Ethanol and Bioelectricity Sugarcane in the Future of the Energy Matrix

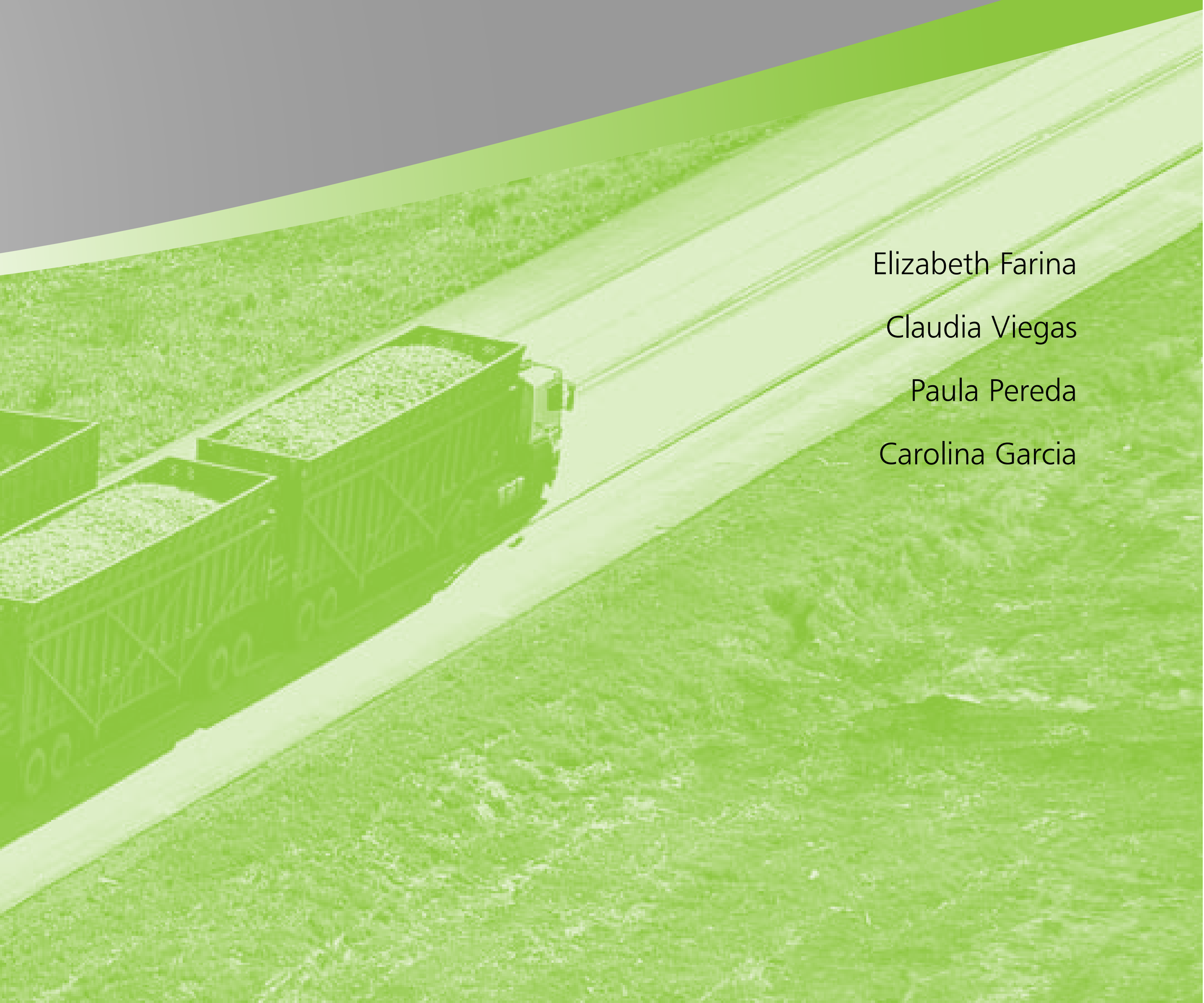
Ethanol Market and Competition

Elizabeth Farina

Claudia Viegas

Paula Pereda

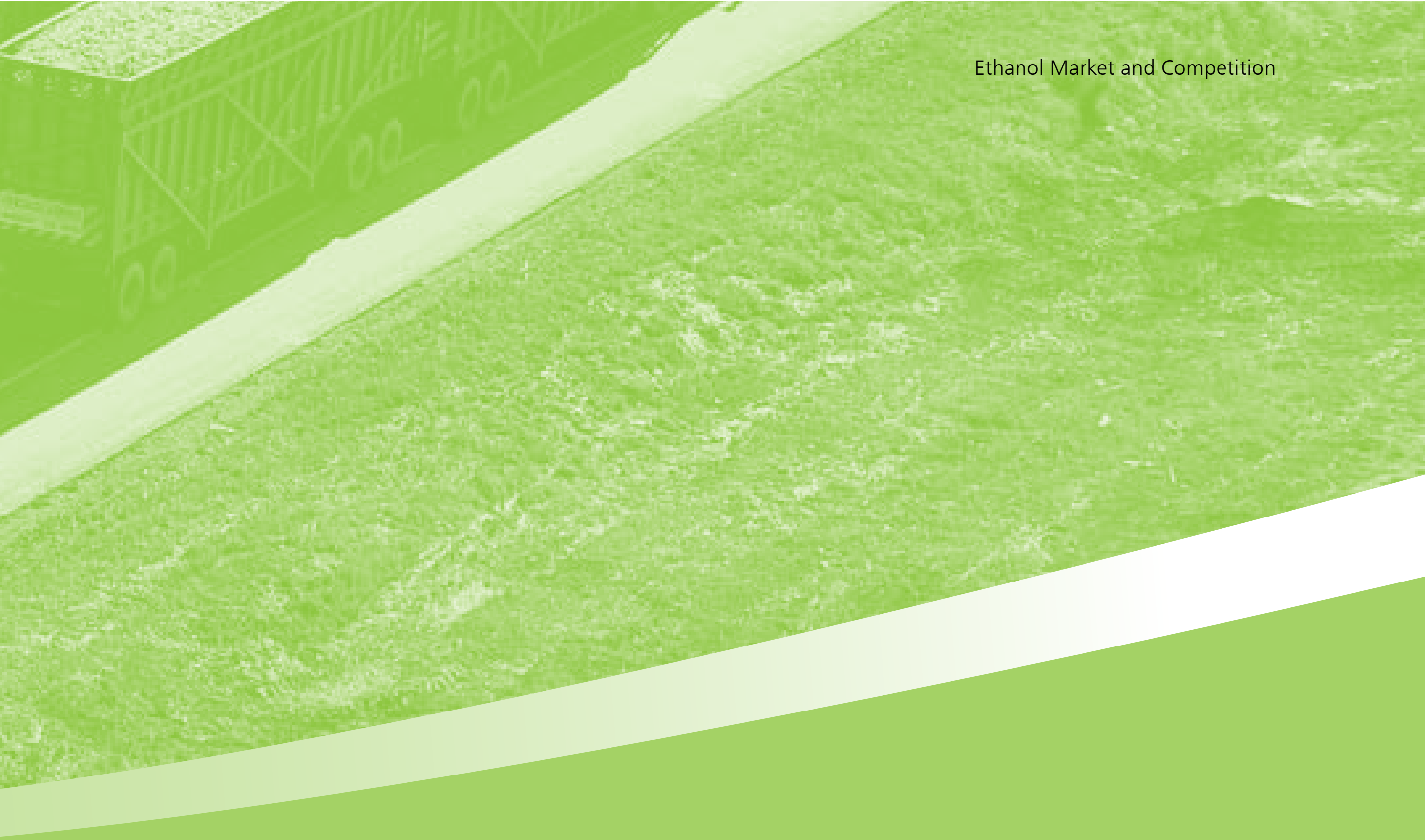
Carolina Garcia



To a greater or lesser extent, fuel production and distribution has historically been regulated in every country in the world. The availability of energy is strategic for any economy, and the reliance on non-renewable sources represents challenges that are not trivial for public policy.

Despite their seasonality and the possibility of harvest failures, renewable sources help to mitigate the problems caused by dependence on fossil fuels.

In Brazil, ethanol production takes place within a relatively dispersed market. In this context, the question that must be asked is: does this ensure an adequate supply of ethanol? The answer depends, in part, on the policies adopted for petroleum derivatives, and in the case of Brazil, this in turn depends on Petrobras' pricing policy for derivatives. However, since it is clearly shown that hydrous ethanol consumers are more price-sensitive than those of Type C gasoline, we can conclude that in terms of public policies for ethanol, the price variable is adequate for regulating the market.



With respect to anhydrous ethanol, the variation of the mandatory blend – which must lie between 20% to 25% – has so far been an efficient way to reduce price volatility in the Type C gasoline market in times of scarcity. Changes in the blend percentage are justified only by harvest failures that endanger the supply of anhydrous ethanol for blending into Type C gasoline. This policy should not be used to address seasonal variations, because unjustified changes increase business risk and the sustainability of ethanol production.

Among various priority measures, this paper defends the following: establishment of technical criteria to monitor the market with the aim of identifying harvest failures; allowing agents a wider range of action to increase liquidity in the market; and intensification of mechanisms for maintaining private stocks of ethanol.

Improving the operation of the market with a minimum of intervention is the most efficient way to correctly stimulate the sustainable expansion of production.

1 Introduction

It is essential to understand the supply chain for anhydrous and hydrous ethanol if we are to examine competition patterns observed throughout all levels of the liquid fuels sector in Brazil, together with the consequences for domestic market supply and for public policy.

