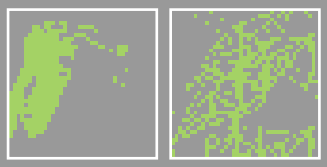


The Sugar-Energy Map of Brazil

Marcos Fava Neves

Vinicius Gustavo Trombin

Matheus Consoli

Sugarcane dates from Brazil's earliest colonization. Despite its historical significance, however, the sector has never been comprehensively described in its entirety. Now, for the first time, this mapping of the sugar and energy sector offers a detailed description of the complete supply chain.

This work was made possible only by using the methodology called Strategic Planning and Management of Agri-industrial Systems (Gestão Estratégica de Sistemas Agroindustriais, better known as Gesis, or ChainPlan in English), developed by Marcos Fava Neves, coordinator of Markestrat (the Center for Research and Projects in Marketing and Strategy, USP).

Application of this methodology indicated that, in 2008, the sector generated wealth totaling US$28.15 billion, equivalent to almost 2% of Brazilian Gross Domestic Product. When taking into account total sales of the various links comprising the sugarcane agri-industrial production system, the value reaches US$86.8 billion.

The industry provides 1.28 million jobs in the formal economy, according to 2008 data from the Ministry of Labor and Employment's Annual Report of Social Information (Rais). The total monthly wage bill is estimated at US$738 million.

The tendency is for sectorial GDP to continue to grow. Ethanol and sugar are still the most significant in terms of revenues, accounting respectively for US$12.5 billion and $9.8 billion, but new products adding to sector revenue will grow in importance. Bioelectricity already generates annual revenues of nearly US$400 million and is expected to grow exponentially in coming years, while yeasts already represent annual revenues exceeding US$60 million. Products such as bioplastics entered large scale production in 2010. Sugarcane diesel, biobutanol and cellulosic ethanol represent important new technological frontiers and offer real promise for the years ahead. As for carbon credits, they will also gain in importance, in proportion to the growing concern about low carbon economies.

1. Introduction

The sugarcane industry has for a long time been one of the pillars of the Brazilian economy. For over two centuries following the introduction of the first cane cuttings into the country in 1532, sugar was Brazil's main product.

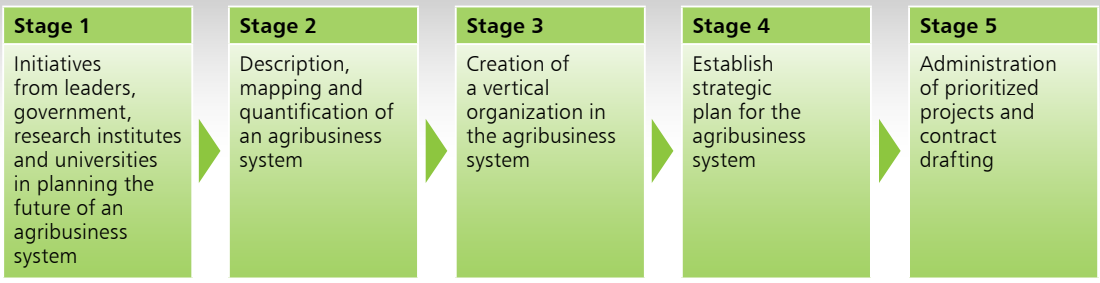
Around 40 years ago, the sector started to undergo a transformation. In addition to sugar, mills started to focus on ethanol production. More recently, attention has turned to bioelectricity, ethanol-based chemicals and carbon credit trading. All this embodies the possibility of employing advanced technologies that enhance productivity and reduce costs. It adds up to a new business paradigm, where competitiveness is the watchword.

However, advances in the sugar-energy sector have not been limited just to technology. Brazil's new production plants are also involved in social and environmental questions. The sugar-energy sector, one Brazil's largest employers, now has a working agenda that includes improving the quality of life of its workers, the rational use of land and water, mitigating the effects of mechanized harvesting and the preservation of ecosystems. While significant progress has been made, much remains to be done if the sector is to grow even more.

Internationally, it is essential to convince critics that the increase in Brazilian sugarcane production is not occurring in forested areas, and that production takes places under sustainable conditions, while persuading them with respect to the regularity of ethanol supply. Domestically, it is necessary to show Brazilian society that choosing to use ethanol as a vehicle fuel brings a number of other benefits, besides the economic saving.

One way of doing, indeed the goal of this report, this is to evaluate the economic and social impact of sector. This study compiles and analyzes data collected over a four-month period by a team of 10 researchers, seeking to measure the total financial weight, jobs and GDP of the sugar-energy sector.

Figure 1 **Proposed method for strategic planning and management of agri-industrial systems**



Source: Neves (2008).

▶ 2. Objectives

The goal of this study is to map out, delineate and quantify the agri-industrial sugarcane sector in Brazil. The main product of the study is an estimate of how much the companies that operate at the different levels of the supply chain billed in the sugar-energy sector in 2008, together with an estimate of sector GDP. In addition to total billings, another focus of research is to quantify jobs and taxes generated in the sector. This research is part of an effort by UNICA to increase available knowledge of the sugar-energy sector and provide public opinion with information about the benefits of producing and using clean, renewable and sustainable energy of agricultural origin.

▶ 3. Methodology

To achieve the objective of this study, the methodology known as Gesis (Strategic Planning and Management of Agri-industrial Systems) was used. This methodology, developed by Professor Marcos Fava Neves in 2004, has been applied to similar studies in Brazil, Argentina, Uruguay, and South Africa. The oranges (2004), wheat (2005) and milk (2007) supply chains were assessed, delineated and quantified under Neves' coordination. The Gesis methodology has been presented and published in several international business conferences and, as such, is familiar to researchers around the world. In 2007, it was used in Uruguay and Argentina for the wheat and milk supply chains, respectively.

Methodology for description, mapping, delineation and quantification Table 1a

Phases of Stage 2	Procedures
Phase 1 Description of the agri-industrial supply chain under study	Design of the agri-industrial system using boxes, reflecting the flow of products, ranging from inputs through to the final consumer (system design).
Phase 2 Presentation of the description to executives and other experts to adjust the structure	With this first version of the description, in-depth interviews are conducted with executives of companies operating in the sector and other specialists (researchers, sector leaders, others) to adjust the proposed design.
Phase 3 Research of sales data in associations, institutions and publications	Some private associations make available their members' sales information, sometimes even on the internet. A careful bibliographic review is also conducted for recent dissertations and theses, in addition to articles in academic magazines and papers, or other general publications.
Phase 4 Interviews with experts and company executives	This is the central point of the methodology. Interviews are conducted with managers, with the intention of finding the total amount sold by companies in the sector under study. Interviews are also conducted with procurement directors, seeking to estimate the market from the opposite side of supply chain links.
Phase 5 Quantification	At this point, all data obtained in the above steps is processed and inserted in the description below the name of the company. The data is then sent to participating companies to examine the values. Companies are asked to send back the data with comments and contributions.
Phase 6 Validation workshop	In the final phase, a workshop is organized for presentation of the results and discussion of the numbers.

Source: Neves (2008).

As presented in **Figure 1**, the description, mapping, delineation and quantification of an agribusiness system is one of the steps that make up the Gesis Methodology. Given the scope of the current project for the sugar and ethanol industry, only this stage of the method will be performed at this time. However, it should be noted that, because it is the initial step of the method, it lays the groundwork for the other steps to be undertaken in the future, thereby extending the focus of the study to include the development of collective goals and strategies.

Stage 2 of the Gesis Methodology, which constitutes the focus of the current study, consists in implementing the six phases described in **Table 1a** above.

