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FORECAST OF PRODUCTION OF FLEX FUEL CARS AND ETHANOL DEMAND IN BRAZIL IN 2014

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ABSTRACT

Brazil is currently an important world example of the successful incorporation of biofuel (ethanol) into its energy matrix. This article aims to estimate ethanol demand and the evolution of the total share of vehicles that are expected to use this technology in the Brazilian fleet by 2014. To do this, the authors used the Gompertz and the Fisher-Pry methods, both having been verified using the STATA statistical system. Data from January 2005 to October 2009 were extrapolated up to December 2014. The Fisher-Pry model was used to build the scenario of analysis of the replacement of conventional gasoline vehicle technology by flex fuel or bi-fuel technology. This estimate indicated an 18.2 percent growth over five years, from the 78.4% posted in October 2009 to 96.6% in December 2014. The main assumption was that the price ratio between ethanol and gasoline from January 2002 to October 2009 would be maintained. During the 2002/2009 period, ethanol was marketed at a price lower than the minimum required to make it competitive with gasoline for 88 of out of 95 months. The Gompertz model indicated that ethanol should account for roughly 43.9% of all the fuel marketed by the distributors by the end of 2014, whereas this share, at present, stands at 18.2% only.

Key words: Forecast. Biofuels. Ethanol. Gomperz. Fisher-Pry

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PREVISÃO DE FABRICAÇÃO DE CARROS BICOMBUSTÍVEIS E DE DEMANDA DE ETANOL NO BRASIL EM 2014

RESUMO

O Brasil se configura como um importante exemplo mundial no que se refere à incorporação bem sucedida do biocombustível etanol em sua matriz energética. Neste artigo, objetiva-se estimar a demanda por etanol e a evolução da participação total dos veículos com esta tecnologia na frota brasileira até 2014. Para tanto empregou-se o método de *Gompertz* e o método *Fisher-Pry,* ambos verificados através do sistema estatístico STATA. Extrapolou-se dados de janeiro de 2005 a outubro de 2009 até dezembro de 2014. O modelo *Fisher-Pry* foi utilizado para elaborar o cenário de análise da substituição da tecnologia convencional movida exclusivamente à gasolina por carros com tecnologia *flex fuel* ou bicombustível. Esta projeção apontou para um aumento de 18,2 pontos percentuais em cinco anos, passando dos 78,4% registrados em outubro de 2009 para 96,6% em dezembro de 2014. Como premissa, foi considerada a continuidade nos preços do etanol e da gasolina apresentados entre jan/02 e out/2009, que mostra o etanol sendo comercializado a um preço inferior ao mínimo necessário para tornar este combustível renovável competitivo com a gasolina em 88 dos 95 meses. O modelo de *Gompertz* indicou que o etanol passará a representar aproximadamente 43,9% de todo o combustível comercializado pelas distribuidoras no final de 2014, ao passo que atualmente esta participação é de apenas 18,2%.

Palavras-chave: Previsão. Bicombustíveis. Etanol. *Gomperz. Fisher-Pry*

1 INTRODUCTION

For at least the last 30 years, industrial society has been warned about problems associated with using fossil fuels and the consequent greenhouse gas emissions, as well as their effects on the earth's climate. Among the many academic debates, it has become clear that there is a need for an improvement in industrial processes in order to avoid waste, increase the rational use of resources, increase the recycling of materials and make society aware of the possible effects of uncontrolled consumption. In the same context, the world has also gone through various oil crises, the two most serious of which occurred in the 1970s, when the price of oil exceeded the mark of US$ 100 per barrel.

Given this set of factors, it is becoming evident that there is a growing need to expand the use of alternative renewable energy sources sustainably in order to provide greater security for energy supply and reduce the environmental impact associated with the use of fossil fuels. Given these circumstances, according to BNDES and CGEE (2008), ethanol from sugarcane became regarded in Brazil as a renewable and economically viable alternative. It is also a safe source thanks to the significant potential for expanding its production.