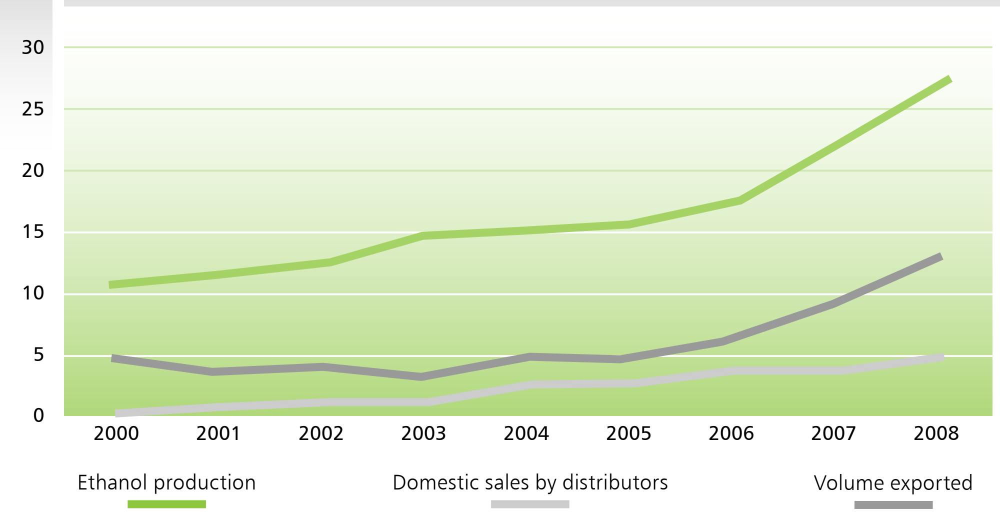
Figure 1 illustrates the flows within the entire agri-industrial system of the sugarcane business. This present study focuses on the ethanol production subsystem, even though the inter-relationship with the sugar subsystem is essential to understanding the dynamics of the former.

With the aim of discussing the possible outlines of a public policy for the ethanol market, this article is structured as follows:

Section 2 presents general aspects of the biofuels market in Brazil, highlighting the relationships between sugar and ethanol, gasoline and hydrous ethanol, and anhydrous and hydrous ethanol. In **section 3**, the ethanol supply chain is studied, examining the competitive environment and concentration in different segments in the supply chain. Section 4 is dedicated to estimating the domestic demand of hydrous ethanol and Type C gasoline. Section 5 looks at the impacts of variations in the price of anhydrous ethanol on variations in the gasoline price and calculates by how much production has to fall to constitute a situation of risk for anhydrous ethanol supply.

In conclusion, this paper discusses the role and the outlines of a public policy that would encourage renewable energy production, in particular sugarcane ethanol, and guarantees regular supply of the market.

Graph 1 **Production, exports and domestic sales of ethanol** *In billions liters*



Source: UNICA. ANP. Prepared by the authors.

▶ 2 General characteristics of the Brazilian biofuels market

Brazilian ethanol production has been boosted by growth in domestic consumption, most notably with the arrival of flex-fuel vehicles in 2003 – see **Graph 1**. Until 2003, the market was sustained by a mandatory blend of anhydrous ethanol in gasoline and by an aging fleet of ethanol-powered vehicles. Things changed in 2004, as shown in **Table 1**. In 2004, flex-fuel vehicles represented 2% of the fleet; in 2008 they were equivalent to 31%. The result was rapid growth in the demand for hydrous ethanol, which overtook Type C gasoline sales in 2009.

2.1 Relation between sugar and ethanol

The sugar and ethanol markets compete for the same raw material input, namely planted and crushed sugarcane. From the supply side, therefore, they could be considered as competing products. This relationship is beneficial for the producer, who can count on alternatives in the event of demand/supply shocks for the product. It acts as a reducer of business risk, given that these products are independent on the demand side, that is, they are independent from the consumer's point of view.

Sugar and ethanol production reacts to relative prices and technical characteristics. Sugar mills with attached distilleries can direct cane juice from crushing to the production of sugar or ethanol, depending on the relative profitability of the two products. The decision also depends on rainfall. During rainy periods, the sugar content of the cane is low and it is preferable to produce as much ethanol as possible, reducing sugar production to a necessary minimum, with the opposite happening during dry periods. However, production plants have a pre-determined volume of cane to crush during the harvest and limited capacity

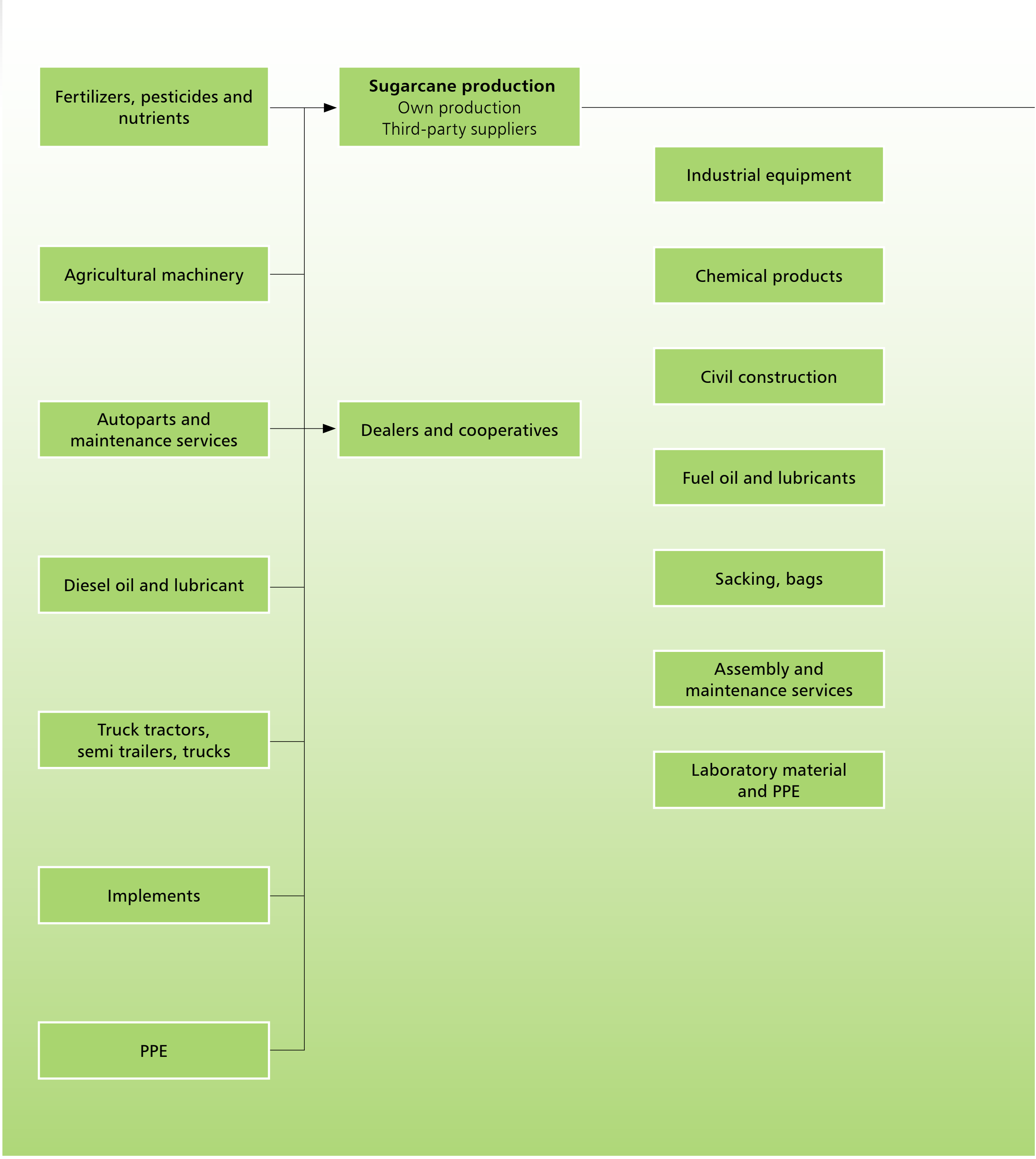
Table 1 — **Light vehicle fleet** *In units*

Year	Flex-fuel	Gasoline	Ethanol	Total
2000		12,171,156	3,088,471	15,259,627
2001		13,259,902	2,704,089	15,963,985
2002		14,201,202	2,353,114	16,554,316
2003	48,142	14,972,939	1,990,045	17,011,126
2004	331,762	15,560,064	1,698,340	17,590,166
2005	1,182,052	15,807,570	1,389,977	18,379,599
2006	2,596,846	15,534,130	1,122,169	19,253,145
2007	4,568,256	15,106,423	899,183	20,573,862
2008	6,843,750	14,554,392	711,428	22,109,570

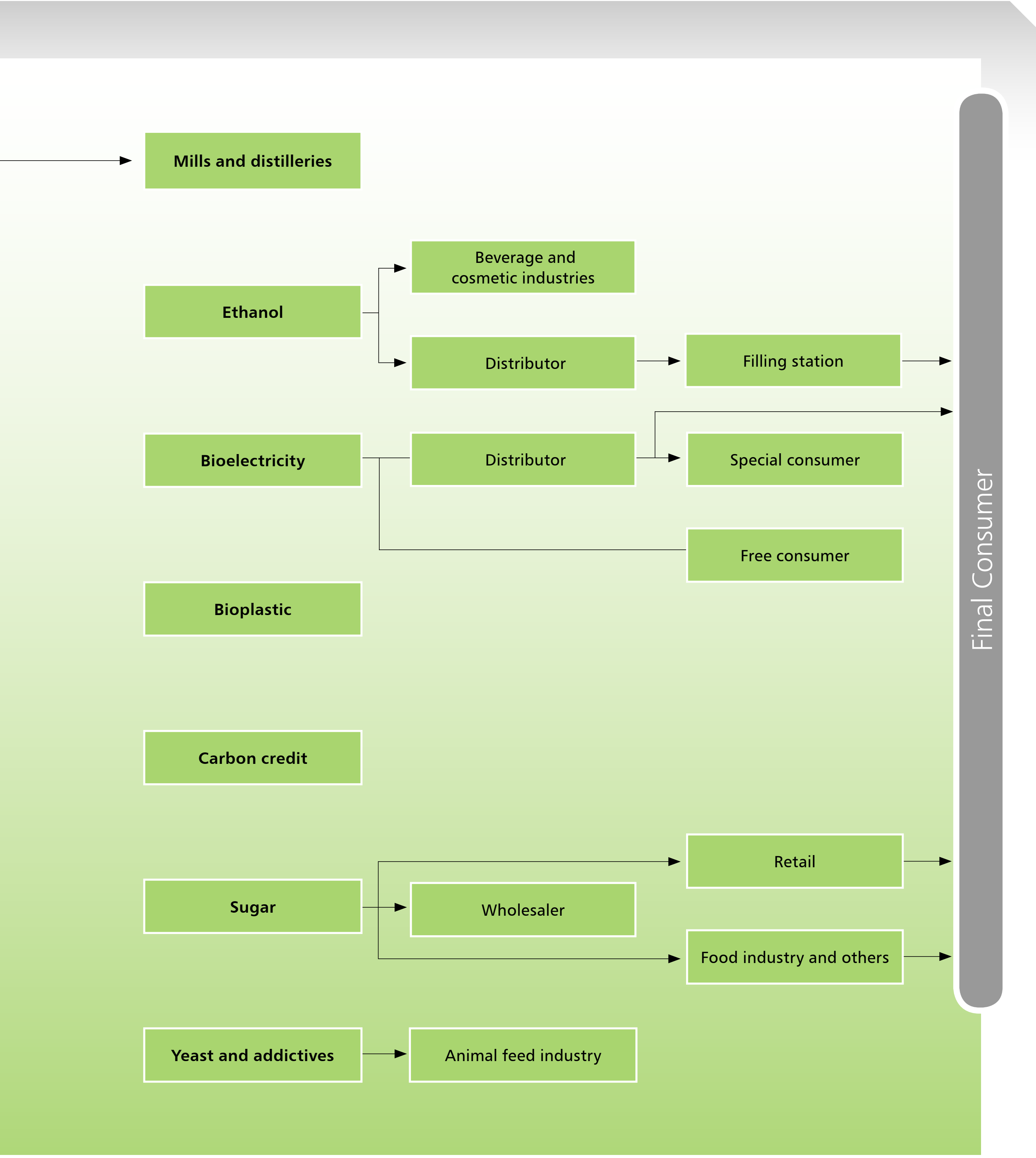
Source: Anfavea/UNICA.

