



*International Food and Agribusiness Management Review*  
Volume 13, Issue 3, 2010

## Measurement of Sugar Cane Chain in Brazil

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### Abstract

Despite the historical importance of the sugarcane business in Brazil, which is as old in the country as its colonization, it has never been “photographed in widescreen”. This research on the mapping and quantification of business generated in the sugarcane chain in 2008 for the first time gives the scale of the entire sugarcane productive chain in Brazil. The sector now shows the numbers that indicate the industry’s role in building the country's GDP, as well as in job creation, tax generation, and the distribution (capillary) of economic activities.

By applying the method Strategic Management of Agro-Systems (GESIS), developed by the first author, Professor Marcos Fava Neves, coordinator of the Marketing & Strategic Projects and Research Center, USP (MARKESTRAT), it was found that the sugarcane sector GDP is around \$28.1 billion USD, equivalent to almost 2% of the Brazilian GDP—or almost all of the income generated in a year in a country like Uruguay. The majority of the industry’s inputs are local, explaining its favorable trade balance situation.

A series of new products has become increasingly more important and a major transformation is going on in this sector that has one of the oldest and, at the same time, most modern plants with regard to clean energy on the planet.

**Keywords:** chain mapping, chain quantification, agro-industry system, sugar cane sector, ethanol, sugar.

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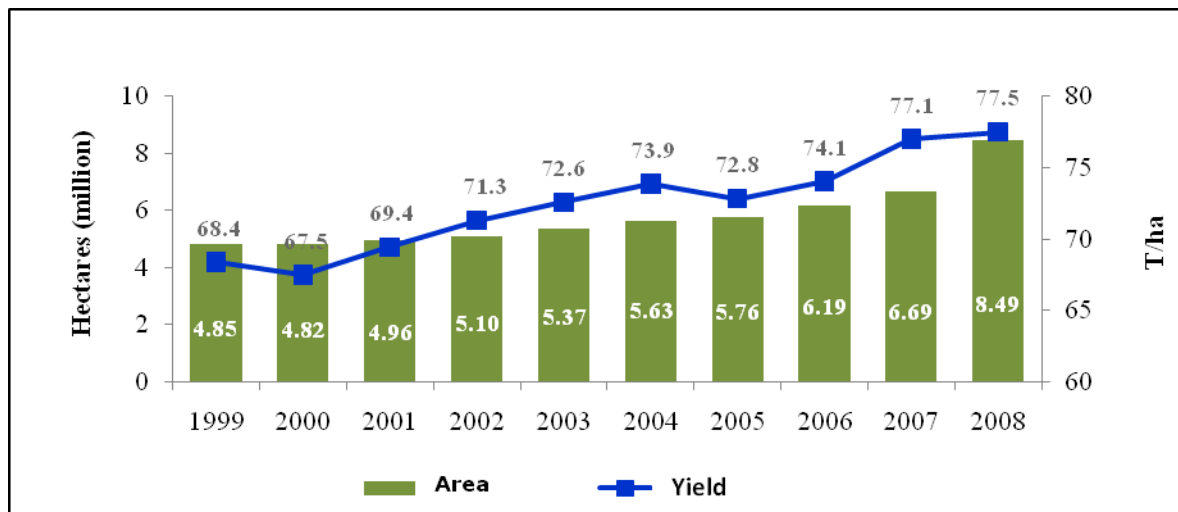
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## Introduction

Sugar has historically been the mainstay of the Brazilian economy. It not only provides food and ingredients into the food and beverage industry, but currently, it also supports the energy sector with inputs for the bioenergy industry. Together, ethanol and sugarcane bagasse represent 15% of the Brazilian energy matrix. It also supports significant levels of employment and tax revenues throughout its supply chain.

According to The Brazilian Sugarcane Industry Association (UNICA), the largest organization representing the sugar and bioethanol sectors, Brazil is the world's leading sugarcane producer. The 2008/09 harvest year saw a record crop estimated at 569 million tonnes of sugarcane, processed at around 423 plants nationwide. Of these, 248 were combined mills and distilleries producing both sugar and ethanol, while 159 produced just ethanol. All mills are self-sufficient in producing their own electricity needs. Production grew 85% in the last ten years due to increased area and yield. As shown in Figure 1, sugarcane currently covers 8.49 million hectares in Brazil, or 2.3% of the country's total arable land.



**Figure 1.** Area and Yield of Brazilian Sugarcane Production

Source: UNICA

Indeed, Brazilian sugar industry leaders are focusing on sustainability and social responsibility issues because of their increasingly importance. Improving the workers' quality of life, the rational use of land and water, mitigating the effects of mechanized harvesting, and the preservation of ecosystems are parts of the work agenda of the sector, which is one of the major employers in Brazil.

Although the advances are not modest, there is still much work ahead for the industry to grow even more. Externally, Brazil must convince critics that the increase in Brazilian sugarcane production does not occur in forest and food production areas, and also demonstrate the regularity of ethanol supply and the sustainability of production (social, environmental, and economic). Internally, Brazil must show that there are a number of other benefits, in addition to financial savings, by using ethanol in their vehicles. This would justify further support from the federal government, for example, through increasing the mixture of ethanol in gasoline from the

current 25% to 30%, and a greater presence of the Brazilian Development Bank (BNDES), providing long-term financing to improve the competitiveness of the sector and more investments on co-generation of electricity. One of justifying further support is to present the economic and social impact of the activity in the country.

In this sense, this paper brings data collected over four months, showing the financial outcomes generated in every link of the sugarcane productive chain, the jobs generated, taxes, and the sectoral GDP. Thus, the paper can help to enhance appreciation of the complexity of capturing value contributions for agribusiness industries. It can also be used by the sugarcane sector to get an active participation in the formulation of governmental politics for the industry and to influence the process of building the sugarcane image among the world's opinion leaders.