▶ 4. Results

The GDP of the sugar-energy sector was US$28.2 billion, equivalent to almost 2% of domestic GDP or almost the entire wealth generated in one year by a country like Uruguay (US$32 billion). Sector GDP was estimated by calculating the aggregate sales of final goods by the sugarcane agri-industrial system, and applying the 2008 average exchange rate of US$1.00 = R$1.84. **Table 1b** presents the billings of the sector's main products in the domestic and foreign markets.

Figure 2 represents the sugarcane agri-industrial system. The values below each link indicate the gross billing for this segment with the sugar-energy sector in 2008. The sugar-energy sector's gross revenue in that year was US$86.8 billion. This value represents the sum of estimated sales of the various links in the agri-industrial chain and the financial operations of facilitating agents. The gross revenue of the sector is not comparable to the domestic GDP, because of double counting. Following **Figure 2**, the gross revenue of each link in the supply chain is presented in detail.

Table 1b **Estimates of the sugar-energy sector GDP based on final products** *in US$ millions*

Product	Domestic Market (DM)	External Market (EM)	Total (DM + EM)
	With taxes	Tax-exempt	With taxes
Hydrous ethanol	11,114.50[a]	23.78	11,138.28
Anhydrous ethanol	2,972.89[b]	2,366.33	5,339.22
Non-fuel ethanol	438.78[c]	n/a	438.78
Sugar	5,297.14[d]	5,482.96	10,780.10
Bioelectricity	389.63[e]	n/a	389.63
Yeast and additive	21.41	42.20	63.61
Carbon credit	n/a	3.48	3.48
Total	20,234.35	7,918.75	28,153.10

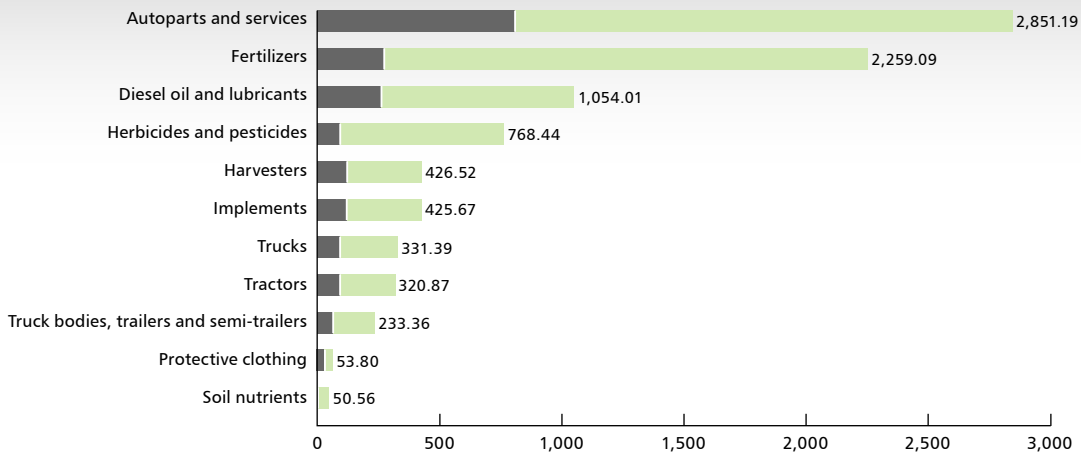
[a] Sales by filling stations, counting both the formal and informal markets. • [b] Sales by distilleries to fuel distributors, counting both the formal and informal markets. • [c] Sales by distilleries to beverage and cosmetics sectors. • [d] Sum of sugar sales by mills to industry and retail sales. • [e] Sales at energy auctions.
Source: Nevis, Trombin and Consoli, with data generated by Markestrat (2009).

The agricultural inputs industry *Prior to the plantation*

The agricultural inputs industry billed US$9.3 million in sales to the sugar-energy sector in 2008 (including revenues of US$477.5 million from herbicides and pesticides sold by agricultural cooperatives and dealers). Graph 1 summarizes all revenues of this link, which are detailed in the following text.

Sugarcane accounted for 14% of agricultural fertilizers sales in Brazil in 2008, totaling US$2.3 million (3.14 million tonnes). This is an input essential for sugarcane plantations, and the increase in sugarcane planted area in the past few years has caused an increase fertilizer demand despite the unfavorable terms of trade. While in 2007, 19.8 tonnes of sugarcane were needed to purchase one tonne of fertilizer, in 2008 the vol-

Billings of agricultural inputs *Prior to the plantation – US$ millions* **Graph 1**

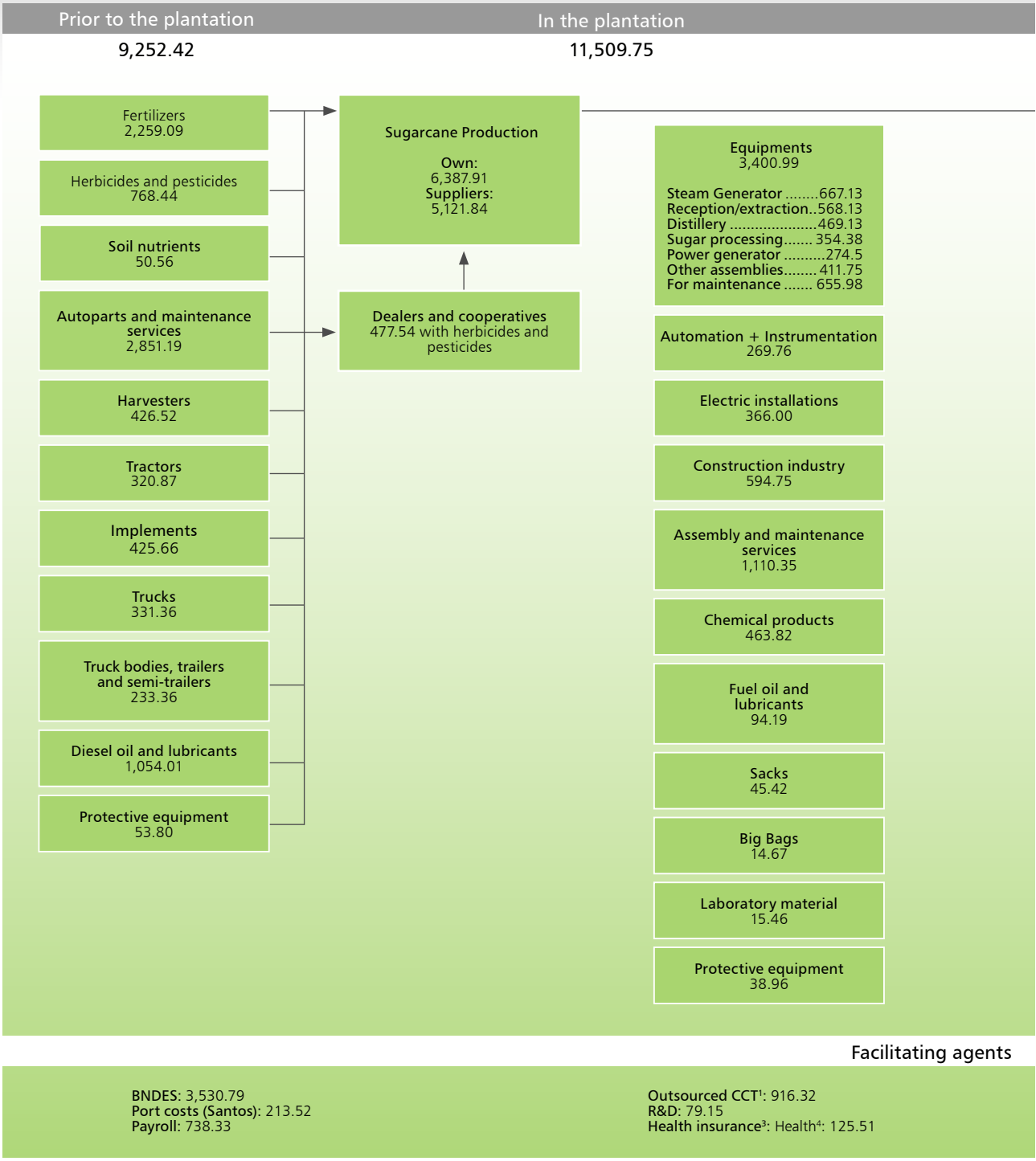


Agricultural inputs	Gross value	Sales tax[1]	Net value
Autoparts and services	2,851.19	810.00	**2,041.19**
Fertilizers	2,259.09	271.09	**1,988.00**
Diesel oil and lubricants	1,054.01	258.44	**798.57**
Herbicides and pesticides	768.44	92.21	**676.23**
Harvesters	426.52	121.17	**305.35**
Implements	425.67	120.93	**304.74**
Trucks	331.39	94.14	**237.25**
Tractors	320.87	91.16	**229.71**
Truck bodies, trailers and semi-trailers	233.36	66.30	**167.06**
Protective clothing	53.80	15.28	**38.52**
Soil nutrients	50.56	6.07	**44.49**