Figure 1

Agri-industrial Sugarcane System



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



Mills and distilleries
Ethanol
Beverage and cosmetic industries
Distributor
Filling station
Bioelectricity
Distributor
Special consumer
Free consumer
Bioplastic
Carbon credit
Sugar
Retail
Wholesaler
Food industry and others
Yeast and addictives
Animal feed industry
Final Consumer

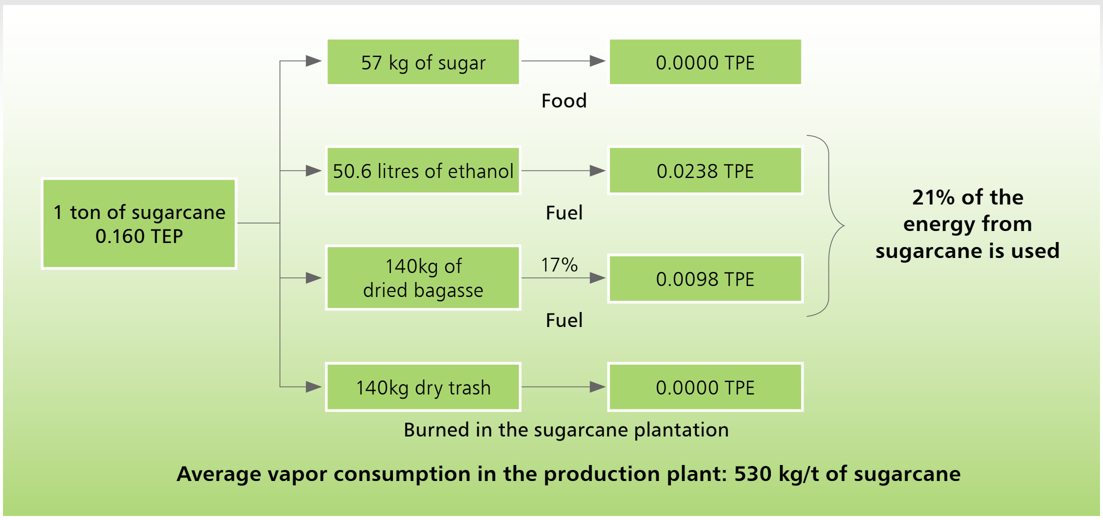
to produce sugar and ethanol. There are therefore operational constraints to the productive process that require combined mill-distilleries to produce both sugar and ethanol, with the margin of substitution of these products varying from 5% to 10% (Zanão, 2009). The production of a typical Brazilian mill-distillery is shown in **Figure 2**.

Another factor that influences the production decision of mill-distilleries is the cost of stocking ethanol, which due to the specific characteristics of the product is extremely high. Investments in storage assets are specific to the production volume of ethanol and could represent an economic limitation for switching between sugar and ethanol to respond to changes in the relative price.

Xavier (2008) classifies ethanol storage infrastructure in Brazil in two major categories: the first comprising fuel tanks that belong to the distilleries; and the second comprising tanks operated by distributors, Transpetro terminals, ethanol collection centers and, to a lesser extent, port terminals. The same author estimates that a typical distillery has sufficient tankage to store 50% of its total production for one harvest.

With respect to the static capacity for ethanol storage in Brazil, Zanão (2009) reports that distilleries can store approximately 11.6 billion liters. Within this total tankage, 5.3 billion liters or 45% is for anhydrous ethanol, while 6.3 billion liters or 55% is for hydrous ethanol. Distilleries in the state of São Paulo accounted for 56.2% of total national storage capacity during the 2007/2008 harvest.

Figure 2 **Production of a typical Brazilian combined sugar mill and ethanol distillery**
1.3 million tonnes of sugarcane/year, in 2008[i]



Source: : Center of Sugarcane Technology, from Simtec 2008 (International Symposium and Technology Show for Sugar and Ethanol Agribusiness)

2.2 Relationship between gasoline and hydrous ethanol

Brazil's Proálcool (national ethanol promotion program) was created in the 1970s as a response to the two oil crises that pushed up international prices. The program created a basis for fuel ethanol to return the national energy matrix, including the introduction of ethanol used by itself as a fuel. Even with the high oil prices of the period, hydrous ethanol depended on subsidies to be competitive with gasoline. Petrobras played an important role in creating and developing the fuel ethanol market, given that it made possible the distribution of ethanol through the same retail channels as gasoline and diesel distribution.

The development of the Brazilian ethanol fuel market also reveals how sensitive technological development can be to changes in the market of the substituted product in the short and medium term. After the initial boost given by Proálcool, technological development lost momentum due to declining oil prices and hydrous ethanol's "loss of reputation" as a gasoline substitute. At this time, fuel substitution effectively occurred at the moment when the vehicle was purchased or converted. In other words, the consumer migrated totally from the market, ceasing to consume Type C gasoline any more. Hydrous ethanol's loss of competitiveness and its lack of availability at filling stations left consumers with no other option, and this affected the reputation of the Proálcool program. The result was that the hydrous ethanol fleet virtually ceased to exist.

The advent of flex-fuel vehicles in 2003 transformed the fuels market in Brazil. The possibility of filling up with ethanol, Type C gasoline or any proportion of the two types of fuel prompted the return of hydrous ethanol as a potential competitor for Type C gasoline. In that year, 48,000 flex-fuel vehicles were sold. Sales reached 2.3 million in 2008, demonstrating not only the favorable conditions but also the strong participation of the auto industry[ii].

Today, ethanol is competitive with petroleum derivatives within a certain price range, dictated by the relative energy efficiency of the fuels. Graph 2 compares the history of the average index price for a barrel of petroleum (WTI) negotiated on the New York Mercantile Exchange (NYMEX) with the index price for Brazilian Type A gasoline (zero ethanol content) and the index consumer price for Type C gasoline. The graph shows the gap between the indexes, highlighting the stability of Type A and Type C gasoline prices.

2.3 Relationship between anhydrous and hydrous ethanol

Vehicles in Brazil use two different types of fuel ethanol, hydrous and anhydrous, where the latter is blended with Type A gasoline by distributors to produce the Type C gasoline available at filling stations. Currently, the amount of anhydrous ethanol added to Type A gasoline to make Type C gasoline varies between 20% to 25% in volume (fixed by the Ministry of Agriculture via Decree No. 3.966/2001, issued under Law no. 10.696/2003).

Since anhydrous ethanol is derived from hydrous ethanol[iii], its production costs are higher that those for the hydrous version. **Graph 3** compares anhydrous and hydrous ethanol prices received by producers in the state of São Paulo, excluding shipping and taxes. The vertical arrows on the graph indicate the effective starting dates for Ministry of Agriculture decrees adjusting the percentage blend of anhydrous ethanol with Type A gasoline, to make Type C gasoline. The respective details are in **Table 2**.

Since the 1999/2000 harvest, production of anhydrous ethanol has surpassed that of hydrous ethanol only in the period between the 2000/2001 and 2004/2005 harvests. From the 2003/2004 harvest through the 2008/2009 harvest, hydrous ethanol production grew at an average rate of 21% per year. **Graph 4** shows the growth trend for ethanol production, reflecting the reduction in the ethanol-powered vehicle fleet at the start of the millennium and the advent of flex-fuel vehicles as of 2003.

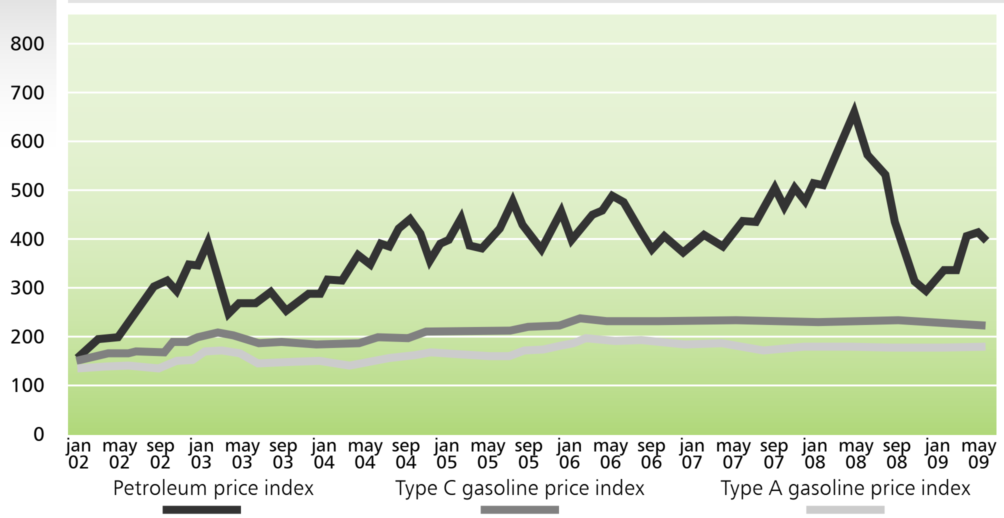
▶ 3 The ethanol supply chain

This section analyzes the relationship between the markets for ethanol, sugar and petroleum derivatives, and the impact of the productive structure on the dynamics of the sector.