Ethanol, mainly as vehicle fuel, started being produced and used on a regular basis in Brazil in 1931, but only in recent decades did its consumption evolve until it reached maturity and consistency, with a production model that can be adapted and developed in similar contexts. This evolution in the use of ethanol as vehicle fuel, along with the co-generation of electricity, transformed sugarcane into the second most important primary source of energy and the main form of renewable energy in the Brazilian energy matrix (BNDES & CGEE, 2008).

During this same period, the automotive industry made a great effort to meet the new needs of society and invested heavily in research to develop lighter automobiles that consume less and, principally, pollute less. In international motor shows, expectation usually focuses on models with engines that can be adapted for use with alterative renewable energy, such as biofuels and electric cars. In this context, Abramovay (2009) states that the automobile industry now has 10 car manufacturers producing more than 60 models with flex-fuel technology. According to the author, the good news is that there are now ethanol powered motorcycles, buses and even aircraft (hydrous alcohol).

Brazil is currently an important global example of the successful incorporation of the biofuel ethanol into its energy matrix. According to Abramovay (2009), ethanol was first used in 1920, but only in 1970, as a result of the severe international oil crisis and Brazil being heavily dependent on oil imports, was the country obliged to press ahead with a plan capable of making ethanol viable as an energy source in order to balance, above all, its trade balance. To this end, in 1970, the Pró–Álcool [*Pro-Alcohol*] program was instituted, which became responsible for the growth of the project throughout the country.

Ethanol was very successful during its implementation phase in the 1980s, when the state, with its subsidies and financing, was very heavily involved. According to Fernandes and Coelho (1995), in 1985 ethanol had a 96% share of the fuel used in Otto cycle engines. However, the stabilization of oil levels and also, according to the authors, the lack of assured ethanol availability, a gradual increase in the price of ethanol relative to gasoline and a gradual decrease in the Excise Tax (IPI) incentive for ethanol-powered automobiles contributed to a severe crisis in the alcohol sector.

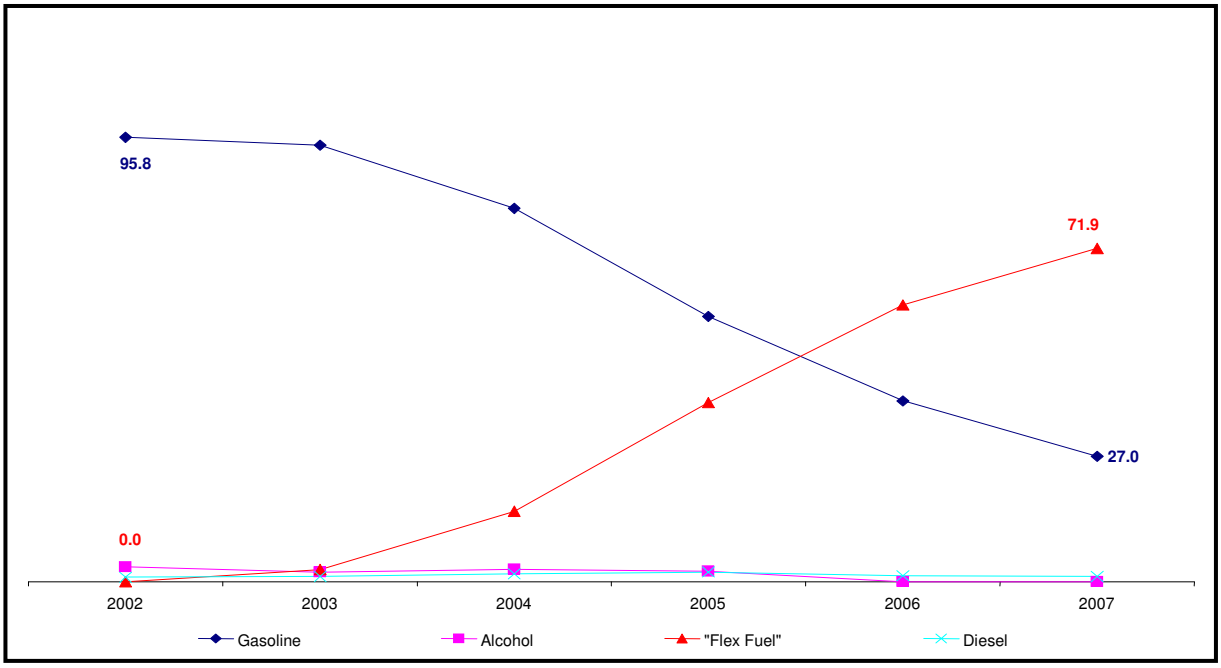
Shikida (1998) provides a summary of the alcohol periods that allows for a greater understanding of the historical facts.