The objective of this article is to apply the mapping and quantification method to the sugarcane chain in Brazil. The final information of this method is a one page description of a food chain, showing all the participants and the revenue of the different links of the productive chain in a year of analysis. Besides these financial numbers, other results possible with the method are the quantification of jobs and taxes generated by the chain in a year basis<sup>1</sup>.

## **Bibliographic Review**

It is important to say that this article does not use a network approach, since the unit of analysis is not a network, it is a food chain. A food chain here is considered as limited by the boundaries of a particular country. Its actors are input suppliers, farmers, industry, distributors and service providers. Like the Dutch flower chain, Danish pork chain, or other country chain.

Until the early 20th century, the concept of agribusiness was not used in the agro-food system, the families made their food and the excess was sold in local market. Later, production systems have become specialists, decentralizing the stages of production, distribution and marketing. Even apart, all activities continued somehow interrelated, featuring a production chain. The understanding of this new system became the interest of researchers leading them to formulate theories that could explain the new approach (Watanabe 2005).

It is a traditional view that literature had coming from two different approaches, developed in different places and times. The first one was developed by Goldberg (1968) in the USA, which presented the term *commodity system approach* (CSA) in studying the citrus, wheat, and soy production systems. The CSA approach, beyond analyzing the traditional buyer-seller relationship, analyzes the institutional influences and concludes that the final destination of agricultural products is not the final consumer but the agro industry, which influenced the analysis of the subsystems that compose the agro industrial system.

The theoretical basis of the CSA is derived from the neoclassic theory of production and the Leontief input-output matrix. Such an approach was the basis for the introduction of inter-sector

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<sup>1</sup> This research is part of a broader effort of the Brazilian Sugarcane Industry Association (UNICA), the largest organization in Brazil representing sugar, ethanol, and bioelectricity producers. The association is working to increase knowledge about the sugar and ethanol industry and to convey to the public, in a concise and uniform way, the benefits of production and use of clean energy from renewable and sustainable agricultural origins.

dependence and also expressed concern with the measurement intensity of inter-sector linking (Zylbersztajn, 2000). The CSA methodology emphasizes the sequence of product transformations in the system.

Goldberg's research had its merit in changing the center of the analysis from inside the firm to the system, which prevented dealing with the agricultural sector as isolated from the overall economy. The idea of *agribusiness* reinforces the existing inter-sector bonds, in that it places the agricultural production as part of the commodity system, emphasizing its relations with the world of business (Silva, 1991). Goldberg (1968) still stresses the importance of the systemic approach's use to support cooperative decisions.

The second approach, proposed by Morvan (1985), considers a chain ("*filière*") as linked operations for the transformation of a good. The chains are influenced by technology and have complementary interdependences, according to Batalha (2001). The *filière analysis* applies to the sequence of activities that transforms one commodity into a product for final consumption and represents a tool of the French industrial economy's school.

According to Morvan (1985), the *filière analysis* is an important instrument to describe systems, define technologies role in the framing of productive systems, organize integration studies, and analyze industrial polices, firms, and association strategies.

Although not used here, there are important additional contributive theories. The *supply chain* is viewed as a system that integrates raw material suppliers, factories, distribution services and consumers (Stevens *apud* Omta et al., 2001). Furthermore, there is the network concept when organizations are directly involved in different processes that add value in the elaboration of goods and services until the final consumer (Christopher *apud* Omta et al., 2001).

Lazzarini et al. (2001) integrate chain and network concepts in a new study on *net chains*. According to these authors, the integration of these approaches allows the consideration of existing organizational interdependences in a network, as well as the different mechanisms of coordination (managerial plans, processes standardization, and adjustments) and sources of value (production and operations optimization, transaction cost reduction, diversity and "co-specialization" of knowledge).

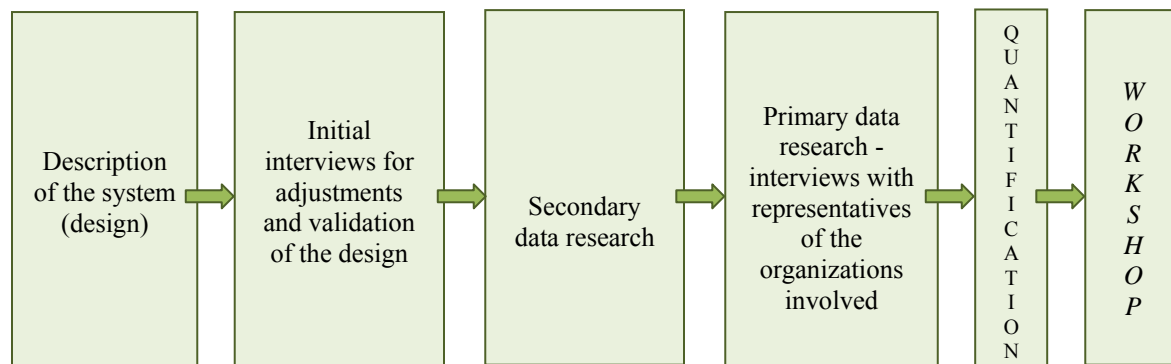
Hardman et al. (2002) demonstrated the possibility of increasing the competitiveness of the South African apple chain exports through the cooperation among producers, packers, and exporters. From the ideas of CSA and the *filières*, it is possible to develop tools and managerial activities to improve the chains' efficiency. Thus, the concepts of *Supply Chain Management* (SCM) and the set of networks and *net chain* ideas are important theoretical concepts and empirical notions for the development of agro-industrial systems (Batalha & Silva, 2001).

After this introduction and delimitation of relevant literature, session 3 will bring details on procedures and operationalization of the empirical research that quantified the sugar cane chain, for the year of 2008.