3.1 The competitive environment

The role of public policy and the design of market intervention mechanisms depend crucially on the competitive process observed in each segment of the supply chain, and their vertical relationships. Within this general perspective, the present section examines the structure and competition pattern in the ethanol supply chain,

Graph 2 **Comparison of price trends for petroleum, Type A gasoline, and Type C gasoline**



Source: ANP, Bloomberg. Prepared by the authors.

paying particular attention to price-formation mechanisms. The main focus is on the sugar and ethanol production segment, and downstream segments – liquid fuel distributors and retailers.

There were 423 sugar and ethanol plants registered with the Ministry of Agriculture (MAPA) in Brazil as of August 2009. Of these 248 were mixed units (producing both sugar and ethanol), 159 were distilleries (producing just ethanol) and 16 produced just sugar[iv].

An important factor in the competitive environment of Brazilian mills is the heterogeneity of sizes. In the Center-South region 58% of the companies crushed less than two million tonnes of cane in the 2009/2008 harvest, representing only 31% of cane crushing in the region.

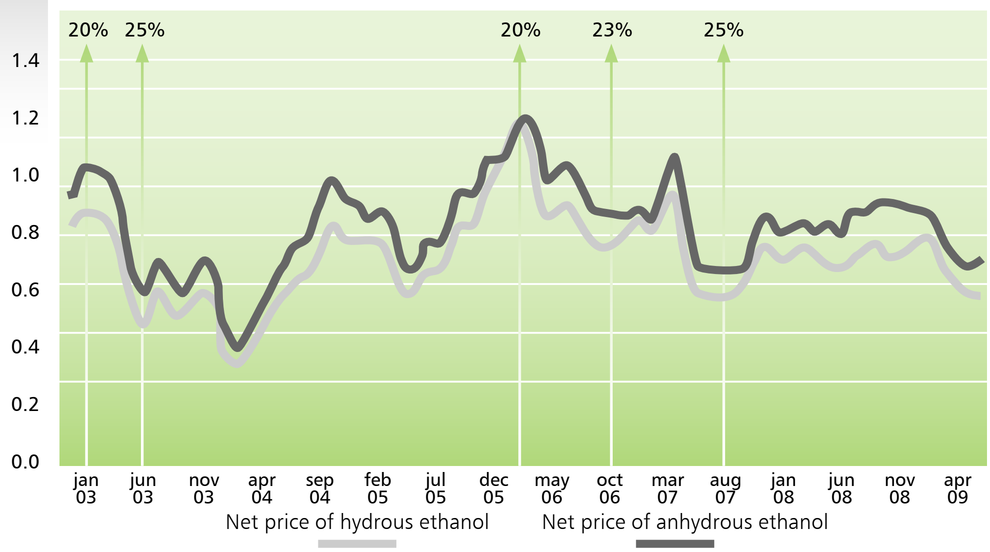
Table 2 **Changes to the anhydrous ethanol blend in gasoline**

From January 2003 to June 2009

MAPA Instruction Nº	Date published	Percentage fixed	Operational date
17	22/01/03	20%	01/02/03
554	27/05/03	25%	01/06/03
51	22/02/06	20%	01/03/06
278	10/11/06	23%	20/11/06
143	27/06/07	25%	01/07/07

Source: Ministry of Agriculture; prepared by the authors.

Graph 3 **Price trend of anhydrous and hydrous ethanol[v]**



Source: UNICA, prepared by the authors.

With respect to ethanol, 60% of distilleries produced less than 100 million liters of ethanol each and together accounted for 31% of total production, while just 8% of mills produced 25% of all the ethanol in the Center-South region.

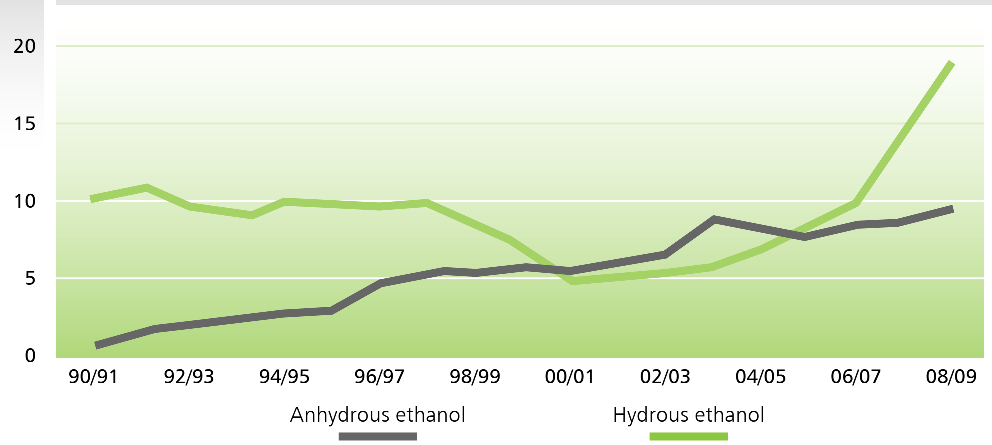
According to the Syndicate of the Ethanol Production Industry in the State of Minas Gerais (Siamig)[vi], 13 of the 15 largest production plants in the country are in São Paulo, with the other two located one in Mato Grosso and one in Minas Gerais. The difference between the first and the last in this ranking was approximately three million tonnes in the 2007/2008 harvest, revealing the difference in scale of the leading companies. Of these 15 companies, two exceed six million tonnes.

Also according to the Siamig report, concentration is a recent phenomenon in the Brazilian sugar and ethanol sector. There have been more than 60 mergers and acquisitions since 2004, producing the large groups in the sector. However, concentration is still low. No producer accounts for more than 10% of domestic production in terms of crushed sugarcane.

Sugarcane processing involves moving large volumes of low-value cargo. For this reason, mills and distilleries are located close to sugarcane plantations and freight usually involves road trains of special sugar-cane trailers, known in Brazil as "treminhões" (Xavier, 2008).

In the ethanol-production segment, "distribution" includes responsibility for the acquisition, storage, transport, marketing and quality control of the fuel (Xavier, 2008). According to the ANP, Brazil has 508 fuel distribution depots, 36,730 filling stations and 459 companies authorized to transport and effect retail sale of fuel (such companies are known in Brazil as Carrier Dealer Retailers (TRR in the Portuguese acronym)[vii]. The flowchart in **Figure 3** summarizes the fuel distribution chain.

Graph 4 **Growth of Brazilian ethanol production** *In billions of litres*[viii]



Source: UNICA, ANP. Prepared by the authors.

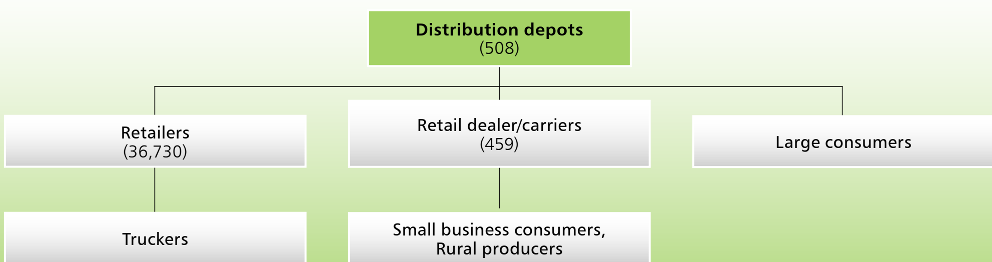
Fuel distribution depots are mainly located in regions close to ports and consumer markets. Products are transferred and stored in distribution depots, where tanker trucks fill up and the products are shipped to the final clients of the company – filling stations, large consumers and wholesalers (Rodrigues and Saliby, 1998).

Deregulation of the sector favored the entry into the market of new distributors and encouraged the use of logistics as a competitive differential in the Brazilian fuels market (Maligo, 2005). Distributors, who emerged on the scene after deregulation, became known in the sector as "newcomers" (emergentes in Portuguese). As discussed below, the newcomers are located principally in São Paulo, according to the ANP, and have become very important in the distribution of hydrous ethanol.

Of the 36,730 filling stations existing in the country, 43% are independent, not tied to a specific brand – see **Graph 5**. These independent stations can be supplied by any distributor, while tied filling stations can be supplied only by a distributor of their own brand.

Currently, the pump price for hydrous ethanol can be divided into four components. First is the cost of producing hydrous ethanol, which represents the price at which it is sold by producers to fuel distributors, net of taxes and shipping. The second refers to taxes. There are two taxes on ethanol: ICMS, a state tax; and PIS/Cofins, a federal tax. Both are paid by producers and distributors. In the state of São Paulo, ICMS was 25% on top of the sale price for producers and distributors in 2003, then since January 2004 it has been 12%. PIS/Cofins on hydrous ethanol was 3.65% for producers and 8.2% for distributors between January 2003 and September 2008, then since October 2008 mills have paid R$48 per thousand liters, while distributors pay R$78[ix]. The third component of the hydrous ethanol pump price is logistics, comprising freight from the distillery to the distribution depot, and subsequent delivery to the filling station. The fourth and last item relates to the margins of distributors and filling stations[x].

Fuel distribution chain, 2009 Figure 3



Source: ANP. Prepared by the authors.

Graph 6 illustrates the change in the composition of hydrous ethanol pump prices in the state of São Paulo, showing the compression of producers' margins – a situation that has worsened since 2007. However, data for 2009 includes just the period from January to September, when production is greater and prices are lower. It is therefore possible that the price paid to the producer is underestimated.