- ✓ From 1975 to 1979 – period of moderate expansion.
- ✓ From 1980 to 1985 – period of rapid expansion.
- ✓ From 1986 to 1995 – slowdown and crisis.

The crisis, however, favored the development of a technology of "non-dependence" on a single energy system. Therefore, the automotive industry was once more encouraged to develop engines capable of running on more than one fuel. In March 2003 the first version of the flex fuel, or bi-fuel (ethanol or gasoline-powered) automobile was introduced by Volkswagen as the Gol Total Flex model and took to the streets of Brazil. Kamimura and Sauer (2008) add that the introduction of flex fuel engines in the Brazilian market for passenger cars was a successful way of not only saving but also recovering the ethanol producers' market, with its "seductive environmental appeal for reducing climate change."

According to ANFAVEA (2008), during the flex fuel car launch period, Brazilian production of these vehicles accounted for just 2.6% of total passenger vehicle production. By 2007, however, this share jumped to 71.9%, meaning that in 2008 Brazil reached the milestone of 5.5 million cars with flex fuel engines in circulation, or some 30% of its fleet.

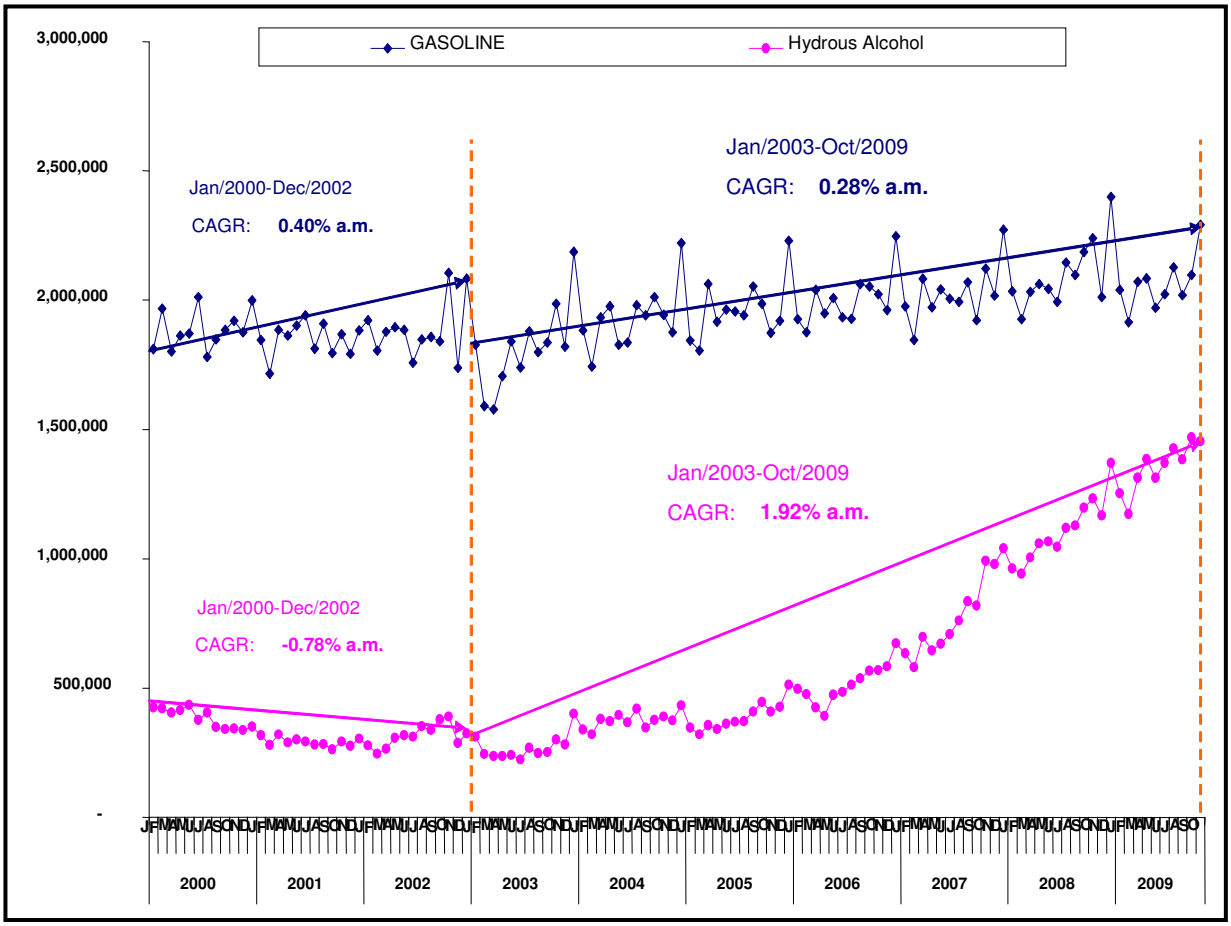
In October 2009, the share of production of flex fuel vehicles reached 78.4%, indicating that the technology was here to stay. Graph 1 clearly shows the drop in the production of automobiles driven only by gasoline, as a direct and growing consequence of the number of hybrid cars produced in the same period.