## Procedures and Operationalization

The first step in characterizing an analyzing a system is to define its boundaries, subsystems and their objectives. This will facilitate a definition for the system's environment (Malhotra, 2001). Batalha (2001) comments that for a chain analysis, the researcher must define the objectives to be reached. The most important and difficult definitions are related to the analysis of scope and the levels that should be detailed. Zylbersztajn (2000) also comments that the definition of the chains boundaries is dependent on the researcher's purposes, which are generally focused on a flow of product. In this study, the established scope was the sugarcane chain in Brazil, focusing on sugar, ethanol, and their main derived products.

As it shown in Figure 2, the sequence of this methodology can be summarized in six stages. This methodology had been applied in several studies in Brazil, by Rossi and Neves (2004), Neves and Lopes (2005), and Consoli and Neves (2006) in the PENSEA (Agribusiness Intelligence Center)<sup>2</sup> researches of the Brazilian wheat, orange and milk agro-industry systems, respectively.



**Figure 2.** Method of Mapping and Quantification of Chains

Source: Neves et al. (2004)

The first step consists of elaborating a preliminary description of the chain participants, represented in small boxes, based on theory and the researchers' experience. It is also necessary to scope which segments will be studied, keeping the focus on its central axle and the research objectives. This research was focused on sugarcane chain, contemplating the Goldberg (1968) notion of the CSA, as well as emphasizing a product as the starting point for the chain analysis.

After the chain description, the second step involves submitting the analysis to chain and industry specialists and working with them to adjust the original framework to reflect the industry's reality. It is very common to forget participants, agents, and this second stage helps to map all possibilities.

The third stage consists of searching of the secondary data research, which according to Malhotra (2001) is collected for ends that differ from the problem of the research. This step

<sup>2</sup> A program of the School of Economics, Business and Accounting at the University of Sao Paulo (USP).

involves gathering secondary data from sources that have academic and statistical credibility, reputation, and integrity.

After the collection of the available secondary data, which in some countries and environments may be very limited, starts the collection of primary data (fourth step), which are the data originated by the researcher for the specific purpose of solving the problem in question (Mattar, 1993; Malhotra, 2001). In this empirical research, in depth interviews were performed with representatives of several organizations in the sugarcane sector. The major information needed is amount of sales of a particular segment of the chain, employment and taxes.

To select and define the interviews, it is first necessary to identify which data were not found through the secondary data sources. To be interviewed, the agent needs to match some characteristics—i.e., have access to the information and data of the sector in study, have knowledge and experience about the chain, be willing to collaborate with the research and establish a communication channel for future contacts, and indicate other possible agent to contribute with more data.

The quantification (fifth stage) involves determining the turnover of each sector in the chain, through each sector's companies' revenues, and estimating several sub-sectors of the sugarcane chain. In order to guarantee the data reliability some secondary and primary data were contrasted, attempting to find incongruous possibilities. In this process, at least two different data sources to check the results, with additional interviews with similar agents when needed.

Finally, in the sixth step is the data validation. It can be accomplished with a workshop, where information were sent to participants prior to the event, and then discuss the numbers or by sending the materials to relevant agents of all the "boxes" of the chain, for verification. After that, the research was presented to the press, National Congress and the most important Brazilian sugarcane producers' States, such as São Paulo, Goiás, and Paraná.

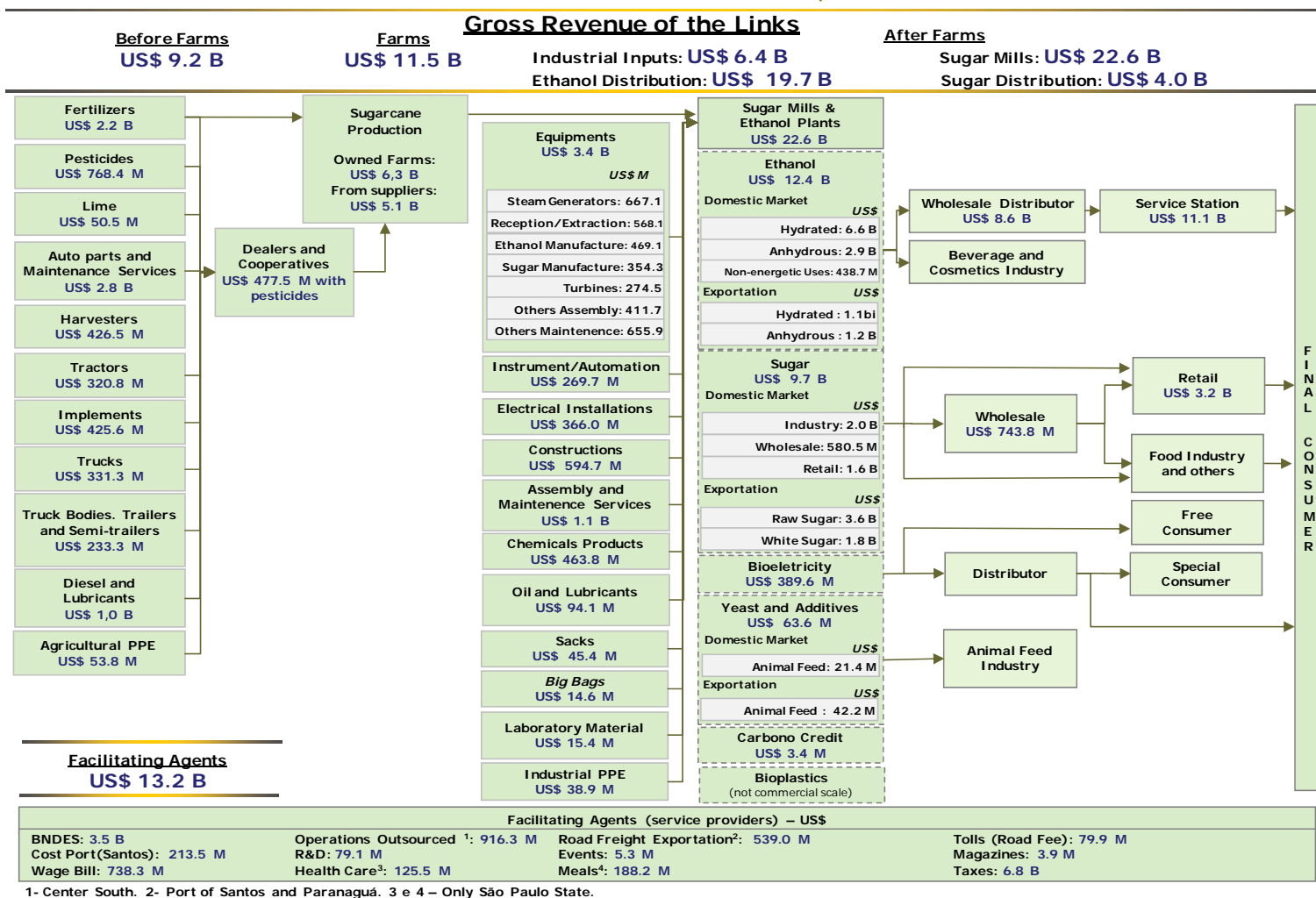
After definition of relevant literature and the procedures done for the empirical work, session four brings the results.