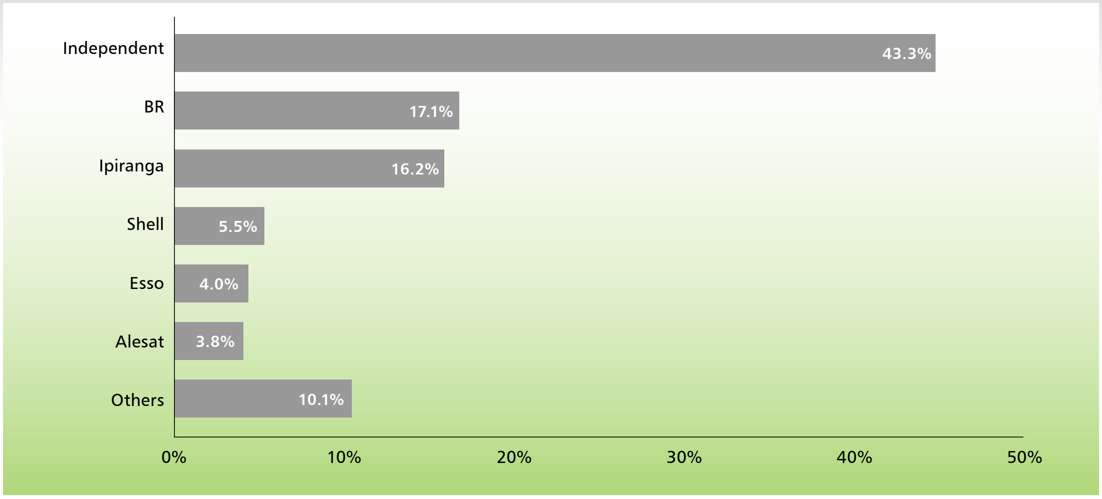
While all values have been normalized so that the pump price is equal to one, in some years the column in the graph exceeds one. In 2003 and 2004 this was due to a negative margin for distributors, and in 2008 and 2009 to a negative margin for producers. Thus, if we add together all the values that make up the price, including the negative margins, the price at the pump will be equal to one[xi].

3.2 Concentration in the supply chain

The behavior of ethanol supply is also influenced by the structure of the market, to the extent that this reflects the relative price bargaining conditions between ethanol producers and purchasers (distributors).

Concentration is a basic characteristic of market structure and can be measured by tools such as the Herfindahl-Hirschman Index (HHI) and the Concentration Ratio (CR_K). The studies that most contributed to this topic were Rocha et al (2007), Mori and Moraes (2007) and Mattoso (2008). This literature permits the conclusion that the ethanol production sector was, until recently, characterized by low concentration, but in recent years there has been a strong trend towards mergers and acquisitions.

Graph 5 **Distribution depots in Brazil, by brand**[xii] *In percentage, situation at 31/12/2008*

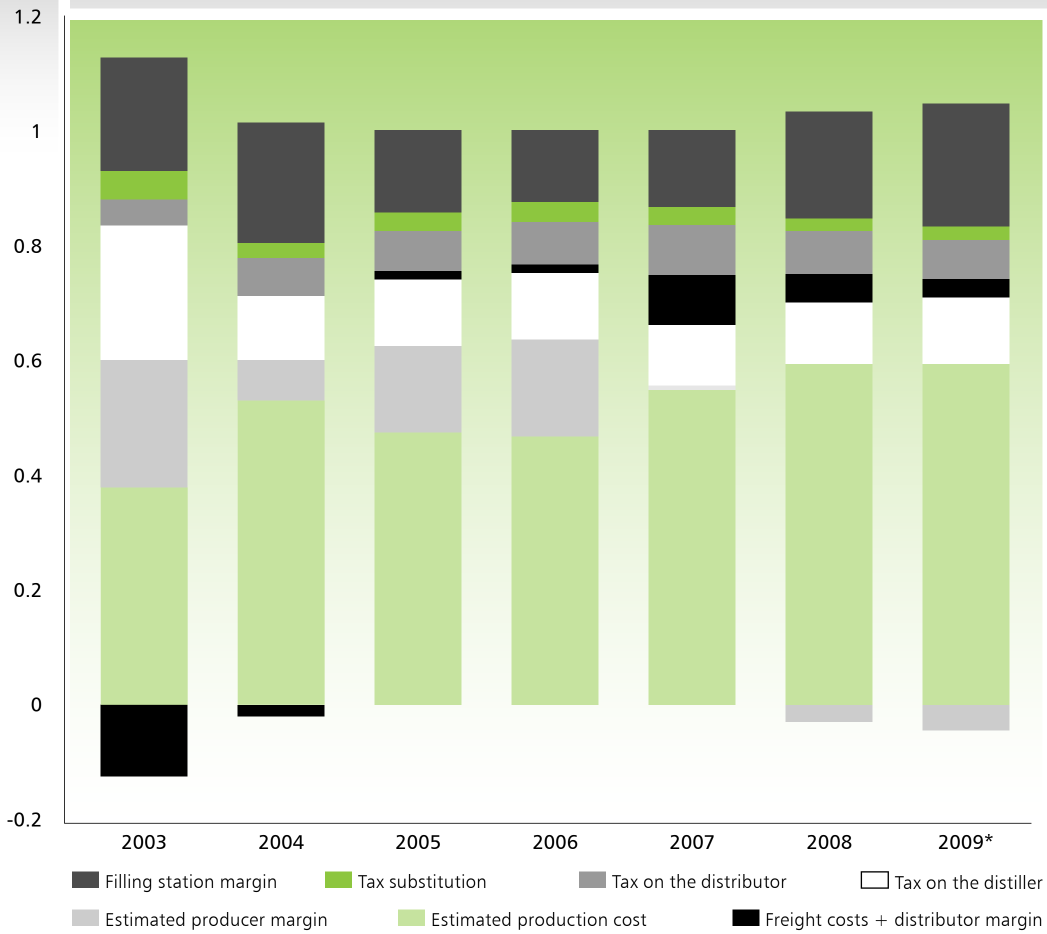


Source: ANP.

Table 3 shows the results of three concentration indexes – HHI[xiii], Equivalent Number and CR5 – for fuel distributors in Brazil for 2008, taking Brazil as the reference market.

Despite the substantial participation in the market of the five largest, the HHI is below 1,800 for distribution of hydrous ethanol and Type C gasoline, indicating low concentration. The markets for fuel oil, aviation gasoline and aviation kerosene are extremely concentrated.

Graph 6 **Breakdown of the hydrous ethanol pump price, in São Paulo**



* The data for 2009 refers to the period January-September. While the values were normalized to make the pump price one, in some cases the value on the graph exceeds one due to the negative margin received by the distributors or the producers, so "compensating" for the value above one at the pump. • *Source:* Agroconsult, Cepea/UNICA, ANP. Prepared by the authors.

As we know, HHI varies with the participation of each company in the market and also with the disparity between them. The Equivalent Number corresponds to the number of companies of equal size that would generate the same HHI. This number is relatively high for both ethanol and Type C gasoline. A dozen companies of equal size competing in the market could generate strong competition via the purchase of raw materials or sales to filling stations.

It is worth noting that these indexes can be skewed by excessive aggregation of data. Given that this data is not available disaggregated; we opted to calculate the HHI by state, using data from Sindicom and the ANP for hydrous ethanol and Type C gasoline.

When calculated by state, HHI continued to show a low degree of concentration in 2008 in the states of São Paulo, Minas Gerais, Rio de Janeiro, Santa Catarina, Paraná and Mato Grosso (HHI<1,800). In the case of São Paulo we found HHI below 1,000, which indicates a fragmented market on both the purchase and sales sides. For other states we obtained HHI greater than 1,800.

However, interviews with distillery executives in São Paulo revealed that some mills do not sell to the majority of "newcomer" distributors, in particular those that are not members of Sindicom (the National Syndicate of Fuel and Lubricant Distributors) for reasons associated with tax evasion and non-payment. This means that buyers would be restricted to the five liquid fuel distributors that are members of Sindicom. To evaluate this question, we calculated concentration taking into account just that part of the market where only the so-called Sindicom distributors operate. Only then did HHI exceed 1,800 in all states. This means that distillers selling only to Sindicom distributors effectively face higher concentration on the demand side.

When only the distributors within Sindicom are considered in every state, the HHI for ethanol sales was relatively stable in the period 2003-2008. There was a slight increase in 2008, given the acts of concentration that occurred that year. The distribution arm of the Ipiranga Group was acquired by Ultrapar and Petrobras.

Table 3 **HHI, number equivalent to CR5 of fuel distributors in 2008**[xiv]

Fuel	HHI	Equivalent Number	CR5 (%)
Hydrous ethanol	951	11	55
Type C gasoline	1,395	7	66
Diesel oil	2,050	5	71
Fuel oil	5,946	2	99
Aviation gasoline	4,036	2	100
Aviation kerosene	4,377	2	100

Source: ANP. Prepared by the authors.

The former got the filling stations and fuel and lubricant distribution in the South and Southeast regions[xv], while the latter got the same operations in the North, Northeast and Midwest regions[xvi]. Ultrapar (Ipiranga) subsequently bought Texaco's fuel distribution operations[xvii].

The HHI for Type C gasoline is slightly higher than that for ethanol. Once again, the index is below 1,800 in the state of São Paulo, as it is in Mato Grosso, Minas Gerais and Bahia. Considering only Sindicom distributors, the index is higher and above 1,800 in every state.

In the distilleries sector, we calculated the HHI, equivalent number and CR5 for the production of distilleries in the state of São Paulo in the 2008/2009 harvest, examining not individual plants but the economic groups to which they belong (economic concentration). The calculation is restricted to the state of São Paulo because of the availability of information. However, given the major share of this state within the national ethanol market, the index is relevant for this analysis. Of the 317 distilleries located in the Center-South region, 182 are in the state of São Paulo. Ethanol production in São Paulo state and the Center-South region represent respectively 60.8% and 91.3% of the national total[xviii].

The results shown in **Table 4** indicate a fragmented sector, with 108 economic groups controlling 182 distilleries. Despite approximately 60 mergers and acquisitions since 2004[xix], the sector still cannot be described as concentrated. The equivalent number of companies shows that this same HHI value corresponds to a market with low concentration, with a relatively high number of companies. Moreover, the combined market share of the five largest distilling groups also points to low concentration.

Tabela 5 shows HHI, equivalent number and CR5 data for distilleries by unit of production (technical concentration), in the period between the 2004/2005 and 2008/2009 harvest. Calculations were based on the production ranking of mills in the state of São Paulo, as provided by UNICA.

Table 4 **Pulverized sector**

HHI, equivalent number and CR5 for distillery production in São Paulo by economic groups, 2008/2009 harvest

Product	HHI	Equivalent number	CR5 (%)
Sugarcane	311	32	27
Sugar	428	23	32
Anhydrous ethanol	429	23	36
Hydrous ethanol	246	41	24
Total ethanol	270	37	25

Source: UNICA. Prepared by the authors.

Tabela 5 reveals a sector with very low concentration, as indicated by the low values for HHI and CR5, and the high equivalent number. There is also a slight trend to dispersal, if we consider total ethanol production, reflecting the growth of the relative volume of hydrous ethanol and the entry of new mills.

