found reflect the economic profile of the city and agriculture, in particular with regard to the sugar-energy sector. There is a specific group to sugar-energy plants, but there are also support the entire production chain companies. Since suppliers of implements and equipment for maintenance of industrial services, education and consulting (Table 5).

Table 5: Categorization of the products / services offered

CATEGORIES	ITEMS
Education, Training and Consulting	Vocational education - Regular courses, Assistance to companies - Courses and technical and technological advice; Technical and technological services; Business Consulting; Tax Planning; Engineering Projects.
Implements for plants	Diffuser Sugarcane, Steam Generator, soot blower, Centrifugal Sugar, Control Valves, lubrication system, Boilers, Surface Condensers, turbines, Modular Panels; Heaters and Pressure Vessels etc.
Auxiliar services	Asset Protection, Vehicle Tracking, Personal Protection Supply.
Equipment Maintenance	Electronic maintenance, carbon steel pipes, fittings, industrial maintenance, bearing, spare parts in bronze iron, conveyor belts, rotating screens.
Plants Sucroenergéticas	Sugarcane residual, ethanol; power management.
Industrial services	Industrial Packing, Instrumentation Maintenance, Industrial Automation, Research and Development Electronics, Industrial Maintenance.
Others	Clothes, panels, LED spotlights, cabinets, toiletries.

Source: Author's elaboration.

Only five responding companies have only Sertãozinho and region as their main sales destination. The sales target is concentrated in other Brazilian states, and other regions of the state of São Paulo. Among the respondents, $\frac{1}{4}$ of the companies have export practices. Of these, half say export regularly. Export destinations are Latin America and Africa. The main difficulty faced by the group of respondents for not export concerns the difficulty of access to markets and then by certifications necessary to export process.

Another relevant topic is the access to financing capital. The resources availability is needed in investment projects preparation, working capital and maintenance of core activities of the organization. When asked about funding access to 64% of respondents say they have access to sources of funding. In addition we sought to identify which banks have been used as financing sources. For this, we asked the respondents to mark among public banks, private banks and the National Bank for Economic and Social Development of Brazil (BNDES).

Respondents could select more than one bank, since it is possible to have funding in several banks: only 16% of respondents have used all sources of funding; in 41% of companies will use financing in private banks; in 34% of companies will have access to sources of financing by BNDES; and in 25% of companies will have access to sources of financing other public banks;

When asked about the main difficulty in accessing financing support, the most frequent topic is interest rate, followed by required guarantees and payment terms.

We were able to identify whether companies are participating in associations and what was their level of involvement. Among respondents 66% say join associations, mostly citing CEISE-BR, the Union of Industries Canavieiras (UNICA), the Federation of São Paulo State Industries (FIESP) and the Center of São Paulo State Industries (CIESP).

When considering only the participating companies 62% of them also develop some joint action with another company, especially in the responses to joint product development (innovation activities), training and input purchase.

It was also asked which the benefits of cooperation activities were perceived. One of the pointed benefits is access to markets, also previously mentioned during the analysis of exports and new markets. However, another point that stood out was the level of companies that did not respond this question. It can be inferred that many of them do not clearly distinguish benefits from these activities.

Among evaluated companies two thirds use technological services provision such as laboratory tests, technical reports and certifications. These services, according to respondents, are usually mostly conducted in Sertãozinho or next region.

On innovation capacity in the organization, 66% of them claim to carry out innovative activities in process and product. Regarding amounts invested they vary between 1 and 10% of the total budget of the organization. This may also be related as to a lack of research department and structured development (existing in less than 1% of the responding organizations).

Finally, there have been two open questions about the main challenges and opportunities for these organizations today.

Several challenges were meaningful and was possible to group them into two categories macro (internal and external environment), as some say respects to own questions of the organizations while others are focused on the macro environment in which organizations are located. Items were further divided into 8 major challenges. Figure 5 schematically shows each item, which will be specified in sequence:

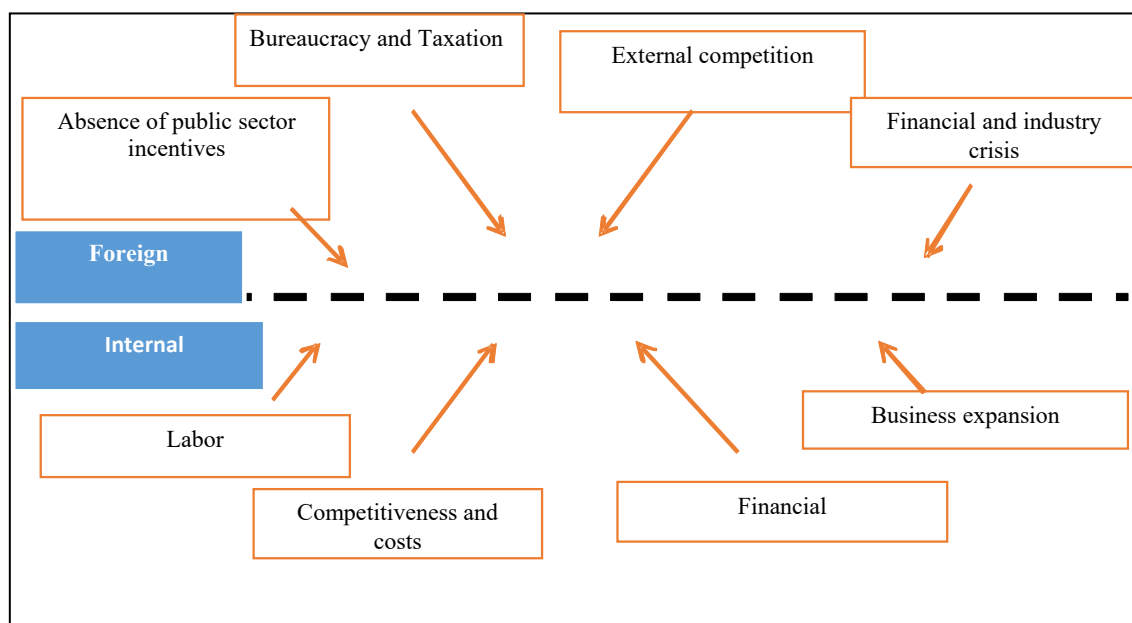


Figure 5: Main Challenges in Sertãozinho Sugarcane LPA

Source: Author's elaboration.