Graph 1: Percentage Distribution of the Production of Passenger Cars by type of fuel

Source: Anfavea, 2008. Graph devised by the authors

Comparing the production of passenger cars and analyzing the consumption of gasoline versus ethanol, one sees that there has been a significant increase in the volume of the latter product. It is clear that year after year ethanol has gradually expanded its share in the Otto cycle. Graph 2 shows the evolution of fuel consumption from 2000 to 2009. In 2008, ethanol hit a record high of more than 1.5 billion cubic meters when flex-fuel automobiles reached 30% of the total fleet of passenger cars in Brazil.



Graph 2: Evolution of fuel consumption in m^3 in Brazil

Source: ANP, 2009a. Graph devised by the authors

Given what has been presented and the impact of flex fuel technology, this article's objective is to produce a forecast of the total share that flex fuel vehicles are likely to achieve of annual passenger car production by December 2014, as well as predicting the share that ethanol will account for in the sales of Brazilian fuel distributors.

2 BIBLIOGRAPHIC REVIEW

Technological forecasting and evaluation is a relatively new field as compared to many more traditional disciplines. Bouhid & Goodrich indicate that the 1960s were the time when technological forecasting became a technological strategic planning and decision-making tool. Authors differ on when future studies began. For Coates et al. (2001), systematically structured future studies

appeared in 1935 in a report prepared by the New Deal's National Resource Commission, which dealt with the 13 greatest inventions. However, it was only in 1999 that a greater interaction and exchange of ideas on prospecting and technological evaluation really began. In subsequent years, many support tools were developed to help academics, governments and especially industry.

Coates et al. (2001) believe that society is, at present, completely dependent on technology, which drives the economy, maintains and improves living standards and protects the planet against population and urban life pressures. It is, therefore, an extremely important tool in an innovative and extremely competitive globalized economy.

Ethanol is more than an alternative energy source for times of world energy crises. In a unique manner, it can also project Brazil internationally in the struggle against global warming, since sugarcane is proving to have better energy performance than other by-products used for making ethanol.

According to Abramovay (2009), ethanol derived from sugarcane yields 9.3 units of renewable energy for every unit of fossil fuel, while corn, sugar-beet and grain rarely exceed two units. Furthermore, one hectare of sugarcane yields about 7,000 liters of ethanol, while sugar-beet (commonly used in Europe) yields 5,500 liters and corn (widely used in the U.S.) only 3,800 liters; and sugarcane productivity may reach 13,000 liters per hectare.