HHI, the equivalent number and CR5 were also calculated by individual distillery for the 2008/2009 harvest in the Center-South region. Results are in **Table 6**. As can be seen, the HHI results were approximately 40% lower than those found in the state of São Paulo during the same period, pointing to even greater dispersal of the sector when looking at the Center-South region. The increase in the equivalent number of companies and reduction of CR5 also confirm the lower concentration of the Center-South region when compared to the state of São Paulo.

We therefore have an upstream segment with low economic concentration, where HHI is below 430 when looking at economic groups and below 116 when considering individual mills. The upstream segment is legally required to sell its production via distributors, a segment where concentration is higher, but nevertheless below levels considered worrisome in the main consumer states.

As is well known, concentration by itself does not determine the level of competition and market power, although it is an important element. Other factors such as rivalry, market entry and countervailing power must be taken into account. Furthermore, low concentration hampers but does not eliminate the possible formation of cartels, while in the fuel retail segment the Brazilian Competition Policy System (BCPS) has identified and condemned several groups of filling station for price-fixing. Condemnations have been achieved in the cities of Florianópolis (SC), Goiânia (GO), Lages (SC), Belo Horizonte (MG) and Recife (PE).

Allegations of filling station cartels are so frequent that the Secretariat of Economic Law of the Ministry of Justice (SDE) has, as part of its functions with respect to competition law, published a booklet dealing exclusively with gasoline retailing. Of the 298 cartel investigations under way at the SDE, 152 are related to fuel retailing.

Table 5

Sector with low concentration

Trend of HHI, equivalent number (n) and CR5 (%) of distilleries in São Paulo, from 2004/2005 to 2008/2009 harvest years

	2004/2005			2005/2006			2006/2007			2007/2008			2008/2009		
Product	HHI	n	CR5	HHI	n	CR5	HHI	n	CR5	HHI	n	CR5	HHI	n	CR5
Sugarcane	112	89	12,1	109	92	12,0	104	96	11,3	94	106	10,1	87	115	9,8
Sugar	126	79	13,0	124	81	12,4	113	88	11,5	112	89	11,2	109	92	11,3
Anhydrous ethanol	145	69	14.8	149	67	15,1	153	65	14,8	169	59	17,5	159	63	16,5
Hydrous ethanol	147	68	13,0	140	71	14,5	119	84	12,6	97	103	10,2	94	106	9,9
Total ethanol	118	85	12,7	114	88	12,1	108	93	11,8	93	108	10,1	87	115	9,6

Source: UNICA. Prepared by the authors.

Market power is limited by the behavior of demand. The more sensitive demand is to price variations, less will be the ability of a company to increase prices to boost profit. The following item is dedicated to the study of ethanol demand.

▶ 4 Analysis of domestic demand for hydrous ethanol and Type C gasoline

The main characteristic of the Brazilian consumer market for fuel is the competition at the pump between hydrous ethanol and Type C gasoline for flex-fuel vehicles. Competition between the two fuels is related to their sensitivity of demand given variations in the relative price.

The fact that ethanol has increased its participation and importance in the Brazilian energy matrix has prompted several studies focusing on the sector[xx]. Examples include: Bentzen (1994), Eltony and Al-Mutairi (1995), De Negri (1998), Alves and Bueno (2003), Roppa (2005) and Nappo (2007).

The literature suggests that gasoline demand is not sensitive to variations in income or fuel price (Marjotta-Maistro, 2002; Iootty and Roppa, 2006; Nappo, 2007). For ethanol, the price elasticity is positive for supply, while the price elasticity for demand shows divergent results in the studies of Oliveira et al (2008) and Silvério (2007). Moreover, both studies indicate that the demand for Type C gasoline became more elastic beginning in 2003, when flex-fuel vehicles were introduced into the Brazilian market. This shows that hydrous ethanol has become a less-imperfect substitute for Type C gasoline. The evidence also shows that the price of gasoline is not influenced by the price of ethanol, while the inverse is true.

Pursuing another line of investigation, Lucilio (202) looked at price transmission between the main products in the sugar and ethanol sector between 1998 and 2002. The results show that the price of anhydrous ethanol does not explain the price of industrial and exported crystal sugar. The article by Lamounier et al (2006) studies the trade-off between sugar and ethanol production in the mills, indicating that sugar and ethanol prices affected the production ratio only in some states and certain harvests. In addition, Alves and Bacchi (2004) estimate the export supply of Brazilian sugar. The authors' results indicate that increases in export prices and exchange rate depreciation significantly increase Brazilian exports.

Table 6

Lower concentration in the Center-South region

HHI, equivalent number and CR5 for individual distilleries the Center-South, 2008/2009 harvest

Product	HHI	n	CR5 (%)
Sugarcane	53	187	6,7
Sugar	75	133	7,1
Anhydrous ethanol	105	95	8,9
Hydrous ethanol	54	185	5,5
Total ethanol	52	192	6,7

Source: UNICA. Prepared by the authors.

In summary, these studies do not provide evidence of demand sensitivity for gasoline faced with changes in the ethanol price; neither do more complete analyses of the relationship between ethanol demand and fuel prices. It must be noted that these studies do not include recent periods when hydrous ethanol has been gaining strength as a direct competitor for gasoline. One of the main questions debated in the above-mentioned studies is the inclusion of information about sugar and petroleum markets and other macroeconomic information in the supply model for ethanol. According to the literature, these variables are relevant in the decisions taken by mills.

The following items analyze the demand for hydrous ethanol and Type C gasoline. They take as a starting point the hypothesis that hydrous ethanol can be characterized as a normal good: one with negative price elasticity (demand sensibility to prices) and that responds significantly to variations in Type C gasoline prices, given that this is its main competitor.

4.1 Domestic demand of hydrous ethanol

The analysis of the relations of demand for hydrous ethanol makes possible the calculation of the price elasticity of demand and the identification of the effects of the principal factors that influenced domestic demand, such as: the prices of substitutes, income, length of loans for financing vehicles, and real interest rates, among others. The database that was used for this analysis is in the form of a time series, from July 2001 to August 2009. The data was organized based on information from ANP, UNICA, IBGE, BCB and Bloomberg as described in **Annex 1**.

The method used for the estimates of demand equations is based on cointegration analysis. The aim of this modeling is to verify the existence of short-term and long-term relationships between liquid fuel prices in Brazil and sales of the product.

The demand equation for ethanol to be tested for the data for Brazil and São Paulo can be written as follows:

$$\Delta Q_t^D = \alpha_0 (Q_{t-1}^D + \beta_1 p_{t-1} + \beta_2 pg_{t-1}) + \sum_{i-1}^{L} \alpha_1(i) \Delta Q_{t-i}^D + \sum_{i=1}^{L} \alpha_2(i) \Delta p_{t-1} + \sum_{i=1}^{L} \alpha_3(i) \Delta pg_{t-1} + \lambda . D_t + \varepsilon_t$$

where:

- Q_t^D is the volume of hydrous ethanol demanded per vehicle (total fleet) in period t, Brazil and the state of São Paulo;
- p_t is the price of hydrous ethanol during period t;
- pg_t is the price of Type C gasoline during period t;
- D_t is a vector of variables that influence the demand for hydrous ethanol during the period t (average real income of workers and unemployment rate, among others) and temporal dummy variables (annual and monthly);
- ε_t is the erro term of the equation;

α_0 is the short term adjustment coefficient;

β_1 , β_2 are the parameters of the cointegration vector, which indicate the long-term relationship between variables;

$\alpha'_1 , \alpha'_2 , \lambda'$ are parameter vectors to be estimated.

According to Enders (1985), the definition of cointegration is related to three important points: the same order of integration of all cointegrated variables; stationary linear combination of non-stationary variables; and the number of existing cointegration vectors is equal to the quantity of variables of the model minus one.

The results of the unit root tests for the relevant variables of the model indicate that the variables of interest are non-stationary in the first order[xxi]. The next stage consisted of cointegration testing among variables, using the Johansen Procedure (1988), with the final results for the estimated coefficients by the VEC summarized below[xxii]:

Results for the whole sample (Brazil):

$$\Delta Q_t^D = -0,78(Q_{t-1}^D + 0,70 + 1,23 p_{t-1} - 1,45 pg_{t-1}) + \hat{\lambda}.D_t + \hat{\varepsilon}_t$$
$$[-6,0] \qquad [0,4] \quad [8,24] \qquad [-4,38]$$

Results for the state of São Paulo:

$$\Delta Q_t^D = -0,75(Q_{t-1}^D + 1,92 + 1,33 p_{t-1} - 1,54 pg_{t-1}) + \hat{\lambda}.D_t + \hat{\varepsilon}_t$$
$$[-5,7] \qquad [1,1] \quad [7,48] \qquad [-3,94]$$

The results obtained demonstrate the high relative sensitivity of ethanol demand to the prices of ethanol and gasoline. In other words, the long-term elasticities found by the cointegration method are superior, in module, to the unit, and have the correct signs (negative for ethanol and positive for gasoline)[xxiii]. Note that elasticities for São Paulo were significantly higher than those for Brazil, which indicates that consumers in São Paulo are more sensitive to price than the average Brazilian consumers of fuel. This sensitivity reflects the composition of the fleet, which contains an increasing percentage of flex-fuel vehicles.

Adjustment coefficients are expected to exhibit signs opposite to the signs of the components of the cointegration vector to conclude that an adjustment to equilibrium happens in the short term. The adjustment coefficient was significant and negative for both equations. Taking as an example the model for Brazil, and starting from a point where the variables are in a long-term relation, then an increase in gasoline price turns the error term negative. Given the negative adjustment coefficient, the change of this variable is positive, so that there is an increase in the demand for ethanol in the following month, ***t***, towards the restoration of the long-term relation. The speed with which this adjustment occurs is -0.78 in the model for Brazil and -0.75 for São Paulo. Therefore, if there is an unexpected increase (positive shock) of 1% in the demand for ethanol in ***t-1***, then there will be a reduction in demand of 0.75% (0.78%). In other words, approximately 75% (78%) of the shock is transmitted to the following period[xxiv].

In summary, it is believed that the results obtained in this study appear to be more price-sensitive, when compared to the reviewed literature, due to period of analysis, which includes the years where ethanol gained importance by virtue of the success of flex-fuel vehicles in the market.

4.2 Domestic demand for Type C gasoline

The analysis of the relations of gasoline demand makes it possible to calculate the price elasticity of demand. The estimates of these measurements of consumer sensitivity to acquire gasoline are important to compare with the measurements found for hydrous ethanol. The assumption to be verified in this empirical analysis is that "the demand for ethanol is more sensitive to gasoline prices than the demand for gasoline is sensitive to ethanol prices." The database used for this analysis is also in a time series format, from July 2001 to August 2009, with the sources of data the same as those used in the previous subsection.