## **Results: Description and Analysis of the Sugarcane Sector**

The sugarcane chain's GDP was \$ 28.1 billion, equivalent to 2% of the Brazilian National GDP or almost the overall economic output produced in a country like Uruguay (\$ 32 billion). The chain GDP calculation was estimated by adding the sales of all final goods and services offered in the economy. As shown in Table 1, subtracting sales taxes, the amount is \$ 24.3 billion.

Figure 3 is the major output of this method, and represents the sugarcane chain, and the values below each link indicate its gross sales in this productive chain in 2008. Total gross revenue (financial movement of a chain in a year) of the sugarcane chain was about \$ 86.8 billion. This value represents the sum of all estimated sales done by every link of the chain and the financial transactions of the facilitating agents described.

## Sugarcane Sector Sectorial GDP in 2008: US\$ 28.1 B



**Figure 3.** Sugarcane Chain (gross revenue)

Source: Neves, Trombin, and Consoli, with data generated by MARKESTRAT (2009)

**Table 1.** Estimates of the sector’s Gross Domestic Product based on the end products

Product		Domestic Market		Exportation	Total	
		\$		\$	\$	
		With Taxes	Taxes Free	Tax Exempt	With Taxes	Taxes Free
Ethanol	Hydrated	11.1 B <sup>a</sup>	9.1 B	23.7 M	11.1 B	9.1 B
	Anhydrous	2.9 B <sup>b</sup>	2.2 B	2.3 B	5.3 B	4.6 B
	Non-energetic Uses	438.7 M <sup>c</sup>	351.5 M	n.d.	438.7 M	351.5 M
Sugar		5.2 B <sup>d</sup>	4.4 B	5.4 B	10.7 B	9.9 B
Bioelectricity		389.6 M <sup>e</sup>	242.8 M	n.d.	389.6 M	242.8 M
Yeast		21.4 M	19.4 M	42.2 M	63.6 M	61.6 M
Carbon Credits		n.d	n.d	3.4 M	3.4 M	3.4 M
<b>Total</b>		<b>20.2 B</b>	<b>16.4 B</b>	<b>7.91 B</b>	<b>28.1 B</b>	<b>24.3 B</b>

<sup>a</sup>Sales done by gas stations, considering the formal and informal markets.

<sup>b</sup>Sales done by the ethanol plants to ethanol wholesale distributors, considering the formal and informal markets.

<sup>c</sup>Sales done by ethanol plants to the beverage and cosmetics industries.

<sup>d</sup>Sales done by sugar mills to the food industry added with the sales done by retailers to final consumers.

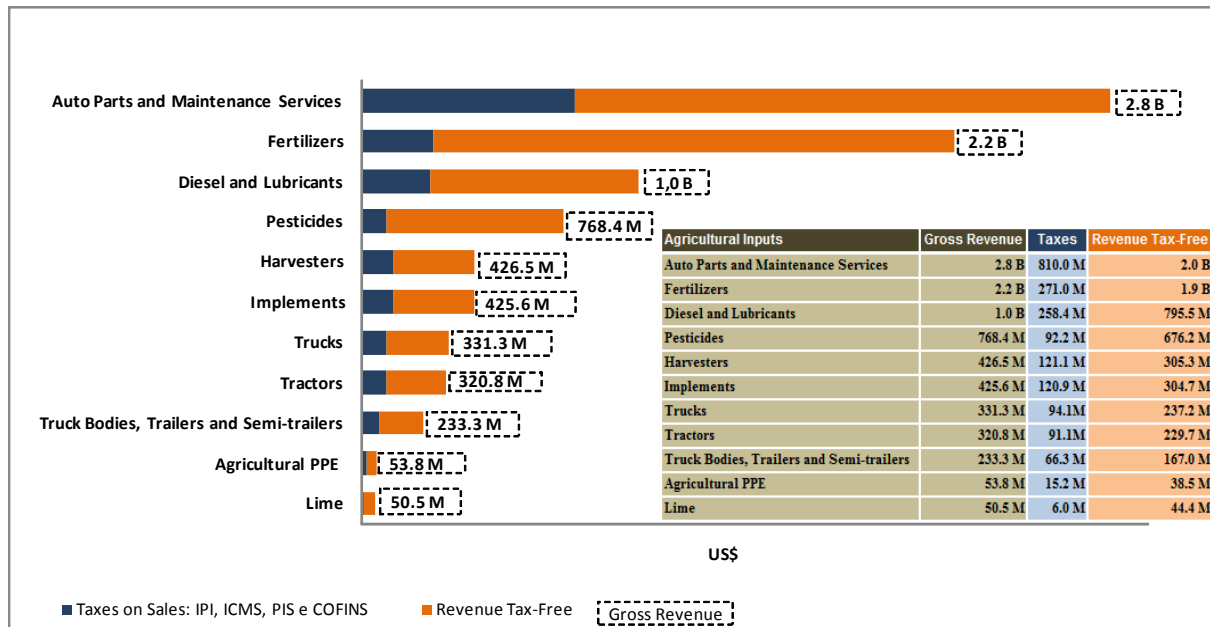
<sup>e</sup>Sales done by the sugarcane mills and ethanol plants in energy auctions.