Emanating from the external environment challenges of survival were described. One of them was the financial crisis period - started in 2008 - along with crisis period of sugarcane. "The crisis that shakes the region makes it that people spend less with my company", so the challenges are "market and effects of the financial crisis." To another "our main challenge today, would the current economic situation of the regional and national sugar-alcohol market."

In this topic, several challenges relate to the lack of public incentives. "The main challenge is to survive with the lack of support and investment of the politicians in our industry," "lack of incentive to mechanical metal industry." Also question bureaucracy and taxation issues primarily related to excess taxes paid and labor laws "predatory and outdated".

Another challenging point regards to foreign competition of imported products, citing the case of "competition with Asian manufacturer". This fact turns out to strengthen a number of references to efficiency and cost competitiveness issues and seeking to "improve industrial performance," "improve logistics structure" or issues of "competitiveness and cost."

Internally there are several challenges related to train labor resources. This point is recurrent as in the previous topic 75% of respondents pointed to problems qualifying. Cite "training and staff qualification", "Quality Workforce in the areas of production, and sales" and provide "hand-to-work enough qualified that meets industry expectations."

The issue of skilled labor turns out to be related to business expansion challenges as a challenge is "growth structure while maintaining the quality service" with specific challenges in "commercial, in the search for new markets." In general challenges have been to "seek new clients, dealing with delinquent customers, grow, handle and measure the productive capacity".

Finally, this set of external and internal factors culminate in financial challenges. For some, the biggest challenge is to "keep the company operating", "working capital" and "financial resources to fund marketing and business trips to new markets."

The opportunities cited are distinct, focused mainly on competitive advantages acquired over time by the organizations. Generally observe some market opportunities in "new markets" that focus on "different in different markets of the sugarcane".

Others are guided in "old customers" to be "recognized for service quality" or able to remain active for "have multiple certifications" making it easy to get quotes and customer contacts. There are also those who have seen an opportunity to provide customized services to low prices for other agricultural sectors.

4. FINAL CONSIDERATIONS

This study aims to analyze the configuration, efficiency and innovation in the equipment industry to sugar mills, ethanol and energy by means of a survey of business leaders and key industry bodies as well as to know the profile of the companies constituting the largest cluster of companies in this sector in Brazil, located in Sertãozinho, Sao Paulo.

The first point to note is the strong modernization of existing plants. This process has generated strong growth in manufacturing employment in the city in which this industry is located. The industry is characterized by national capital and is heavily concentrated in the state of São Paulo, which demonstrates the need to be close to the consumer market. The technology is relatively simple and does not constitute a serious obstacle to the entry of competitors in this segment.

Thus, despite the possibility of importing equipment, the practice is quite limited. It is important to note difficulties, however, that the appreciation of the currency in the country created for domestic producers. The growth of such production plants could have been even higher if the country had not such a high cost, allow speed up its modernization programs and technological modernization, replacement of equipment, and expand the co-generation of energy.

This component producers' sector was not a barrier to the expansion of sugar cane and energy sector. However, the increasing modernization of the sector will require efforts in the equipment industry to provide the necessary technological advances and possible efficiency gains for industry.

Additionally, with analysis of the machinery industry companies and equipment for the sector, located in the APL of Sertãozinho, it was realized a business opportunity to support organizations and for companies listed in the group Education, Training and Consulting. Guidance and assistance during the export process, from the design of new products and seeking markets can generate training opportunities and relevant advice.

Despite advances in processes and increases in products, it is worth noting, however, that few companies in the city invest in technology and training. They are lacking in management training, which leads to loss of valuable opportunities. These entrepreneurs need to invest and change the competitive industry standard.

It was noted also a need for greater cooperation among companies and between companies and supporting organizations and / or representation. The growth of the sector, in particular through access to new markets could be facilitated if the companies meet in joint associations or missions.

Working in partnership, they would increase their bargaining power in the negotiation rounds, would share costs of prospecting and transaction and experiences and could have greater ease in seeking financial support from public and private institutions.

Finally, another suggestion would be to seek support in government agencies, universities and all possible institutional frameworks to assist in the export process. With specific regard to industrial exporting process can be cited here Apex program and Peiex Brazil.

It is suggested to assess how these organizations are perceived by companies. In many cases (especially smaller ones), they do not see themselves represented by these associations. The non-materialisation of the benefits offered by these entities may be the beginning of low involvement generation companies with these organizations.

Future studies should deepen these discussions on what should be invested in R & D in the sector and what can be done to encourage such investment. An analysis of the main research abroad to meet new ethanol production techniques and the growth prospects of international competition make it imperative for the domestic industry of machinery and equipment for sugarcane agro-industry is permanently update, create new products, and meet the changes generated abroad to preserve the country's competitiveness in this sector. Therefore, how should conduct further studies on how to encourage cooperation between companies and between them and the entities to which strengthen the industry in the country.

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