The method used to estimate the equations for gasoline demand was also based on cointegration analysis. The gasoline demand equation to be tested for Brazil data can be written as follows:

$$\Delta q_t^D = \alpha'_0 (q_{t-1}^D + \beta'_1 p_{t-1} + \beta'_2 pg_{t-1}) + \sum_{i-1}^{L} \alpha'_1(i)\Delta q_{t-i}^D + \sum_{i=1}^{L} \alpha'_2(i)\Delta p_{t-1} + \sum_{i=1}^{L} \alpha'_3(i)\Delta pg_{t-1} + \lambda'.D_t + \varepsilon'_t$$

where:

- q_t^D is the volume of Type C gasoline demanded per vehicle (total fleet) in period t, in Brazil;
- p_t is the price of hydrous ethanol during period t;
- pg_t is the price of Type C gasoline during period t;
- D_t is a vector of variables that influence the demand for hydrous ethanol in the period t (average real income of workers and unemployment rate, among others) and temporal dummy variables (annual and monthly);
- ε'_t is the error term of the equation;
- α'_0 is the short-term coefficient adjustment;
- β'_1, β'_2 are the parameters of the cointegration vector, which indicate a long-term relation between the variables;
- $\alpha'_1, \alpha'_2, \lambda'$ are parameter vectors to be estimated.

The results for the coefficients estimated by VEC are summarized below, with the t statistics reported in brackets:

$$\Delta q_t^D = -1{,}57(q_{t-1}^D + 1{,}55 - 0{,}28 p_{t-1} + 0{,}63 pg_{t-1}) + \sum_{i-1}^{6} \hat{\alpha}'_1(i)\Delta q_{t-i}^D + \sum_{i=1}^{6} \hat{\alpha}'_2(i)\Delta p_{t-1} + \sum_{i=1}^{6} \hat{\alpha}'_3(i)\Delta pg_{t-1} + \hat{\lambda}'.D_t + \hat{\varepsilon}'_t$$

$$[-5{,}55] \quad [*] \quad [-3{,}6] \quad [3{,}88]$$

* *Significant/Not reported.*

The results indicate that the relative demand for Type C gasoline exhibits sensitivity to ethanol prices and to the price of gasoline itself. However, unlike the findings for ethanol demand, the price of ethanol has only a small influence in the long-term demand for Type C gasoline. Note that the signs found were in accordance with the theory (positive for ethanol and negative for gasoline)[xxv].

The estimated adjustment coefficient exhibits the opposite sign to that of the main component of the cointegration vector. It can therefore be concluded that there is a short-term adjustment to reach equilibrium. The adjustment coefficient was significant, negative and greater than one in module, indicating rapid adjustment to long-term equilibrium. Therefore, for an increase in the price of Type C gasoline, which would make the error term positive, the change of this variable will be negative (given the negative adjustment coefficient), so that there is a strong reduction in the demand for Type C gasoline in the following month, t, towards restoration of equilibrium.

4.3 Considerations on the market reactions for ethanol and Type C gasoline

Estimates suggest that consumers are sensitive to price, both in Brazil as a whole and in São Paulo, and that ethanol demand responds more to price variation than does the demand for Type C gasoline.

This analysis for hydrous ethanol and Type C gasoline is complemented below with considerations on anhydrous ethanol.

▶ 5 Considerations on anhydrous ethanol

The focus of this section is the role of anhydrous ethanol in determining the price of Type C gasoline. Moreover, in order to improve the effectiveness of public policies in the sector – in particular the change in the mandatory blend of anhydrous ethanol in Type A gasoline – item 5.2 examines by how much ethanol production would need to fall to endanger the supply of anhydrous ethanol.

Consumer sensitivity to price variations

Ethanol Market		
Price-elasticity of ethanol	-1.23 (BR) -1/33 (SP)	An increase of 1% in the price of ethanol negatively affects Brazilian demand for ethanol by 1.23%
Price-elasticity of Type C gasoline	-1.45 (BR) -1.54 (SP)	An increase of 1% in the price of gasoline positively affects Brazilian demand for ethanol by 1.45%
Type C gasoline market		
Price-elasticity of ethanol	0.28 (BR)	An increase of 1% in the price of ethanol positively affects the demand for gasoline by 0.28%
Price-elasticity of Type C gasoline	-0.63 (BR)	An increase of 1% in the price of gasoline negatively affects the demand for gasoline by 0.63%

5.1 The role of anhydrous ethanol in establishing the gasoline price

In the fuels sector, 2002 marked the beginning of freely established prices for consumers (Marjotta-Maistro, 2002). Given the structure of fuel price formation, the aim of this section is to analyze how the institutional environment and the changes in the price of one fuel can affect the price of others. In particular, the model seeks to assess the impact on Type C gasoline price variation of the anhydrous ethanol price and ordinances of the Ministry of Agriculture relating to fuel blend. The model thus consists of estimating the "consumer price of Type C gasoline" variable in the first difference. To explain price variations, the control variables are mainly those that shift the supply and demand curves of the product as well as other variables exogenous to prices that do not have a direct impact on supply and demand. Technically, the use of variables in first difference allows for correction of the problem of non-stationarity of these variables, which could lead the model to spurious correlations.

The estimated equation can be described as follows:

$$\Delta \ln \mathrm{PgasolinaC}_t = \alpha_0 + X\beta + \mathrm{DummiesPortariasMAPA}_t\theta + \ln \mathrm{Petanolanidro}_t\pi + \varepsilon_t$$

for $t=1,\ldots,T$

- α_0 Parameter that measures model intercept;
- X Matriz of k control variables (T x k);
- β Vector of parameters (k x 1) to be estimated;
- π Parameter that measures the effect of the anhydrous ethanol price on the variation in gasoline price;
- θ Vector of parameters (p x 1) to be estimated, on the p ordinances relating to fuel blend during period t.

Data covers the period from January 2003 to July 2009, and the model was estimated using Least Ordinary Squares with correction of the variance-covariance matrix using White's method (White, 1980)[xxvi]. Stationarity tests of the variables used in the model do not indicate a non-stationary standard[xxvii]. The results of the estimates can be seen in **Annex 2**[xxviii].

The results of the model indicate that the fuel blend of anhydrous ethanol in gasoline reduced, on average, the volatility of Type C gasoline consumer prices (estimated coefficient for the dummies) in 2% to 3%, which is a statistically significant impact[xxix].

The influence of the anhydrous ethanol price on the volatility of Type C gasoline price was captured by the variable of the logarithm of these prices for producers, with the dummies that measure the determination of each blend percentage during the period in question. The estimated coefficients were statistically significant only for the duration of Ministry of Agriculture decrees numbers 17, 51 and 278. During the period in which the blends determined by those decrees were in force, increases in anhydrous ethanol prices for producers had a positive average effect on the variation of Type C gasoline prices for consumers. This relationship reflects the countercyclical behavior of the blend policies, which act in an environment of rising anhydrous ethanol prices. The periods following the blend reductions are also periods when the price of ethanol is more volatile.

5.2 Risk simulation for anhydrous ethanol supply

This section develops simulations for the risk of harvest failure threatening the supply of anhydrous and hydrous ethanol in the Brazilian market. In other words, by how much would the harvest need to fall to create a credible risk of shortage of anhydrous ethanol in the market? This analysis is relevant to inform the discussion about supply risks in relation to policies for the blend of anhydrous ethanol with Type A gasoline. Fuel blend policy should be used as an instrument to regulate quantity rather than price, so giving the market greater predictability for consumer supply and for fuel producers to take decisions.

The following steps illustrate the stages involved in performing a simulation of supply risk.

I Calculation of current domestic production of anhydrous and hydrous ethanol, net of exports;
II Calculation of current domestic consumption of hydrous ethanol and Type C gasoline, with consumption of anhydrous ethanol assumed to be 25% of Type C gasoline consumption;
III Estimate of the Brazilian vehicle fleet by type of fuel;
IV Construction of fuel-use scenarios that could lead to an ethanol shortage in the market;
V Estimate of harvest decrease for each scenario based on information from items **I**, **II** and **III**.

Data is for the period 2004 – 2008[xxx].

Four scenarios[xxxi] were evaluated, namely:

Base-information referring to 2004 – 2008:
Scenario 1: 100% use of Type C gasoline by light flex-fuel vehicles;
Scenario 2: 50% use of hydrous ethanol by light flex-fuel vehicles;
Scenario 3: 70% use of hydrous ethanol by light flex-fuel vehicles;
Scenario 4: 90% use of hydrous ethanol by light flex-fuel vehicles.

Scenario 1: Assuming the use of Type C gasoline by all gasoline and flex-fuel vehicles in the fleet, and looking at ethanol production net of exports, we can say that the percentage production reduction required to create a shortage of ethanol in the market would be[xxxii]:

2004	2005	2006	2007	2008
4.5%	18.49%	21.82%	36.39%	42.13%

These results indicate that in 2008, with everything else remaining constant in the market, there would have had to be a 42.13% harvest failure to create a crisis in ethanol supply.

Scenarios 2 to 4: These scenarios assume that hydrous ethanol is consumed by, respectively, 50%, 70% and 90% of all the flex-fuel vehicle fleet, with Type C gasoline consumption restricted to 50%, 30% and 10% of gasoline-powered vehicles.

In this context, considering ethanol production net of exports in each of these years, the percentage harvest failures required to create a shortage of ethanol in the market are shown in **Table 7**.

The risk of ethanol shortage increases significantly in 2008 as individuals with flex-fuel vehicles switch in mass to consuming ethanol. The worrying level of harvest failure is reduced from 24% to 9.4% as consumption grows from 50% to 90% of vehicles in 2008, with all else remaining constant in the market.

We should stress that changes to the blend are justified only by harvest failures large enough to put at risk the supply of anhydrous ethanol to make Type C gasoline. This policy should not be used to address seasonal variations, because unjustified changes increase risk to the business and to the sustainability of ethanol production.

To better identify critical moments for shortage of anhydrous fuel ethanol it would, for example, to possible to encourage the federal government's Energy Research Company (EPE) to construct models for the ethanol sector to identify the relationship between supply and demand for the fuel, similar to what is done for the electricity market. In that way, decisions about changes to the mandatory blend tend to become less politicized, more technical and more transparent.