[1] IPI, PIS and COFINS
Source: Neves, Trombin and Consoli, with data generated by Markestrat (2009).

Figure 2

SUGAR-ENERGY SUPPLY CHAIN



Facilitating agents

BNDES: 3,530.79
Port costs (Santos): 213.52
Payroll: 738.33

Outsourced CCT[1]**:** 916.32
R&D: 79.15
Health insurance[3]**:** Health[4]**:** 125.51

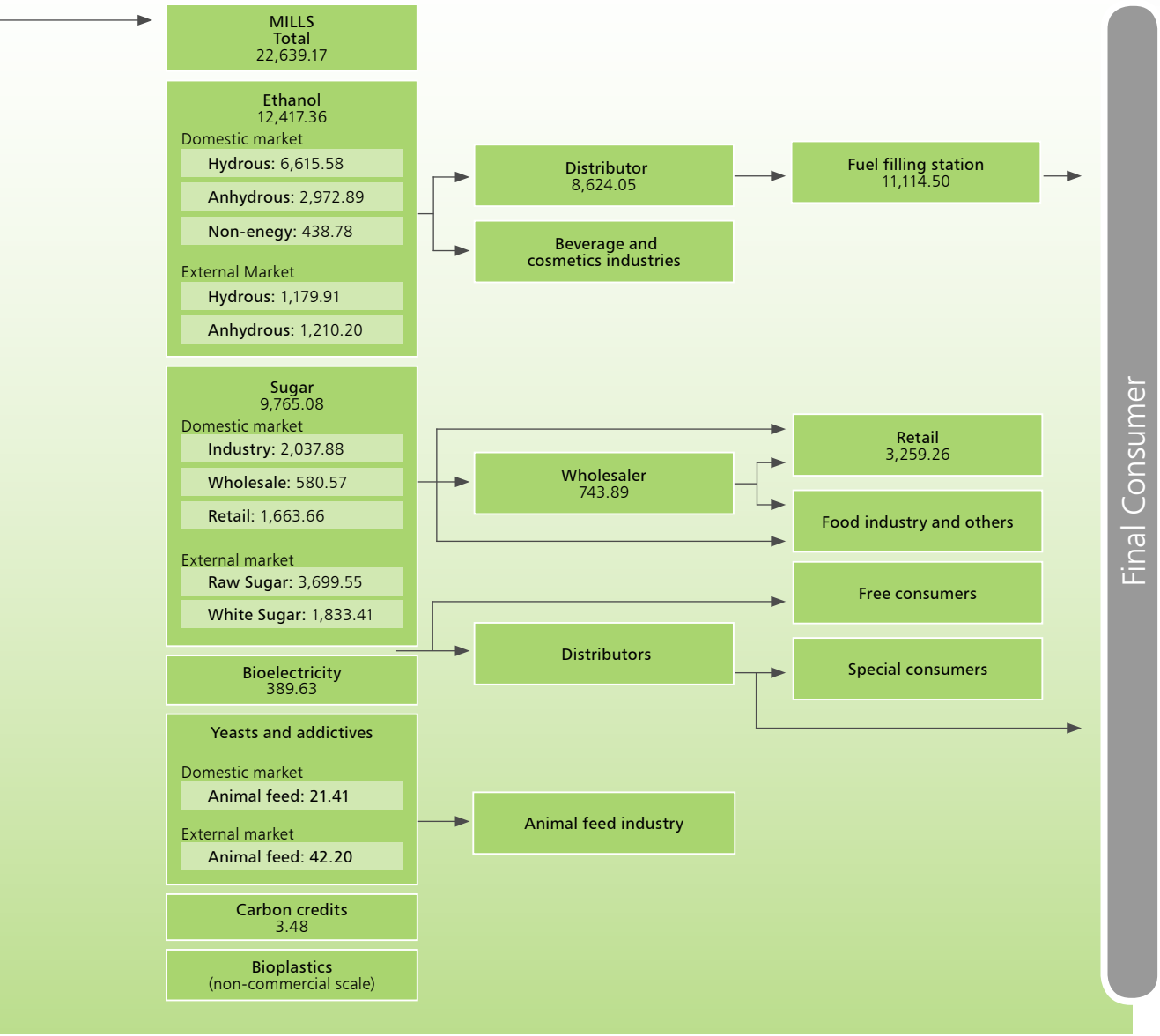
[1] CCT = Cutting, Loading and Transportation, in the Center South.
[2] Volumes exported through Santos and Paranagua Ports. • [3] e [4] Just for São Paulo State.

in millions dollars, 2008

GDP of the sector US$28.2 billions

After the plantation

52,795.27



(service providers): 13,275.58

Highway freight for export[2]: 539.03
Events: 5.32
Food[4]: 188.26

Tolls for export (Santos): 79,96
Inspection: 3,99
Taxes on the agricultural sector: 6.855,41

Source: Prepared by Neves, Trombin, Consoli, 2009.

ume soared to 36.3 tonnes. This happened because of increased fertilizer prices and lower levels of Total Recoverable Sugars (TRS). Sale of soil nutrients for sugarcane plantations were estimated at US$50.6 million in 2008, with consumption of 2,999,000 tonnes.

In 2008, the Brazilian agricultural pesticides and herbicides sector billed US$768.4 million for sales to sugarcane planters. Cooperatives were responsible for 61% of sales of pesticides and herbicides for sugarcane, with agricultural dealerships responsible for 2%. Together these billed more than US$477.5 million. Sales made directly to mills accounted for 37%. Of the total disbursed by sugarcane farmers for pesticides and herbicides, 73.5% was spent on herbicides, 22.8% on insecticides and 3.7% on fungicides.

Approximately 3,970 tractors were sold to the sugar-energy industry in 2008, for a total of US$320.9 million. Sales to the sugar-energy sector represented 9% of total tractor sales in Brazil, and the sector bought 47% of tractors rated at over 200 hp. Revenue from sale of implements was approximately US$425.7 million. This segment includes plows, tipper trailers, disk harrows, sprays, cultivators, self-propelled sprays and irrigation equipment, among others. The autoparts sector and maintenance services for machinery and equipments billed about US$2.9 billion in 2008. These amounts include parts and labor for about 144,000 machines in operation in the sector, which consume roughly US$20,000 in maintenance costs per unit per annum.

The sugar-energy sector acquired 22% of all harvesters sold in 2008, representing US$426.5 million in revenues. The sector purchased 981 units, representing 52% growth over 2007. The fleet of cane harvesters nearly doubled in size in the year, mainly due to the requirement to end pre-harvest straw burning. In 2007 there were approximately 1,280 sugarcane harvesters in Brazilian plantations.