Another factor to consider is that the rising international pressure to reduce CO_2 emissions will tend to intensify over the coming years. Projections of oil production remain a major challenge, but it is known for certain that production costs will continue increasing. Every year the major automotive vehicle manufacturers raise their investments in the development of engines capable of operating with other energy sources, such as hydrogen, electricity and even the capture of CO^2 from the atmosphere, which is a clear demonstration that the scenario in the very near future will be, at the very least, bi-fuel automobiles.

In this context, Porter stresses the importance of analyzing the effects of the technological change. According to him, there are two main reasons for

concern: first, introduction versus adoption, which will imply technological development itself, and then technological management - consumer acceptance, indirect reactions and potential regulatory factors.

The author attributes various applications for the evaluation and lists at least 10 steps for preparing a technological impact evaluation. They are: 1 - Defining the problem; 2 – Describing the technology; 3 – Describing the social context; 4 – A technological forecast; 5 – Forecasting the social context; 6- Identifying the impact; 7- Analyzing the impact; 8 – Assessing the impact; 9 – Analyzing policies; and 10 - Results. Since this research is exploratory by nature, not all the steps proposed by the author will be faithfully followed. Furthermore, the context of the analysis is limited to the technological scope of the evaluation.

At this point, it is necessary to understand the evolution of ethanol sales, associated with the introduction of the flex fuel engine technology. Graph 2 shows a downward curve in ethanol sales until 2003; only in 2004 does this curve start rising, probably because of the impact of the gradual increase in the sales of hybrid cars.

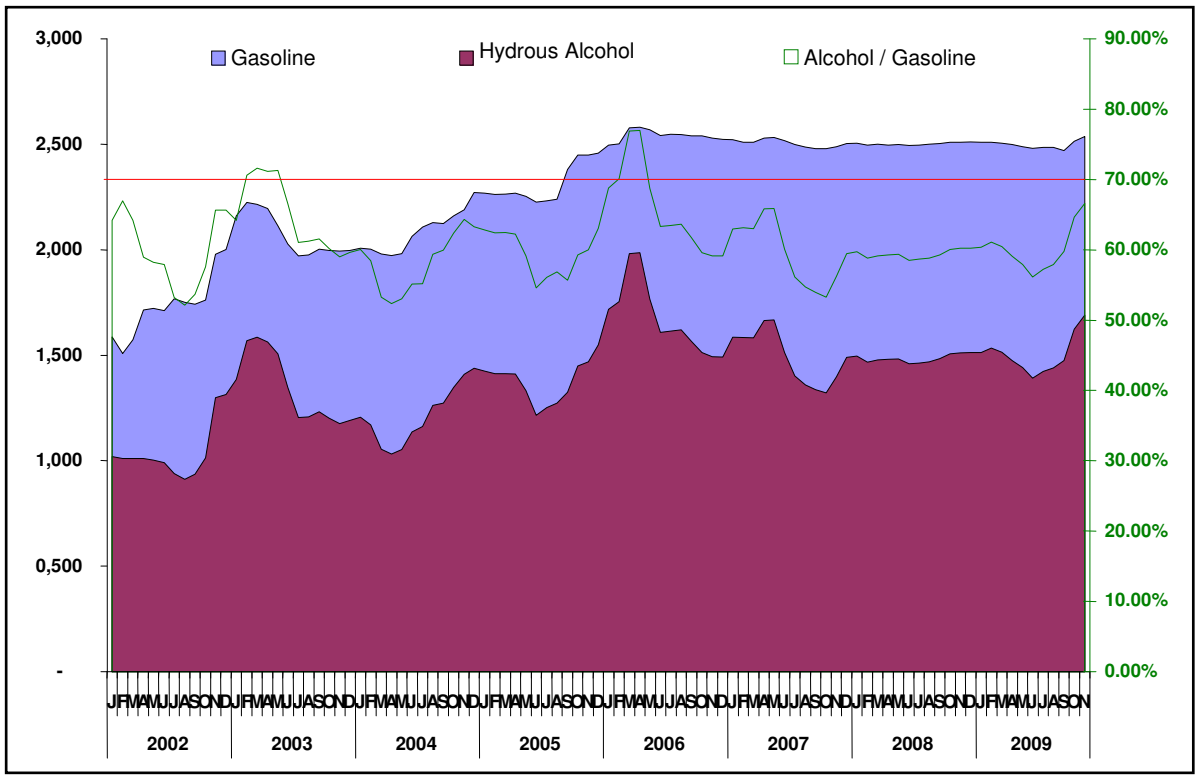
Another extremely important factor in this analysis is the relationship between gasoline and ethanol prices. Although flex fuel technology has provided an alternative to gasoline for consumers, it was not solely responsible for the growth of ethanol consumption as presented earlier. As the calorific power per liter of ethanol is lower than that of gasoline, the price of each fuel also has a direct influence on the choice of fuel by the end consumer.