**Source:** Neves, Trombin, and Consoli, with data generated by MARKESTRAT (2009)

## Before the Cane Farms Sectors

### Agricultural Inputs

The agricultural inputs industry sold to the sugarcane chain about \$ 9.2 billion in 2008, also considering the pesticides sales by agricultural cooperatives and dealers of \$ 477.5 million. Figure 4 summarizes all the agricultural input revenues, which are detailed in the following text.



**Figure 4.** Agricultural Inputs Sales

**Source:** Neves, Trombin and Consoli, with data generated by MARKESTRAT (2009).



This chain accounted for 14% (\$ 2.2 billion) of the agricultural fertilizer sales in Brazil, making it the largest fertilizer market after soybeans and corn. Expansions in sugarcane production have caused an increase in the demand for fertilizer despite unfavorable cane market conditions. For example, 36.3T of sugarcane purchased a ton of fertilizer in 2008 compared to 19.8T in 2007. This happened due to rising prices of fertilizer and the reduction of sugarcane prices. Sales of lime to sugarcane plantations in 2008 were estimated at \$ 50.5 million, corresponding to 2.9 billion tons or 14% of national consumption.

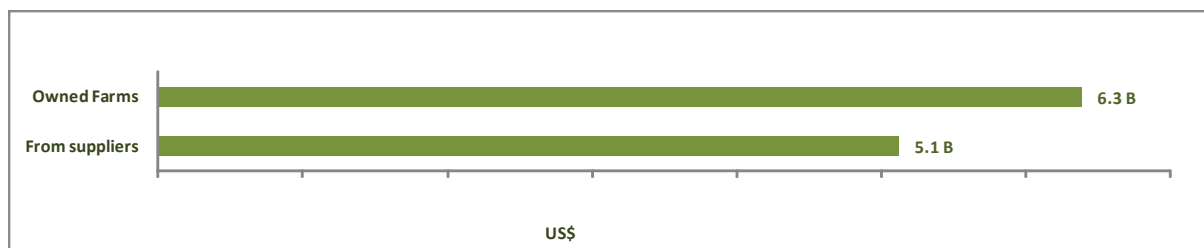
In 2008, the pesticides industry had revenues of \$768.4 million with this chain, 9.5% of the total sales in the country (cooperatives were responsible for 61% of pesticides sales, dealers represented 2% and direct sales accounted for 37%). The sugarcane chain stands out among the 3 cultures that consume more pesticides in the country, highlighting the importance of the sector. Almost four thousand tractors were sold to the chain, generating revenues of \$ 320.8 million and 9% of total tractors sales in the country. Sales coming from agriculture implements was about \$425.6 million, including plows, disc harrows, subsoilers, and self-propelled irrigation systems, among other items. The auto parts sector jointly with machinery maintenance services had revenues of about \$ 2.8 billion, including parts and labor force to maintain nearly 144 thousand machines in operation, which each consume approximately \$ 20.000 in maintenance per year. In harvesters, the chain acquired 981 units, 22% of the total sold in 2008, accounting for a turnover of 426.5 million. All burning must cease in São Paulo by 2014 in areas where mechanized harvesting is possible.

In 2008, 1,962 heavy trucks (weight over 40 tons) were sold to the sector, 5% of this truck category's sales in the country, representing \$ 331.3 million in sales. Truck bodies, trailers, and semi-trailers were estimated at \$ 233.3 million. In addition to the 488 truck bodies sold, the license plates of 4,856 trailers and semitrailers were registered, which accounted for about 9% of total sales to the heavy machine in Brazil, and an 11% increase over 2007. The agricultural mechanized operations and the sugarcane transportation from farm to industry consumed about 1.0 billion liters of diesel fuel and lubricants, equivalent to \$ 1.5 billion.

## **Results of Measurement on Farms**

### *Sugarcane Production*

The sugarcane 2008/09 harvest reached a record production of 568.9 million tons and a planted area of about 8.5 million hectares. The São Paulo State accounted for 68.6% of the sugarcane crushing in the south-central region. The sugarcane was responsible for revenues of \$ 11.5 billion. The yield of raw material was 143.25 kg of total recoverable sugar (ATR) per ton of sugarcane. The ATR average value was \$ 0.14/ATR, and the sugarcane average price was \$ 20.23 per ton. As shown in Figure 5, the sugarcane from suppliers accounted for approximately 44.5% of the industry demand (\$5.1 billion) and 55.5% were harvested on the farms owned by the mills, the called vertical integration (\$6.3 billion).



**Figure 5.** Sugarcane Sales

**Source:** Neves, Trombin, and Consoli, with data generated by MARKESTRAT (2009).

## Results of Measurement After Farms

### *Equipment, Industrial Services and Supplies*

The sugarcane chain was the responsible for the purchase of \$ 6.4 billion in industrial inputs. The industrial equipment and assembly services were estimated by considering the investments done in the 29 ethanol plants and sugar mills that started operation in 2008. Of the 29 industrial units, the premise adopted was that: four are sugar mills (3 have a milling capacity of 1.5 million tons of sugarcane per year, and 1 has a capacity of 3 million tons) and 25 are ethanol plants (15 with a milling capacity of 1.5 million tons, and 10 with a capacity of 3 million tons).