Sales of heavy trucks – those with gross weight of 40 tonnes or more – were also driven by the growth of the sugar-energy sector. In addition to transporting ethanol, these trucks carry 80% of sugarcane after harvesting. It is estimated that in 2008, the sector purchased 1,962 heavy trucks, equivalent to 5% of total truck sales in this category in Brazil. This generated billings in the order of US$331.4 million.

Sales of truck bodies, trailers and semi-trailers in 2008 were estimated at US$233.4 million. In addition to the 488 truck bodies sold, 4,856 sugarcane trailers and semi-trailers were registered. This represented about 9% of total heavy truck body and trailer sales in Brazil, and was an increase of 11% over 2007.

Mechanized operations in sugarcane agricultural production and transportation from the field to the mill consumed almost one billion liters of diesel oil and lubricants in 2008, at a cost of US$1.0 million. Following the publication of Regulatory Norm No. 31 in 2005, mills increased their investments in the employee health and safety. This was reflected in 2008 sales of agricultural personal protective equipment (PPE), which totaled US$53.8 million.

Sugarcane production *In the plantation*

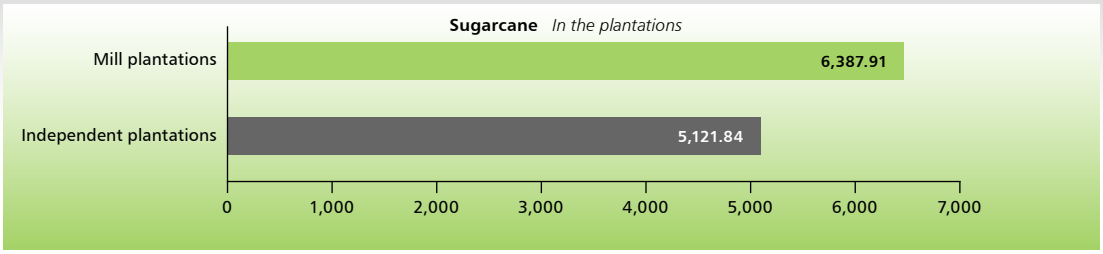
The 2008/09 sugarcane harvest reached a record production of 568.9 million tonnes with a planted area of approximately 8.5 million hectares (including areas in production, in formation, producing seedlings, and ripe sugarcane). The State of São Paulo was responsible for 68.6% of sugarcane crushing in the Center-South region of the country. In this region, the State of Minas Gerais saw the greatest increase in production during the last five years, with 1.8% growth, followed by the State of Goiás with 1.6% growth. The 568.9 million tonnes of crushed sugarcane in the 2008/09 harvest generated US$11.5 billion in revenues for the sugar-energy sector. The yield of raw material was 143.25 kg of Total Recoverable Sugars (TRS) per tonne of cane, down 2% compared with the previous harvest. The average TRS value in the 2008/09 harvest was US$0.14 . The average value per tonne of sugarcane in the 2008/09 harvest was US$20.23 (R$39.85). In the 2008/09 harvest, as shown in Graph 2, independent sugarcane suppliers accounted for approximately 44.5% of the industry's total supply (US$5.1 billion), with 55.5% coming from sugar and ethanol producers' own plantations (US$6.4 billion).

Equipment, services and industrial inputs *After the plantation*

The industrial inputs sector billed US$6.4 billion for sales to the sugar-energy industry in 2008. This value is presented in detail below.

In order to quantify the billings of industrial equipment suppliers and companies that provide assembly services, we considered the investments of the 29 industrial units that came on stream in 2008. Given that these investments would have started in 2006, they do not represent these companies' revenues in just that year. Rather, they offer an estimate of the cost of building these new units that began producing in 2008. Of the 29 industrial units, the following assumption was adopted: four were sugar mills that produce both sugar and ethanol and 25 were distilleries, for the production just of ethanol. Of the former, three had crushing capacity of 1.5 million tonnes of sugarcane, and one a capacity of three million tonnes. Of the distilleries, 15 had crushing capacity of 1.5 million tonnes and 10 had a capacity of three million tonnes.

Sugarcane revenues *US$ millions* **Graph 2**



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

The average investment for setting up an industrial plant was estimated at US$85 per tonne of sugarcane for milling capacity, and US$75 per tonne of sugarcane for distilleries. **Table 2** shows the proportional breakdown of required investment, and **Table 3** details the investment in equipment.

In addition to investments related to construction of new units, the study also considered sales of equipment and services for the maintenance of industrial units, which takes place between harvests. Under this heading, the study used an estimated maintenance cost in South-Central Brazil of US$1.68/tonne of crushed sugarcane. Of this 62.50% was spent on equipment and 37.50% on services. In the North-Northeast region this cost was US$2.08, with 86.70% spent on equipment and 13.30% on services. The study also included projects for automation and instrumentation sold to the sugar-energy sector in 2008 – there were about 41 such projects, in addition to those that were sold to the 29 new units already mentioned.

Table 2 **Distribution of investment by type of spending**

Item	% of total investment
Equipment	60
Electromechanical assembly	7
Civil construction	13
Electrical installation	8
Instrumentation and automation	2
Engineering services, thermal insulation and painting	10
Total	100

Source: Prepared by Markestrat from data provided by Procknor Engineering.

Table 3 **Distribution of investment by type of equipment**

Type of equipment	% of investment in equipment	
	Mill	Distillery
Steam generators	25	20
Reception/extraction system	20	25
Distillery	15	30
Sugar processing	15	0
Turbines/electricity generators	10	10
Others	15	15
Total	100	100

Source: Prepared by Markestrat from data provided by Procknor Engineering.

Based on these assumptions, the aggregate billing of industrial equipment suppliers was estimated at approximately US$3.4 billion. Automation and instrumentation sales were US$269.7 million, while assembly and maintenance service providers received approximately US$1.1 billion. The civil construction industry billed approximately US$594.8 million, and the electrical installations sector billed a further US$366.0 million for new industrial units.

The sugar-energy sector purchased chemical and specialty products worth US$463.8 million used in the production of ethanol and sugar, including quicklime and slaked lime, chemical commodities, polymers, processing aids for sugar and ethanol production, yeast, water treatment products and ion exchange resins, among others.

Fuel and lubricating oil consumed in industrial operations totaled 70 million liters, generating US$94.2 million in purchases. The sector purchased laboratory materials worth US$15.5 million, while US$45.4 million was spent on 50 kg sacks and US$14.7 million on 1,200 kg big bags. Industrial protective clothing purchases came to US$38.9 million.

Graph 3 summarizes the billing of this stage of the supply chain.

Billing *Mills*

Mills billed a total of US$22.6 billion on all marketed products, divided as follows: ethanol US$12.4 billion (55%); sugar US$9.8 billion (43%); bioelectricity US$389.6 million (1.7%); and yeasts, additives and carbon credit US$67.1 million (0.3%). The products and their distribution channels are presented below.