Table 1: Properties of Gasoline and Ethanol

PROPERTIES	GASOLINE	ETHANOL	ETHANOL/GASOLINE
Chemical formula	C4 – C12	C_2H_5OH	
Lower calorific power (kJ/liter)	32,180	22,350	69.45%
Density (kg/liter)	0.72 – 0.78	0.792	

Source: BNDES (2008)

Given that the ratio between the calorific powers of ethanol and gasoline is about 70%, the use of ethanol as a fuel is only advantageous for the end user if its price is no more than 70% the price of gasoline.



Graph 3: Average price of Gasoline and Hydrous Alcohol in Brazil and the ratio between the average prices of Alcohol and Gasoline

Source: ANP, 2009b. Graph devised by the authors.

An analysis of Graph 3 shows that only in seven months since January 2002 has the price of alcohol been higher than 70% of the price of gasoline, which logically did not encourage ethanol consumption. Goldemberg et al. (2004) showed that the evolution in the hydrous alcohol production process, as well as economies of scale and technological evolution, allowed production costs to drop considerably, allowing ethanol to be sold at prices below the minimum required to make this renewable fuel competitive with fossil fuels in subsequent years.

The recovery of the ethanol market in Brazil, also seen in Graph 2, shows the evolution of fuel consumption in Brazil in cubic meters from 2000 to October 2009. After the introduction of flex fuel technology in the domestic market in 2003, ethanol consumption grew at a monthly rate of 1.92% between January 2003 and October 2009; in the period immediately prior to this, between January 2000 and December 2002, consumption had decreased at a monthly rate of 0.78%. This recovery also affected the national gasoline market, which is now increasing by 0.28% per month, instead of maintaining the growth rate of 0.40% per month of the same period prior to the entry of flex fuel technology.

This set of factors meant that in October 2009, when 78.4% of the cars produced in Brazil were flex fuel automobiles, the ethanol share of the total fuel sold in Brazil reached 18.2%, vs. 6.4% in January 2003 (ANP, 2009).

3 METHODOLOGY

This article has two parts. First, it was necessary to carry out a broad exploratory study to understand the historical context of ethanol as an energy source in the country. Articles, books, seminars and the records of conferences whose main theme was ethanol were analyzed. Then extensive temporal research was carried out to analyze the impact on energy demand of the Brazilian Otto cycle, having as its basic premise an analysis of before and after the introduction of flex fuel engine technology.