The average investment to assemble the industrial part of a sugar mill was estimated at \$ 85 per ton of sugarcane milling capacity and for an ethanol plant at approximately \$75per ton. Table 2 shows the proportion of the investment amount needed, and Table 3 details the investment in equipment.

**Table 2.** Proportion of Investment to Build a New Sugar Unit.

Item	% of the Total Investment
Equipments	60%
Electromechanical Assembly	7%
Constructions	13%
Electrical Installations	8%
Instrumentation/Automation	2%
Engineering Services, Thermal Insulation, and Painting	10%
Total:	100%

**Source:** Prepared by MARKESTRAT from data provided by Procknor Engineering

**Table 3.** Proportion of the Equipment Investment per Equipment.

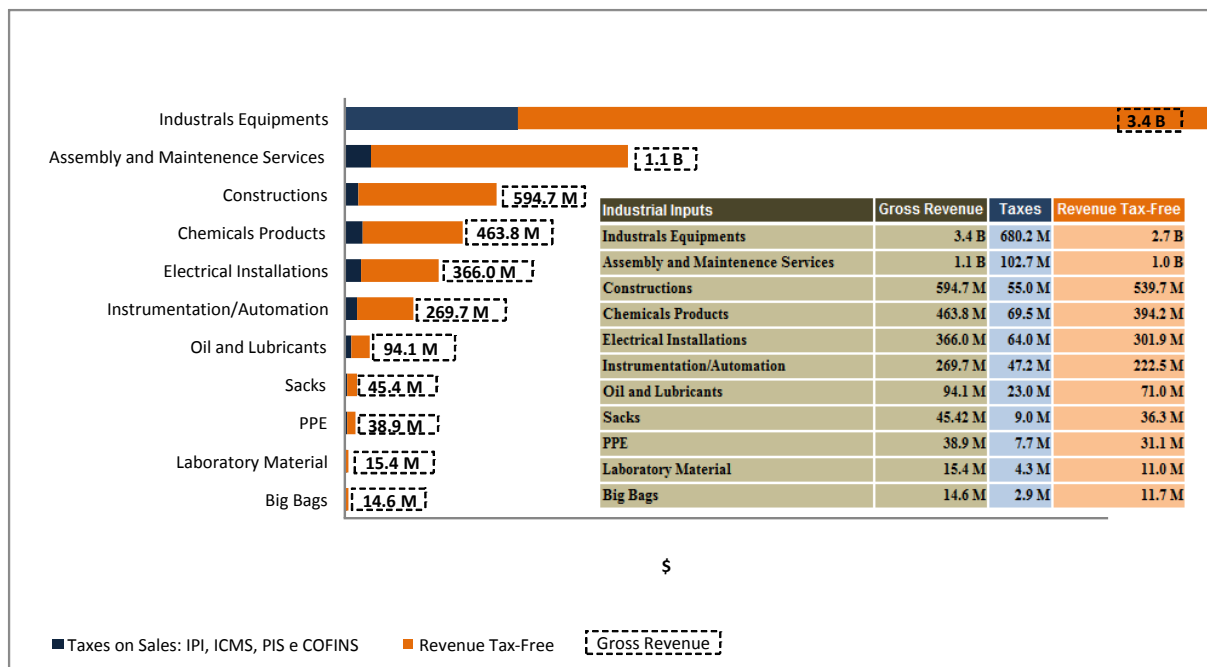
Equipments	% of the investment in equipments	
	Sugar Mill	Ethanol Plant
Steam Generators	25%	20%
Sugarcane Reception, Preparation, and Extraction System	20%	25%
Ethanol Manufacture	15%	30%
Sugar Manufacture	15%	0%
Turbines/Power Generators	10%	10%
Others	15%	15%
Total:	100%	100%

**Source:** Prepared by MARKESTRAT from data provided by Procknor Engineering

In addition to investments related to the new units' installation, it was also considered the sales of equipment and services for the maintenance of industrial units, which is performed between crushing sessions. Maintenance cost is \$ 1.68/ton of sugarcane milled, being 62.50% spent on equipment and 37.50% spent on services. Given these assumptions, the revenue of the industrial equipment suppliers was estimated at approximately \$ 3.4 billion. Sales of automation and instrumentation were \$ 269.7 million, and service providers of assembly and maintenance had revenues of approximately \$ 1.1 billion.

The sugarcane chain had generated revenues of \$ 463.8 million purchasing the products and specialty chemicals for ethanol and sugar production, including quicklime, polymers (auxiliary in the production of sugar and ethanol), yeast, water treatment, and ion-exchange resins, among other inputs.

The fuel and oil consumption for the industrial operation was 70 million liters, generating revenues of \$94.1 million. Costs of laboratory material were \$15.4 million. Sacks of 50 kg for packing sugar were \$ 45.4 million, and big bags of 1,200 kg also for packing sugar were \$ 14.6 million in 2008. Industrial PPE (Personal Protective Equipment) was \$ 38.9 million. Figure 6 summarizes the revenue generated with the industrial inputs.



**Figure 6.** Industrial Inputs Sales

**Source:** Neves, Trombin, and Consoli, with data generated by MARKESTRAT (2009)

### *Sugar Mills and Ethanol Plants*

The industry sold about \$22.6 billion with all of the products, being \$12.4 billion with ethanol, \$9.7 billion with sugar, \$389.6 million with bioelectricity, and \$67.0 million with yeast, additives, and carbon credits. These products represent, respectively, 55%, 43%, 1.7%, and 0.3% of their sales.

This industry had \$12.4 billion in sales with ethanol in 2008, considering the domestic and international markets.