Ethanol *Mills*

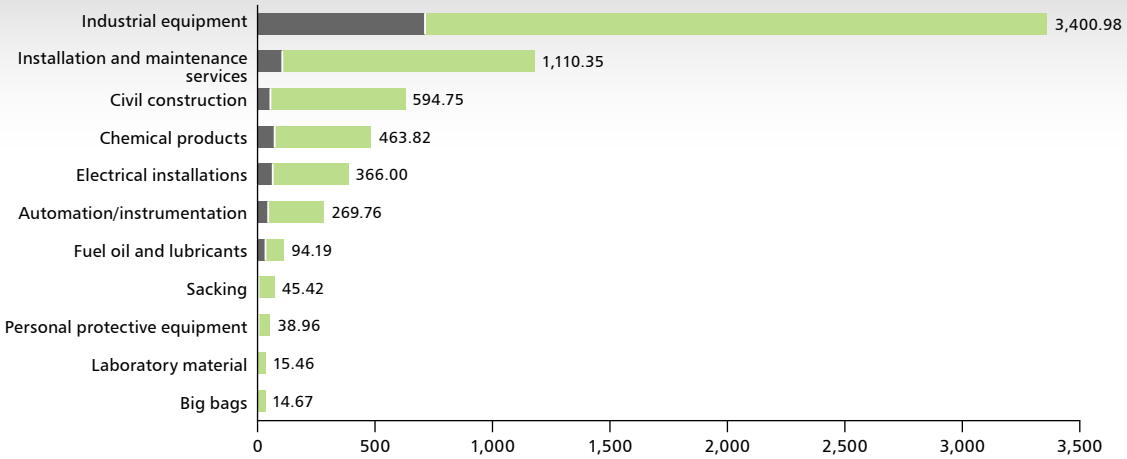
Mills earned US$12.4 billion in ethanol sales in 2008, counting domestic and export markets. Exports were worth US$2.4 billion (US$1.2 billion each for hydrous and anhydrous ethanol). However, anhydrous ethanol exports were atypical in 2008. One of the reasons for this growth was the higher demand from the United States, due to a reduction in the corn harvest caused by floods in the country's main producing region, in addition to the significant increase in the price of oil, which exceeded US$100 per barrel for part of the year.

Brazilian ethanol exports totaled 5.12 billion liters. The main buyers were the United States (34%), Netherlands (26%), Jamaica (8%) and El Salvador (7%). Despite the small volume of exports compared to total production, this shows the great potential for growth – since 2001 the volume exported has grown 14-fold, and export revenues 24-fold). The most significant increase came in 2004, when exports rose 220% by volume to approximately 2.4 billion liters. This includes ethanol destined for the chemical and beverage industries.

The domestic market in 2008 consumed 14.1 billion liters of hydrous ethanol, counting the formal and informal markets, generating US$6.6 billion in revenues for mills. Sales volumes of this product have grown considerably in recent years, with an increase of 87% over 2006. The main reason for this expansion was the introduction of flex-fuel vehicles, which in 2008 accounted for 90% of light commercial vehicle production in Brazil.

Mills sold 6.5 billion liters of anhydrous ethanol worth US$3 billion in the domestic market in 2008, counting the formal and informal markets. The main use of this product in Brazil is for blending with gasoline, currently at a proportion of 25%. Given the increase in consumption of ethanol compared to gasoline, because of the increase in flex-fuel vehicles, the consumption of anhydrous ethanol has declined in recent years.

Graph 3 **Billings of industrial inputs segments** *After the plantation – US$ millions*



Agricultural inputs	Gross value	Sales tax[1]	Net value
Industrial equipment	3,400.98	680.20	2,720.78
Installation and maintenance services	1,110.35	102.71	1,007.64
Civil construction	594.75	55.01	539.74
Chemical products	463.82	69.57	394.25
Electrical installations	366.00	64.05	301.95
Automation/instrumentation	269.76	47.20	222.55
Fuel oil and lubricants	94.19	23.09	71.09
Sacking	45.42	9.08	36.34
Personal protective equipment	38.96	7.79	31.17
Laboratory material	15.46	4.39	11.07
Big bags	14.67	2.93	11.74

[1] IPI, ICMS, PIS and COFINS
Source: Neves, Trombin and Consoli, with data generated by Markestrat (2009).

Sugarcane ethanol is also used in Brazil for non-energy purposes, mainly in the production of beverages, cosmetics, pharmaceuticals and chemicals. According to data from the National Energy Balance, this consumption was 720 million liters in 2008, representing revenues of US$438.8 million for the mills.

Ethanol *Distributors and service stations*

Distributors billed US$8.6 billion; filling stations US$11.1 billion.

Sugar *Mills*

Mills earned US$9.8 billion from sugar sales in 2008, including domestic and export markets. Exports produced revenues of US$5.5 billion (67% from raw sugar; 33% from white sugar). Of the 19.5 million tonnes shipped, 83% was produced in the Center-South of Brazil and 17% in the North-Northeastern region. About 50% of exports went to five countries, with the remainder distributed among more than 100 other countries. Between 2000 and 2008, on average, 25% of sugar exported by Brazil went to Russia, the leading international market, followed by Nigeria, Egypt and Saudi Arabia. Exports take the majority of sugar produced in Brazil, and Brazilian production has grown much faster than domestic consumption, which has maintained steady growth averaging 3% a year over the past six years.

Mills billed US$4.3 billion for sugar sales in the domestic market. Of this, sales to the food industry were worth around US$2.0 billion (US$1.6 billion retail and US$580.6 million wholesale). Part of the sugar volume going to industrial consumers is sold indirectly via specialized wholesalers to small factories. These wholesalers also repack sugar into smaller packages for retail sale. This specific case was not considered in our mapping, given the difficulty of estimating the volume of sales and prices for this type of wholesaler – no source of relevant secondary data was found.

The main industrial consumers of sugar are producers of soft drinks (20%), candies and chocolates (10%), chemicals (10%) and dairy products (7%), with other industries comprising 53%. The main type of sugar sold is granulated (61%), followed by refined granulated (36%), and other types (4%).

In terms of volume, the Center-South region sold 10.5 million tonnes and the North-Northeast 1.02 million tonnes. Center-South production was sold 60% to industry, 28% direct to retail and 12% via wholesale. North-Northeast production broke down as follows: 53% retail; 25% industry; 22% wholesale. Total sugar sales to industry were 6.6 million tonnes (direct sales for retail were 3.5 million tonnes, and for wholesale, 1.5 million tonnes).

Sugar *Wholesale and Retail*

Wholesalers billed US$743.9 million with sugar in 2008; retailers US$3,259.3 million.

Bioelectricity *Mills*

Bioelectricity generated from sugarcane bagasse is becoming an increasingly important byproduct for mills. In 2008, approximately 30 mills negotiated 544 MW average for annual sale over a 15-year period, providing annual billings of US$389.6 million.

Yeast *Mills*

About 10% of yeasts used in ethanol production (for fermentation of sugarcane juice) is subsequently recovered and destined for mixing into livestock feed. Exports of sugarcane ethanol yeasts in 2008 totaled 32,000 tonnes, worth US$16.8 million. That was an atypical year, however, because another 15,000 tonnes could have been exported but for a problem of contamination, now resolved. Revenues in the domestic market were US$11.1 million from the sale of 24,000 tonnes of dry yeast. The price per tonne in the domestic market was higher because of logistical costs and taxes.

Mills also sell additives based on sugarcane yeast (such as the cell wall). Exports of this byproduct in 2008 totaled 13,400 tonnes, generating revenues of US$25.4 million. A further 5,000 tonnes of additives were sold in the domestic market, generating US$10.3 million in revenues. This means that revenues from yeast and their additives in 2008 totaled US$63.6 million, of which US$21.4 million in the domestic market and US$42.2 million in the foreign market.

Carbon Credit *Mills*

Brazil ranks third in the world amongst seller countries, in terms of traded volume, but had only 3% of the global market in 2008. China and India were in first place with 84% and 4%, respectively. However, Brazil had a share of nearly 8% in primary Certified Emission Reductions (CERs) between 2002 and 2008. The worldwide traded amount in 2008 was 389 million tonnes of CO2 valued at US$6,52 billion, 14% down on 2007.

Brazil participates in the carbon credits market via the Clean Development Mechanism (CDM), because it is the only Kyoto Protocol mechanism that allows voluntary participation of developing countries. The 68 Brazilian projects registered by the United Nations Framework Convention on Climate Change (UNFCCC) in the carbon credit market generated an estimated reduction of 3.45 million tonnes of CO2 in 2008, with revenues of about US$25.4 million – the average price in the voluntary market was US$7.3 in 2008. Of the 68 projects, 24 were from the sugar-energy sector, generating an estimated reduction of 473,900 tonnes of CO_2 (US$3.5 million).