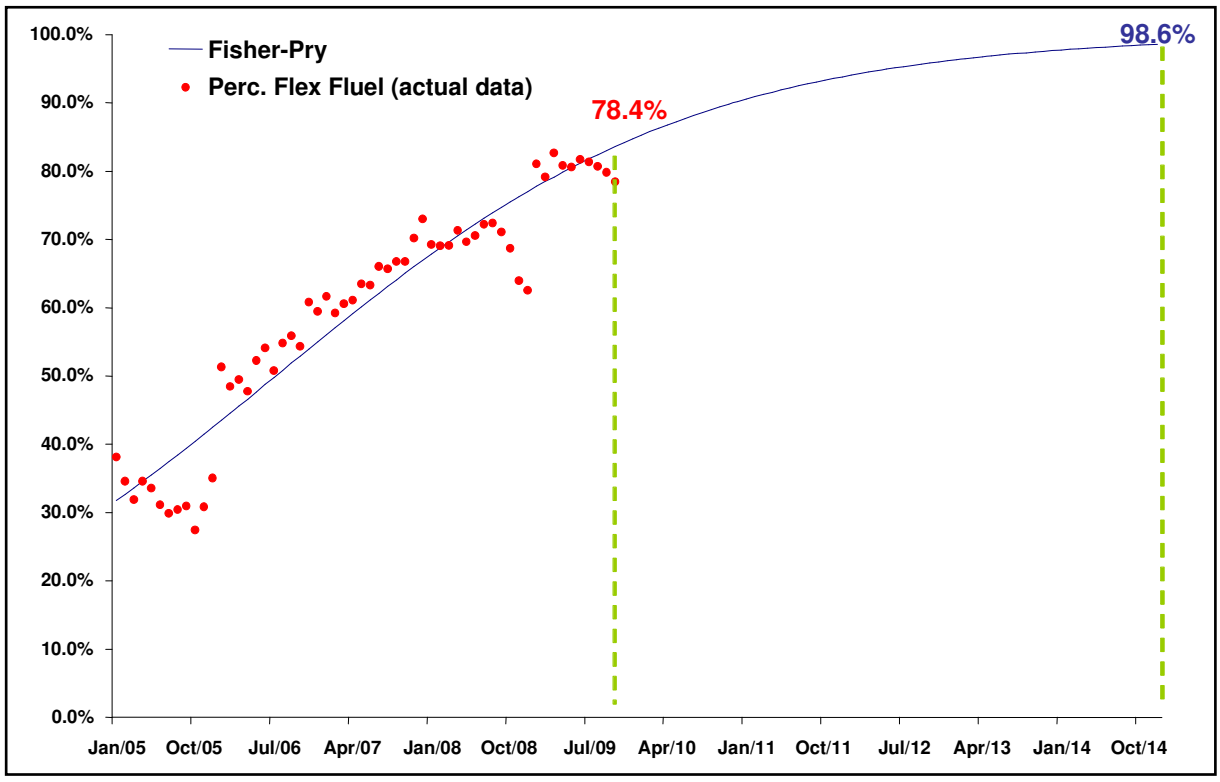
The projections made assume that over the next five years (up to 2014) the price ratio between ethanol and gasoline will be maintained (ethanol pricing remaining below 70% of the price of gasoline), that there will be no major events in the global scene that might dramatically change the consumption of either of these fuels, and finally, that future investments in the alcohol sector will be able to meet growing demand.

In addition, data from the major industry agents, such as UNICA (Sugarcane Industry Union), ANFAVEA (National Association of Automobile Manufacturers), Petrobras, ANP (National Petroleum Agency) and others were analyzed, in order to compare their projected results. These data are widely available on their respective websites.

4 DATA PRESENTATION AND ANALYSIS

The data used as the basis of this work were obtained from the ANFAVEA (2008) and ANP (2009a) websites and were used for generating an historical series for the January 2005 to October 2009 period, including these months; this was then extrapolated to December 2014. For the future projection of the number of flex fuel cars in 2014, the Fisher-Pry model was used, because it portrays the technology substitution scenario best. The Gompertz model was used to estimate demand for ethanol from fuel distributors in Brazil during the same period.

Graph 4 shows the flex fuel vehicle production trend relative to the total number of light passenger vehicles produced annually in Brazil. This estimate shows that by 2014 this particular technology should be able to reach a very major share (98.6%) of all vehicles produced. This demonstrates the value proposition that this technology brings to society, by allowing it to choose the most financially advantageous fuel at the time of purchase.