Exports generated revenues of \$2.3 billion (5.1 billion liters), being \$1.1 billion for hydrous ethanol and \$1.2 billion for anhydrous ethanol. Exports of anhydrous ethanol were atypical in 2008. One reason for its growth was the increment of U.S. demand, due to the decrease in crop because of the flooding in the main producing region of the country, in addition to the significant increase in the cost of oil, which exceeded \$ 100/barrel during the year. The main buyers were the United States (34%), Netherlands (26%), Jamaica (8%), and El Salvador (7%). However, the total exported volume is still small compared with total production, which already indicates great potential for growth, with volume multiplied 14 times since 2001.

The domestic market consumed 14.08 billion liters of hydrated ethanol in 2008, generating a turnover of \$6.6 billion to the industry. The sales of hydrated ethanol have grown considerably in recent years (compared with 2006, the increase was 87%). The main reason for this growth was the introduction of the flex fueled engine cars, which in 2008 accounted for 90% of the light commercial vehicle sales in Brazil. The anhydrous ethanol in the internal market generated a turnover of \$2.9 billion (6.48 billion liters). The major consumption of this product in Brazil is in blending with gasoline, currently at the rate of 25%.

Ethanol for non-energy uses has its destiny mainly to production of beverages, cosmetics, pharmaceuticals, and chemicals. According to data from the National Energy Balance, this consumption was 720 million liters (\$438.7 million as turnover for the ethanol plants). Wholesale distributors earned \$8.6 billion, and the fuel distribution service stations \$11.1 billion.

The sugar mills earned \$9.7 billion with sugar in 2008, counting sales to both the domestic and international markets. Exports generated revenues of \$ 5.4 billion, being 67% with raw sugar and 33% with white sugar. Major buyers are Russia, followed by Nigeria, Egypt, Saudi Arabia, and others. The largest share of sugar production is destined for foreign markets. Production grew at rates much higher than the growth of Brazilian consumption, which remained stable over the last 6 years on average at 3% per year.

The turnover in the domestic market was \$4.0 billion with sugar. Sales to the food industry were \$2.0 billion; sales to retailers were \$1.6 billion, and wholesale, \$580.5 million. Generally wholesalers' transactions occur to sell for small factories and buyers. These wholesalers, in addition to selling to the factories, sometimes pack the sugar and sell it for retail. The main sugar-consuming industries are the producers of soft drinks (20%), candy and chocolates (10%), chemicals (10%), and milk (7%), with other industries accounting for 53%. Sugar for fresh consumption is crystal (61%), followed by refined sugar (36%). The wholesale industry had earned \$743.8 million with sugar, and the retail chains (supermarkets) \$3.2 billion.

The bioelectricity generated from sugarcane bagasse increasingly stands out as an important product of the industry, being sold to electricity markets. In 2008, about 30 plants had negotiated 544 MW, representing annual revenue of \$389.6 million.

About 10% of the yeasts used in ethanol production, specifically in the fermentation of sugar cane, are recovered and dried to be used in the composition of animal feed. In 2008, yeast

exports reached 32 thousand tons, generating revenues of \$16.8 million.

Jointly with the yeast, additives based on sugarcane yeast (such as the cell wall) are marketed. In 2008, 13,400 tons of this product were exported, generating revenues of \$25.4 million. In the domestic market, 5,000 tons of additives were sold, representing a turnover of \$10.33 million. Therefore, sales of yeast added to its additives reached about \$21.4 million in the domestic market and around \$ 42.2 million in exports, totaling \$63.6 million.

For carbon credits, in terms of trading volume, Brazil ranks third among the country vendors, but it still has only 3% of the market. China is the leader with 84%. The amount traded worldwide in 2008 was 389 million tCO<sub>2</sub>e (tons of carbon dioxide equivalent), valued at \$6.5 billion, 14% less than in 2007. The Brazilian participation in the carbon credit market occurs through the Clean Development Mechanism (CDM), because it is the only mechanism of the Kyoto Protocol that allows voluntary participation of the developing countries. The 68 Brazilian projects registered by the United Nations Framework Convention on Climate Change (UNFCCC) on the carbon credit market generated an estimated reduction of 3.4 million tCO<sub>2</sub>e and a turnover of approximately \$25.3 million in 2008, using the average price in 2008 recorded by the voluntary market of \$7.34 per tCO<sub>2</sub>e (tons of carbon dioxide equivalent). Of the 68 projects, 24 were from the sugar-energy sector, which generated an estimated decrease of 473.94 thousand tCO<sub>2</sub>e, valued at \$3.4 million in 2008.

Bioplastic is one of the most promising innovations. If the planned investment really occurs, in a short time this product will be a very important item in the sugar mills' and ethanol plants' portfolios. It is estimated that the demand for this new product has already reached 600,000 tons annually worldwide, although at 15% to 30% higher price than the conventional product. According to the Europe Institute of Bioplastics, almost 331,000 tons of bioplastics are produced today, which is less than 1% of synthesized plastics produced annually.

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Bioplastic is one of the innovations for the exploitation of sugarcane bagasse. If the planned investment really occurs, in a short time this product will be a very important item in the sugar mills' and ethanol plants' portfolios. It is estimated that the demand for this new product has already reached 600 K tons annually worldwide, although at 15% to 30% higher price than the conventional product. According to the Europe Institute of Bioplastics, almost 331 K tons of bioplastics are produced today, which is less than 1% of synthesized plastics produced annually. The Brazilian bioplastics production is still at a minimum scale that is inadequate to put the product on the market.

PHB Industrial, a company controlled by one of the most important groups of sugar mills in Brazil, has in its industrial park one of the first pilot projects of the country. In laboratory scale,

the company can produce about 60 tons per year, which are currently exported to Japan, the United States, and Europe at an average price of \$ 5/kg. However, very little of this material was sold effectively, and the majority was exported for developing applications with international companies. PHB Industrial is designing a plant to start operating at commercial scale in 2 to 3 years. Media reports say the plant will eventually produce 10 thousand tons/year and will begin operations in 2010.