Bioplastics *Mills*

Bioplastics represent an innovative way of using sugarcane bagasse. If investments are made as planned, then in a short time bioplastics will represent a significant revenue source for mills. It is called "bio" because it comes from natural sources, and is biodegradable. Studies indicate that in up to 180 days all traces are eliminated from the environment. Thanks to these characteristics, bioplastics are prized in the organic market. The estimated annual worldwide demand for this new product already stands at 600,000 tonnes, at a price estimated to be 15% to 30% higher than the conventional product. According to the European Bioplastics Institute, almost 331,000 tonnes of bioplastics is produced, representing less than 1% of synthetic plastics produced annually. Brazilian bioplastics production is still at too small a scale for the product to be commercially marketed.

PHB Industrial, a company controlled by Pedra Agroindustrial and Grupo Balbo, has within its industrial complex one of Brazil's first pilot projects, a laboratory-scale operation capable of producing about 60 tonnes/year of bioplastics that is currently exported to Japan, the United States and Europe at an average price of US$5/kilo for pure resin. Very little of this material has been sold. Most of the material exported has gone to international companies for application development. PHB Industrial is designing a commercial plant to start operating in two to three years, an investment that will allow the company to sell bioplastics on a commercial scale to both the domestic and export markets. Press reports indicate that the unit will produce 10,000 tonnes/year and begin operating in 2010.

Braskem, a company from Rio Grande do Sul state, currently has production capacity of approximately 12 tonnes/year in its pilot plant, and has announced investments to begin producing 200,000 tonnes/year by 2011. Dow Chemical announced it was creating the first ethanol chemical complex with production projected at 350,000 tonnes/year as of 2011. And Coopersucar, working in partnership with the Solvay group of Belgium, is set to produce 120,000 tonnes in 2010 according to the Brazilian Industrial Development Agency. If investments planned through 2010 do in fact materialize, the ethanol chemical industry will require 650 million liters of ethanol.

Facilitating agents

BNDES – The bank made available US$3,530.79 million for companies in the sugar-energy sector, so stimulating the development and maintenance of the sector.

Outsourced – The sector has been going through a process of consolidation. New business groups have come into the sugarcane business, bringing professionalized management that focuses on operational efficiency and better financial allocation of capital. This has created a demand for outsourced services, so favoring the entry of companies specialized in services for operating logistics for the sugarcane sector. In 2008, the Center for Science and Technology (CCT) was responsible for US$916.3 million of outsourced services.

Road freight for export of sugar and ethanol – Road freight for sugar and ethanol exports was worth US$539.03 million. Road freight for sugar export in the Center-South of Brazil accounted for US$383.6 mil-

lion, and of that amount, freight for ethanol exports came to US$155.42 million. Freight for sugar exports on Brazilian railroads cost approximately US$34.16/tonne; ethanol US$34.76/m^3. The ports of Santos and Paranaguá were the sector's main export routes in 2008.

Highway tolls for sugar and ethanol exports (Port of Santos) – Total spending on highway tolls for ethanol and sugar export freight in São Paulo state came to US$79.9 million in 2008.

Port costs (Santos) – The Port of Santos had estimated 2008 revenues of US$213.5 million relating to clearance, loading and supervision of sugar and ethanol shipments. It is worth noting that almost 70% (by volume) of Brazil's total ethanol and sugar exports passed through Santos.

Research & Development (R&D) – In 2008, US$79.2 million was allocated to sugar and ethanol industry research by bodies such as FINEP, FAPESP, Canavialis and Allelyx, CTC and IAC. It was used internally or distributed to public and private organizations including USP, UNICAMP, UNESP, EMBRAPA, Ridesa, and others.

Events – Five important sugar-energy industry events were identified in 2008. Together these cost US$5.3 million.

Specialized magazines – The major magazines covering the sector (Cana Journal, IDEA News, Energia Mundo, Cana Mix, Canavieros and Stab) billed US$3.99 million with a total of 61,000 copies in circulation.

Health plans and meals – According to the Union of Workers in Sugar, Food and Allied Sectors, workers in the State of São Paulo receive health plans and meals paid for completely or in part by the mills. The average monthly cost paid by mills for health plans is US$33.00 per person. It can thus be inferred that the health plan industry earned about US$125.5 million in 2008 from the sugar-energy sector. It is worth mentioning the great importance of these health plans for the communities where mills are located, because they reduce the burden on public hospitals. With respect to meal plans, mills in São Paulo disbursed an estimated US$188.3 million in 2008 – an average monthly cost of US$49.00 per person.

Wages / Jobs

According to the Annual Report of Social Information (RAIS) prepared by the Ministry of Labor and Employment, 1,283,258 formal jobs were registered in the sector 2008. The breakdown was 481,662 jobs in sugarcane plantations, 561,292 in raw sugar factories, 13,791 in sugarcane crushing and refining, and 226,513 in ethanol production).

The sugarcane industry has seen a growing incidence of formal employment. According to data from the IBGE, formal employment in the sector reached 80.9% in Brazil in 2007 (66.5% in the North-Northeast region; 90.3% in the Center-South; 95.1% in São Paulo). In all, there are 1.43 million jobs in the sector. Considering that every direct job creates two indirect ones, the figure increases to 4.29 million people em-

ployed in jobs related to sugarcane. São Paulo employs 40% of the total, the highest participation of any state, with 54% in sugarcane cultivation.

Illiterate and poorly-educated workers (with at most 5th grade complete) represented over 55% of the total labor force employed in sugarcane cultivation in 2008, but in the Center-South of Brazil this group did not exceed 5%. The proportion of illiterate and poorly-educated workers in sugar and ethanol manufacture is slightly lower than in cultivation. However, increased mechanization is creating a growing demand for more qualified professionals. A mechanical harvester replaces the work of 100 people with low qualification. On the other hand, it requires 10 employees trained in automation and mechanization. Agencies including SENAR, SENAI, and CTC are helping to train this new type of labor that the industry demands, but there is still room for other organizations to work to improve labor qualification in the sector.

Another issue examined was the wage level of workers in the sector, concentrated mainly between one and three times the minimum monthly salary. Moreover, even with the seasonal characteristic of the sector much reduced in recent years by the application of new technologies in sugarcane cultivation and harvesting, the total of formal jobs was 2.9% higher than the previous year (up from 572,194 in 2007 to 588,826 in 2008).

The Center-South region presents an average monthly income of R$1,062.55 per worker, while in the North-Northeast region the average is R$666.20. The national average is R$942.02. Total wages in the Center-South region are R$786.3 million, with R$422.6 million in the North-Northeast and a national total of R$1.21 billion.

Taxes

Total taxes were calculated by adding up the taxes generated at each stage of the agro-industrial system (SAG), from the sale of agricultural and industrial inputs through to the sale of final products. To eliminate double counting and arrive at a net figure for taxes in the SAG, the taxes on agricultural and industrial inputs generated in the first stage of the supply chain, which can be deducted from their own tax liability by processing companies in the next stage, were subtracted.

This calculation resulted in an estimate that taxes paid by the SAG in 2008 totaled US$9,868.2 million, but US$3,012.8 million of this amount was generated through the sale of agricultural and industrial inputs. Net aggregate taxes paid by the SAG were thus estimated at US$6,855.4 million.