Using information about production and consumption for 2004 – 2008, we simulated ranges for the size of production decrease in the period that would justify changing the mandatory blend, indicating that the risk of ethanol shortage increases as the percentage of flex-fuel vehicles consuming hydrous ethanol increases. In the most extreme scenario for 2008, in which 90% of all flex-fuel vehicles in Brazil are fueled with hydrous ethanol, there would be an ethanol shortage if ethanol production in this year were 10% lower than was effectively observed (or 4.9% greater than ethanol production in the previous year).

Table 7 **Harvest failure for risk of ethanol shortage**

	Scenario 2 (50% ethanol)	Scenario 3 (70% ethanol)	Scenario 4 (90% ethanol)
2004	10.0%	9.3%	8.7%
2005	14.3%	12.1%	10.0%
2006	11.4%	7.3%	3.1%
2007	22.3%	16.6%	11.0%
2008	24.0%	16.7%	9.4%

▶ 6 Final considerations: outlines for public policy

The institutional environment comprises a group of formal and informal rules. It shapes business conduct and is largely responsible for performance of the markets. The institutional environment provides a set of incentives and controls that in one way or another guide the expectations of the various actors directly involved, including sugarcane, sugar and ethanol producers, automakers and consumers, influencing the operational strategy of each of these players.

The orientation and shape of public policies are, therefore, essential tools for directing production. In the case of ethanol, this becomes even more relevant given the strategic importance of the fuel's availability to ensure the supply of the domestic market. This can be clearly illustrated by the crisis that European countries went through recently when Russia cut gas supplies, or by the breach of international agreements, or the renegotiation of prices, as occurred in Latin America with the political changes in Bolívia and Venezuela. No less important have been the effects of oil price volatility on modern economies.

The results of this study allow us to identify which problems in the ethanol supply chain should be a target for public policy, given the goal of increasing ethanol participation in the Brazilian energy matrix. Based on the main results of these tests and empirical evidence, their relationships and implications, we can highlight priority actions to improve the functioning of the market, so benefiting both producers and consumers. These priority actions are: (a) establishing technical criteria to monitor the market in order to identify harvest failures that would prompt changes in the mandatory blend of anhydrous ethanol in Type A gasoline, based on technical and transparent criteria; (b) the participation of a greater number of players, so increasing market liquidity; and (c) the greater use of warrantage contracts (inventory credit system).

These specific actions do not necessarily depend on legal changes. We have focused on creating conditions for ethanol production to expand via market mechanisms, which are capable of providing adequate remuneration for growth of businesses while encouraging efficiency gains that, in a competitive environment, are shared with consumers through lower prices. In the absence of market failures, as identified in this study, improving market functioning with the minimum of intervention is the most efficient way to give proper incentives for the sustainable expansion of production.

Anexo 1 **Names of variables in the model, with description and source**

Variable	Description	Source
lnveh	Logarithm of hydrous ethanol sales by distributors, in liters	ANP
lnpeh	Logarithm of the average consumer price of hydrous ethanol, reais per liter	ANP
lnpdi	Logarithm of the average consumer price of diesel, reais per liter	ANP
lnpgc	Logarithm of the average consumer price of Type C gasoline, reais per liter	ANP
lnpgnv	Logarithm of the average consumer price of vehicular natural gas, reais per liter	ANP
ptax	Exchange rate at the end of the period, reais/dollar	Sisbacen PTAX8
lnp_acucarBRL	Logarithm of the international price of sugar (future contract NYBOT) in reais	Broadcast
lnpib	Logarithm of state GDP	IBGE
prazo_medio_ veiculos	Average financing period for vehicle acquisitions by individuals with pre-fixed interest rate, in days	Sisbacen PESP3
ln_vflex	Registration of flex-fuel cars, per state	FENABRAVE
ln_vgasolina	Registration of gasoline cars, per state	FENABRAVE
juros_real	Real interest rate – Selic rate, deflated by the IPCA inflation index	BCB e IBGE
inadimplencia_pf	Percentage default rate, individuals	BCB
inadimplencia_total	Complete default, in percentage	BCB
Ufs	Dummies for states (and the federal district)	
Anos	Dummies for years	

Annex 2 **Results of the estimates: price model for Type C gasoline**

Least Ordinary Squares with robust matrix for variance

Model Information
Observations: 77 — R2 = 0,770
F(26,50) = 28,23 — R2 Ajust = 0,651
P–value F: 0.00
Dependent variable: dif_ln_pgas_c

Controls	Coefficient
lnpreco_alcool_hidr	–0.03331
dif_in_pdiesel	0.43095 **
dif_in_ppetroleo	–0.01120
ln_prod_veic_flex_alcool	0.01346 **
taxa_desemprego_30d	0.00496 *
lei 554_25p	–0.02745 **
lei 51_20p	–0.03135 **
lei 278_23p	–0.02939 **
lei 43_25p	–0.02977 **
lnpanidro_lei 17_20p	0.15632 **
lnpanidro_lei 554_25p	0.02342
lnpanidro_lei 51_20p	0.12576 **
lnpanidro_lei 278_23p	0.03721 *
lnpanidro_lei 43_25p	0.02279
ln_cambio	0.03036 **
m1	–0.00420
m2	–0.00806
m3	–0.01208 *
m4	–0.01487 **
m5	–0.01612 **
m6	–0.01111 *
m7	–0.01395 **
m8	–0.00836
m9	–0.00139
m10	–0.00427
m11	–0.01097 **
Constant	–0.28408 **

* Indicates statistical significance at 10% • ** Indicates statistical significance at 15%

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Explanatory Notes

[i] A tonne equivalent of petroleum (TPE) is a unit of energy defined as the heat released by combustion of one tonne of crude oil.
[ii] Figures provided by Anfavea (National Association of Automobile Manufacturers).
[iii] For the production of anhydrous ethanol it is necessary to use cyclohexane as a dehydrating agent. Site: http://www.etanol.ufscar.br/palestras-do-dia-02-de-setembro/o-processo-produtivo-do-etanol. Accessed in August 2009.
[iv] Available at: http://www.agricultura.gov.br/pls/portal/docs/PAGE/MAPA/SERVICOS/USINAS_DESTILARIAS/USINAS_CADASTRADAS/UPS_04-08-2009_0_1.PDF. Accessed on 06/08/2009.
[v] Anhydrous ethanol was first added to gasoline in Brazil in the 1930s. The restriction on the period of the graph is due to the lack of a longer price series. It is important to note that the first change in the blend of anhydrous ethanol with gasoline shown in the chart corresponds to the Ministry of Agriculture decree No. 17 which set the percentage at 20%, following a period in which the percentage was 25%, according to Ministry of Agriculture decree No. 266, 21/06/2002.
[vi] Economic Report, Union of the Ethanol Production Industry of Minas Gerais, Belo Horizonte, v. 6, 2009.
[vii] Direct sales to rural consumers, small business consumers, motorists and truckers.
[viii] Data for the 08/09 harvest were not finalized in the North-East when we obtained the information, and refer to the position of production 16 May 2009.
[ix] These rates refer to the period for which we had access to data, from January 2003 to August 2009.
[x] Economic Report, Union of the Ethanol Production Industry of Minas Gerais, Belo Horizonte, v. 11, March 2009.
[xi] One possible explanation for the presence of negative margins is the fact that the industry suffers significant tax evasion, which squeezes the margins of law-abiding agents.
[xii] The category "Other" includes 106 brands.
[xiii] HHI = Σ si^2, which itself is the participation of firm i in the relevant market. The index ranges between 0 and 10,000. The CRK = Σ s_5/S, where s_5 is the production of the five largest and S the production value of any relevant market. The equivalent number N = 1/HHI.
[xiv] Aviation gasoline for piston engines; aviation kerosene for turbo-jets.
[xv] Concentration Act No. 08012.002816/2007-25.
[xvi] Concentration Act No. 08012.002820/2007-93.
[xvii] The purchase of Texaco's fuel distribution operations by Ipiranga was submitted to CADE under AC No. 08012.009025/2008-15, and at the time of writing was in the phase of instruction.
[xviii] 2008/2009 harvest, UNICA.
[xix] KPMG, in: Economic Report, Union of the Ethanol Production Industry in Minas Gerais, Belo Horizonte, v. 11, March 2009.
[xx] Many of the scholarly articles of demand and supply estimation make use of cointegration methods to estimate the price and income elasticities of supply and demand, given the non-stationary characteristics of the time series used for the estimates.
[xxi] We used the following unit root tests: Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkoviski, Phillips, Schmidt and SAIWA (KPSS). All these tests assume the hypothesis of a unit root at the expense of stationarity of the series, taking into account the presence of deterministic terms in the model specification.
[xxii] The t-statistics are reported in brackets.
[xxiii] To obtain the equation for the long-term relationship between ethanol demand and prices, simply equate the equation in brackets to zero, thereby generating elasticities in the correct direction for both products. Example: $Q^D_{t-1} = -0{,}70 - 1{,}23 p_{t-1} + 1{,}45 pg_{t-1}$
[xxiv] The analysis of the waste, making sure that they have approximately normal distribution, is made by conducting the Jarque-Bera test, whose null hypothesis is tested on the normal distribution (symmetry close to zero and kurtosis close to three). The test indicates non-rejection at 5% of the normality of residuals of the equations.
[xxv] To obtain the equation for long-term relationship between ethanol demand and prices, simply match the equation in brackets to zero, thereby generating elasticities in the correct direction for both products. Example: $q^D_{t-1} = -1{,}55 + 0{,}28 p_{t-1} - 0{,}63 pg_{t-1}$
[xxvi] White (1980).
[xxvii] Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test.
[xxviii] Besides the independent variables reported in the Annex, we tested the inclusion of other variables in the model, such as: dummies for year, average real income, amount of Type A gasoline refined, quantity of petroleum imported, among others. None of the above-mentioned variables showed satisfactory joint significance (for significance levels of 5% and 10%), and were thus removed from the estimated equation.
[xxix] This result appears to converge with the current aim of policy for fuel blend, which would be to contain the volatility of prices of both gasoline and anhydrous ethanol. See article in the Folha de S.Paulo newspaper 09 November 2009 http://www1.folha.uol.com.br/folha/dinheiro/ult91u649684.shtml.
[xxx] 2008 was the latest year with complete information available in this study.
[xxxi] It was assumed that one liter of hydrous ethanol is equivalent to one liter of anhydrous ethanol and the fuel blend is constant in the order of 25%.
[xxxii] The production drop is considered in relation to that produced in the period, and not the previous period.