Braskem, a Brazilian petrochemical company, currently has production capacity of about 12 tons/year in a pilot plant and has announced investments to start production in 2011 of approximately 200 K tons per year. Dow Chemical reported the creation of the first ethanol hub that is slated to produce 350 K tons/year starting in 2011. Copersucar, in partnership with the Belgian group Solvay, should produce 120,000 tons in 2010 (Source: ABDI).

If investments for 2010 materialize, press reports estimate that the alcohol chemistry industry will require 650 million liters of ethanol annually. A large potential market signals unparalleled opportunities for the sector.

#### *Facilitating Agents of the Sugar Cane Chain*

Due to further industry consolidation, new groups have been taking the sugarcane business on a professional management basis with a focus on efficient operations and better financial allocation. This created a demand for outsourcing services on the operations of cutting, loading, and transportation of the sugarcane from farms to the plants, favoring the entry of specialized companies in sugarcane logistics operations. In 2008, the outsourced CLT (operations outsourced of cutting, loading, and transportation of sugarcane) had a turnover of \$916.3 million.

The resources dedicated to road freight for sugar and ethanol exportation totaled \$539.0 million. Of this total, spending on road freight for sugar exportation in the center-south region was \$383.6 million, and the ports of Santos, in São Paulo State, and Paranagua, in Parana State, were the main routes of exportation in 2008. Of that amount, freight export of ethanol totaled \$155.4 million. The sugar export freight over the Brazilian road system costs approximately \$34.16/t, and ethanol freight costs \$ 34.76/m<sup>3</sup>. The Revenues from tolls to export ethanol and sugar added an amount of \$79.9 million in 2008. The revenue from the Port of Santos on customs clearances services, lifting, and supervision of loading the sugar and ethanol was estimated at \$213.5 million in 2008. Almost 70% of the entire Brazilian ethanol and sugar exports were made through the Port of Santos.

In 2008, \$79.1 million of resources were allocated to research on sugarcane, sugar, and ethanol production among public and private organizations on research and development, and currently, there are five important events in the sugarcane sector that together mobilized \$5.3 million in 2008. The major Brazilian specialty magazines in the sugarcane chain earned \$ 3.9 million, with about 61 thousand copies printed.

The Brazilian Development Bank provided an amount of \$3.5 billion for all the companies operating in the sugarcane sector, thereby stimulating the development and maintenance of the industry.

According to the Union of Workers in the Sugar and Food Industry, the São Paulo State workers receive health care and food benefits, totally or partially paid by the mills. The average monthly cost paid to health plans is \$ 33.00 per person, bringing sales for the health care segment of \$ 125.5 million. With regard to food, it is estimated that the São Paulo sugar mills and ethanol plants have disbursed about \$ 188.2 million (average monthly cost of \$ 49.00 per person).

According to the Brazilian Ministry of Labor, the industry in 2008 accounted for 1.28 million formal jobs, with 481,662 allocated in the field of sugarcane cultivation; 561,292 in sugar mills for raw sugar production; 13,791 in sugar refining and milling; and 226,513 in ethanol production. This represents 2.15% of all Brazilian jobs, highlighting the importance of the sugarcane chain. The figure of 1.28 million workers is expanded if the informal employment is considered. Adding the informal employment, there are 1.43 million jobs in the chain. Considering also that every direct job generates two indirect (Balsadi, 2007), a figure of 4.29 million people placed in jobs related to sugarcane is reached.

In Brazil, 55% of the workers on sugarcane plantations are illiterate or of low education. The main responsible for the national figures is the North-East region – with more than 80% of workers grouped in that category. In the center-south area the rate did not surpass 5%. In the sugar mills and ethanol plants, the proportion of illiterate and low education is slightly lower than on the plantations, but it is still very high, highlighting illiteracy in the NE, which in 2008 accounted for almost 20% of the workers. However, increased mechanization has created a growing demand for more qualified professionals. A harvester replaces 100 workers with low skills, but it requires 10 workers trained in automation and mechanization. Brazilian institutions are assisting in the formation of this new profile of skilled workers demanded by the industry today.

The average income of the workers in the center-south region was \$578 per month, and in the north-east region it was \$362 per month, generating a national average of \$512 per month. The national wage bill was \$738.3 million in 2008.

The total tax was calculated by summing the taxes generated in each link of the sugarcane chain, from the sale of agricultural and industrial inputs to the sale of final products. To eliminate double counting and consider just the aggregate tax, the taxes generated in the first links was subtracted (agricultural and industrial inputs). The result of this estimate showed that the tax revenues in 2008 totaled about \$9.8 billion, and \$3.0 billion were generated by the sale of agricultural inputs and products. Thus, the aggregate tax in the sugarcane sector was estimated at \$6.8 billion.

## **Managerial Implications and Discussion**

This study sought to map and quantify the sugarcane chain in Brazil. After the application of the method, this chain now shows the numbers that indicate its economic importance to the country. The industry figures are impressive, with a turnover of over \$80 billion per year and the sugarcane chain GDP is \$28.1 billion, equivalent to 2% of the Brazilian GDP.

This data serves as input for public and private decision making, showing who participates, the interconnecting links among chain participants and the industry's enormous capacity to generate resources, taxes, and jobs.

Brazil has one of the cleanest energy matrixes and it is estimated that in 2015 ethanol will represent 80% of the total fuel consumed in Brazil by small vehicles. In addition, Brazil is with nearly 50% of the world sugar market and to the expectation of reaching more than 60% in 5 years. This study demonstrated also that the chain involves a tremendous amount of resources, jobs, and taxes, and that its ability to internalize Brazilian development is very large. It is a sector of fundamental importance for the Brazilian economy.

It was one more application of the Chain Mapping and Quantification method, and as suggestion of future developments and research, further applications of this method in other countries and other chains is a contribution.

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