Taxes were calculated using a weighted average rate, estimated from the rate that applies to the merchandise in the main producing states, taking into account tax incentives and the volumes produced. Only taxes on billings were considered in this calculation – IPI, ICMS, PIS and COFINS. In the case of the ICMS, we used the interstate rate for Center-South states rather than the weighted average. In the case of PIS and COFINS, we used the standard rates of 1.65% and 7.60%, except for ethanol which is taxed at a fixed value in R$ per liter. Also, in the case of IPI we gave priority to the rates applying to the most relevant products

at each stage of the chain. For estimating aggregate taxes in the agri-industrial system, we assumed that all companies opted to be taxed on actual rather than estimated profits.

5. Final remarks

This study set out to provide a complete picture of the sugar and ethanol agro-industrial system. After five months of research it became evident that the complete supply chain is generating some impressive numbers, with total annual economic impact exceeding US$80 billion. This study – probably the most recent and complete picture of this supply chain in Brazil – can be a basis for public and private decision-making.

The sugar and ethanol supply chain has already shown its potential to supply products in a sustainable manner, helping Brazil develop one of the world's cleanest energy matrixes. It is estimated, that by 2015, 80% of the fuel used in Brazil will be ethanol. Bioelectricity has the potential to supply approximately 15% of total national demand for electricity by the end of the decade. The country is on course to dominate global sugar exports, with almost 50% of the world market in 2009 and the expectation of passing 60% in five years. Finally, it should be emphasized that new byproducts like cellulosic or second-generation ethanol, sugarcane-based diesel and biobutanol represent important new technologies that are already operating in pilot projects or on a demonstration scale. These will be important revenue sources in the coming years.

This study also shows that the sugar and ethanol supply chain, which is of fundamental importance to the Brazilian economy, has enormous capacity to spread development into the country's inland rural regions.

Details of methodology and quantification calculations

Annex 1

Stage of the supply chain	Quantification criteria	Sources
	PRIOR TO THE PLANTATION	
Fertilizers	Volume and revenues of the segment, adjusted by the percentage destined for sugarcane production. Secondary data.	ABIQUIM ANDA
Herbicides and pesticides	Volume and revenues of the segment, considering the market share of sugarcane. Secondary data.	SINDAG
Soil nutrients	Estimates based on national consumption (just lime; chalk was not considered): Utilization basis – area (ha) restoration and expansion (A) Dosage: 2 doses of 1.5 tonnes of lime/ha (B) Average FOB price of lime in the leading states (C) Estimated billing = A x B x C	MAPA (A) FNP (B) ABRACAL (C)
Autoparts (includes maintenance)	Estimates based on the amount of equipment per mill and spending with parts and maintenance. Number of mills (A) Average quantity of equipment per mill (B) Average value with equipment maintenance (parts & service) (C) Estimated billing = A x B x C	MAPA (A) RPA Consultoria (B, C)
Tractors	Average price of tractors by power (A) Number of tractors sold to the sugar-energy sector - by power (B) i = power ranges for tractors Estimate = Σ Ai x Bi	Interviews with companies in the segment - Valtra and Case IH dealers (A, B)
Harvesters	Average price of harvesters (A) Quantity of harvesters sold (B) Estimate = A x B	Interviews with companies in the segment - Santal and Case IH dealers (A, B)
Implements	Estimated amount of implements sold annually: Implements = 150% of the number of units of motorized equipment (A). Number of units of motorized equipment = 17.07 units per 1,000 ha (B). Implement lifespan = 10 years (C). Sugarcane area in thousand ha (D). Average price of implements (E) Estimated billing on irrigation equipment (all systems) for sugar-energy sector (F) Estimated billing = [(A x B x D / C) x E] + F	RPA Consultoria/IDEA (A, B, C) MAPA (D) Average of companies in the segment (Sermag, Civemasa, Tracan, DMB, Santal) (E) ABIMAQ (F)
Trucks	Estimate of new vehicles, based on the fleet and fleet renewal rate. Heavy trucks for carrying cane = 2.27/1,000ha harvested (A) Fleet renewal rate = 8.11 years (B) Cane production area, in 1,000ha (C). Average price for heavy trucks (D) Estimated billing = (A x C / B) x D	Idea (A, B) MAPA (B) Interview with dealers in segment - average values (D)
Truck bodies and trailers	Estimate based on number of units sold and average price. Number of units sold (A) Average price (B) i = product type (body, semi-trailer, 2 axle trailer, 4 axle trailer). Estimated billing = Σ Ai x Bi	ANFIR (A) Interviews with companies in the segment - average values (B)

Annex 1 Details of methodology and quantification calculations

Stage of the supply chain	Quantification criteria	Sources
Diesel oil and lubricants	Diesel consumption by activity in cane production (A) Sugarcane area (ha) (B) Average price of diesel (C) i = activities (cane planting, ratoon, harvesting, transporting cane to the mill, transporting inputs) Estimate for diesel = (Σ Ai x Bi) x C Average lubricant consumption liters / ha (D) Average lubricant cost (E) Estimate for lubricants = D x B x E	Agroanalysis (A) MAPA (B) Markestrat survey and Pecege (C, E) Idea (D)
Resellers and cooperatives (just for herbicides and pesticides)	Estimated % of herbicides/pesticides sold indirectly via resellers and cooperatives (A) Estimated margin of distribution channels (B) Revenue for cane herbicides/pesticides segment (C) Estimated billing = A x B x C	Interviews with herbicides/pesticides industries and cooperatives (A, B) SINDAG (C)
Agricultural protective clothing	Average spending/tc (A) Sugarcane production in tonnes (B) Estimated billing = A x B	Research with mills (A) CONAB (B)
	In the plantation	
Sugarcane production	Sugarcane production in tonnes (A) Estimated % of privately-owned cane and suppliers (B) Average total recoverable sugars (kg/tc) (C) TRS value R$/ kg (D) Estimated billing = A x B x C x D	CONAB (A) MAPA (B) CONSECANA (C, D)
	After the plantation (industrial inputs)	
Industrial equipment	New mills and installed sugarcane crushing capacity (A) Estimated value of industrial investments per tonne of installed sugarcane crushing capacity, including equipment, instrumentation/automation, and electric installations in new projects (B) Costs of maintaining the mill between harvests, per tonne of crushed cane in the Center-South and Northeast (C) Estimate (in %) of cost of maintenance spent on equipment in the Center-South and Northeast (D) Volume of sugarcane crushed in the Center-South and Northeast (E) Estimate of automation and instrumentation projects sold in 2008 for mills sold in previous years (F) Average price of each automation project (G) Estimated billing = (A x B) + (C x D x E) + (F x G)	Interviews with capital goods industry (A) Procknor Engenharia (B) Research with mills and Pecege data (C) Pecege (D) MAPA (I) Interviews with automation and instrumentation company (F, G)
Installation and maintenance services	New mills and installed sugarcane crushing capacity (A) Estimated value of industrial assembly service per tonne of installed sugarcane crushing capacity (B) Estimate (in %) of maintenance cost that is spent on services in the Center-South and Northeast (D) Sugarcane volume in the Center-South and Northeast (E) Estimated billing (A x B) + (C x D x E)	Interviews with capital goods industry (A) Procknor Engenharia (B) Research with mills and Pevege data (C) Pecege (D) MAPA (E)
Chemicals	Average expenditure per tonne of sugarcane (A) Sugarcane production in tonnes (B) Estimated billing = A x B	Research with mills (A) CONAB (B)
Fuel oil and lubricants	Average consumption per tonne of sugarcane (A) Sugarcane production in tonnes (B) Average price (C) Estimated billing = A x B x C	Research with mills and Pecege data (A, C) CONAB (B)

Details of methodology and quantification calculations

Annex 1

Stage of the supply chain	Quantification criteria	Sources
Sacking	Number of 50 kg sacks sold (A) Average price (B) Estimated billing = A x B	AFIPOL (A) Interviews with mills and manufacturers of sacks (B)
Big bags	Number of 1,200 kg bags sold (A) Average price (B) Estimated billing = A x B	AFIPOL (A) Interviews with mills and manufacturers of bags (B)
Laboratory material	Average expenditure per tonne of sugarcane (A) Sugarcane production in tonnes (B) Estimated billing = A x B	Research with mills (A) CONAB (B)
Industrial protective clothing	Average expenditure per tonne of sugarcane (A) Sugarcane production in tonnes (B) Estimated billing = A x B	Research with mills (A) CONAB (B)
	After the plantation (mill revenues)	
Ethanol	Volume of anhydrous ethanol sold domestically (A) Average price of anhydrous ethanol (B) Volume of hydrous ethanol sold domestically (C) Average price of hydrous ethanol (D) Volume of ethanol for non-energy uses (E) Average price of non-energy (F) Volume of anhydrous ethanol sold via the informal market (G) Volume of hydrous ethanol sold via the informal market (H) Revenue of ethanol exports (I) Estimated billing = (A x B) + (C x D) + (E x B) + (E x F) + (G x B) + (H x D) + I	ANP from 1999 to 2007, EPE in 2008 (A) CEPEA-ESALQ and MAPA (B) MAPA (C) CEPEA-ESALQ and MAPA (D) EPE (E) Weighted average price using the proportions of anhydrous and hydrated volumes for non-energy recorded in 2007 (F) Estimates from ANP, Sindicom and Fecombustiveis (G, H) MDIC-SECEX, plus the proportions between anhydrous and hydrated ethanol, from UNICA (I)
Sugar	Sugar production in tonnes (A) Sugar exports in tonnes (B) Sugar exports – revenues (C) Volume of sugar sold by mills to industry, apportioned Center-South = 60%; Northeast = 25% (D) Volume of sugar sold by mills to wholesale, apportioned Center-South = 12%, Northeast = 22% (E) Volume of sugar sold by mills to retail, apportioned Center-South = 28%, Northeast = 53% (F) Average price that mills sold to industry (G) Average price that mills sold to wholesale (H) Average price that mills sold to retail (I) Estimated billing = C + (D x G) + (E x H) + (F x I) weighting values and volumes for Center-South and Northeast regions	UNICA, 2008/09 Harvest (A) MDIC-SECEX (B, C) A – B weighted by the % obtained in interviews with mills and Copersucar (D, E, F) CEPEA-ESALQ, MAPA (G) Interviews with wholesalers (H) CEPEA-ESALQ, MAPA, price of 50kg + R$15/sack (I)
Electrical energy	MW sold (A) Average price of MWh in auctions (B) MW conversion in MWh (C) Estimated billing = A x B x C	EPE and Valor Econômico (A) COGEN (B, C)
Yeasts and additives	Yeast revenues in domestic market (A) Yeast revenues in external market (B) Additive revenues in domestic market (C) Additive revenues in external market (D) Conversion of R$ into US$ (E) Estimated billing = (A+C)/E)+B+D	ICC (A, B, C and D)
Carbon credits	Quantity of tonnes of CO_2 equivalent (A) Average price (B) Estimated billing = A x B	United Nations Framework Convention and ABDI (A) World Bank (B)

Annex 1 — Details of methodology and quantification calculations

Stage of the supply chain	Quantification criteria	Sources
	After the plantation (billings in the distribution channels)	
Ethanol distributors	Volume of hydrous ethanol sold in domestic market (A) Weighted average price (B) Estimated billing = A x B	ANP (A, B)
Ethanol filling stations	Volume of hydrous ethanol sold in domestic market (A) Average price (B) Estimated billing = A x B	ANP (A, B)
Sugar – wholesale	Volume sold (A) Average price (B) Estimated billing = A x B	Interviews with mills (A) Interviews with wholesalers
Sugar – retail	Volume sold – wholesale and retail (A) Average price (B) Estimated billing = A x B	Interviews with mills (A) DIEESE (B)
	Facilitators	
Outsourced CCT (cutting, loading and transportation)	Sugarcane production in tonnes (A) % of outsourced mechanized harvest (B) % of outsourced loading (C) Percentage of outsourced haulage (D) Price of harvest service (E) Price of loading service (F) Price of transportation service (G) Calculation of billing: A x B = W; A x C= Y; A x D=Z; W x E = V; C x F= L; Z x G= H Therefore: V + L + H	CONAB (A) Interviews with mills, Pecege (B, C, D) Logtrac, mills and IDEA (E, F, and G)
Freight	Value of shipping R$ per tonne/Km (A) Volume exported (tonne) (B) Distance traveled (C) Estimated billing = A x B x C	Sifreca (A) MDIC/Secex (B) Markestrat research with freight companies (C)
Highway tolls	Ethanol logistics data R$/m (A) Volume of exported ethanol (B) Ethanol toll cost: A x B = Y Average amount spent on tolls, seven-axle trucks (C) Truck capacity (D) Exported volume (E) Calculation: E / D = Number of trips (Z) Estimated toll cost for sugar: Z x C = W Estimated toll cost: Y + W	Copersucar and Sifreca (A) MDIC / Secex (B) Mills (C)
Port costs	**Sugar:** Amount spent on loading: US$/tonne (A) Amount spent on shipping supervision: US$/tonne (B) Clearance cost: US$/shipment (C) Shipment value (Y) C / Y = (D) Volume exported via Santos (E) Estimated cost for sugar = (A + B + D) x E **Ethanol:** Amount spent on loading: US$/M^3 (S) Amount spent on shipping supervision: US$/M3 (G) Clearance cost: US$/order (H) Shipment value (Z) H / Z = (W) Volume exported via Santos: (F) Estimated cost for ethanol = (S + G + W) x F	Copersucar (A, B and C) MIDC / Secex (E and F) IETHA (S, G, H)

Details of methodology and quantification calculations

Annex 1

Stage of the supply chain	Quantification criteria	Sources
Health plans	Monthly number of workers in mills (A) Average health plan cost (B) Estimated billing = A x B	MTE (A) Unimed, São Francisco Clínicas and Sermed (B)
Meals	Monthly number of workers in mills (A) Average spent on meals per month (B) Number of months/year (C) Estimated billing: A x B x C	MTE (A) Interviews with mills (B)
BNDES (financing)	Consolidated financing data for the sugar-energy sector in 2008	BNDES
Events	Costs for developing and organizing events in the sugar and ethanol industry: Fenasucro and Agrocana (A) Ethanol Summit (B) Fersucro Simpo and (C) Simtec (D) Canasul (E) Agrishow (F) Estimated billing = A + B + C + D + E + F	Fenasucro and Agrocana (A) Ethanol Summit (B) Fersucro and Simpo (C) Simtec (D) Canasul (E) Agrishow (F)
Magazines	Interviews with publishers and quantification of revenue. Jornal da Cana (A) IDEA News (B) Energia Mundo (C) Canavieiras (D) Canamix (E) Estimated billing = A + B + C + D + E	Jornal da Cana (A) IDEA News (B) Energia Mundo (C) Canavieiras (D) Canamix (E)
Wage bill	Number of workers in the sugar-energy agriculture sector (A) Number of workers in the sugar-energy sector - industry (B) Average wage in the agricultural sector (C) Average wage in the industrial sector (D) Estimated cost: (A x C) + (B x D)	MTE (A, B, C and D)
Taxes	Gross revenue (A) IPI Value (B) ICMS (C) PIS (D) Cofins (E) Agricultural inputs (F) Industrial equipment and installation (G) Sales tax Σ (A x B) + (A x C) + (A x D) + (A x E) = (I) Estimated total tax: T – F – G	Reis Advogados Associados (C, D and E) Ministry of Finance / Receita Federal (B)

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Explanatory note

[i] In this case only, we used the average exchange rate for the US dollar between April 2008 and March 2009, equivalent to the 2008/09 harvest season. The value used was US$1.00 = R$1.97.