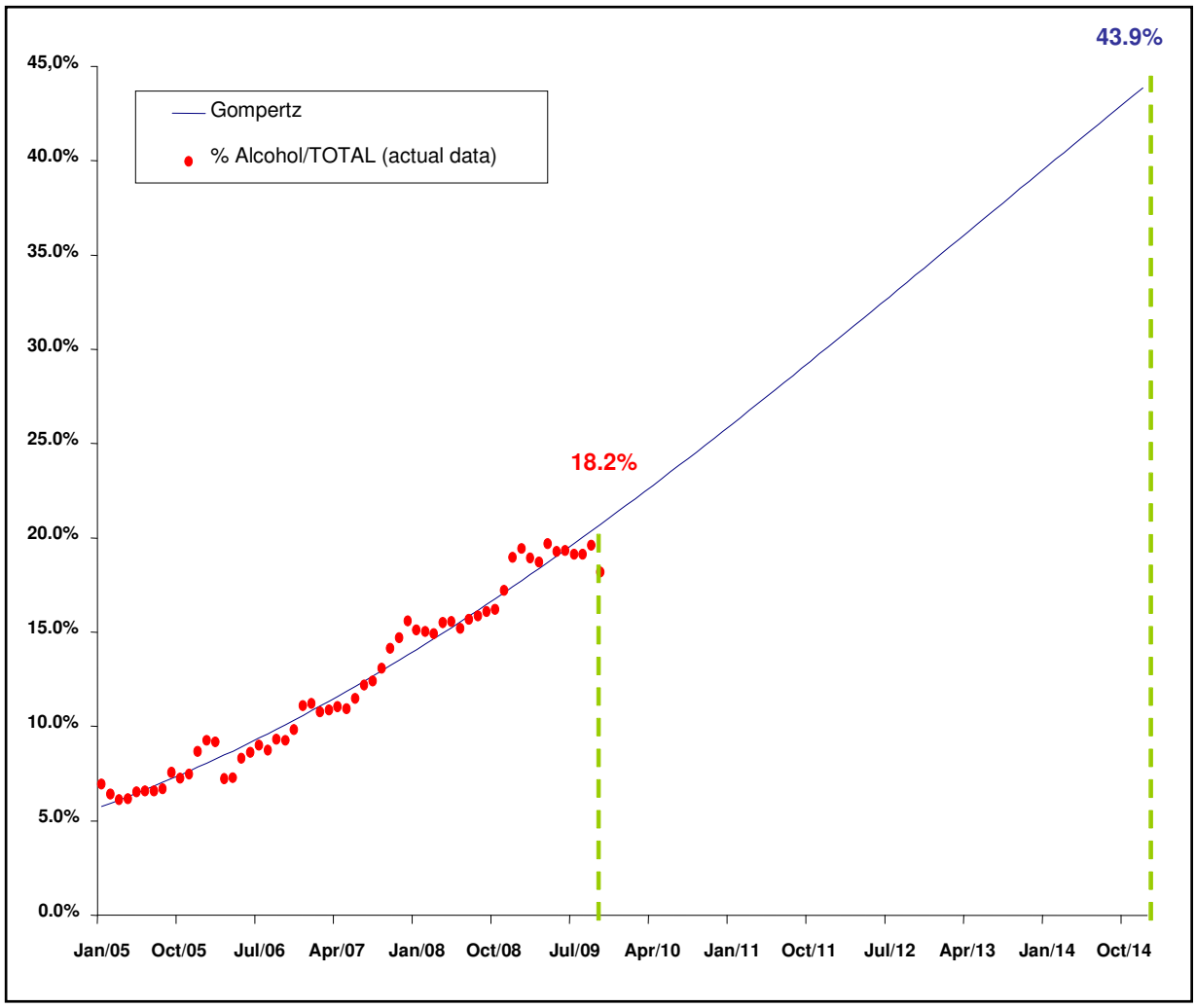


Graph 4: Projection of the Fisher-Pry model up to 2014, for the share of flex fuel vehicles produced in Brazil

Source: Anfavea, 2008. Graph devised by the authors.

These projections assume that over the next five years (up to 2014) the ethanol to gasoline price ratio will be maintained, the price of ethanol remaining below 70% of the price of gasoline. These estimates also assume that there will be no major changes in the global economy that might dramatically bring about a switch from one to the other.

The outcome of the greater production and sale flex fuel vehicles is shown in the projected sale figures of ethanol by Brazilian vehicle distributors. As Graph 5 indicates, the projection points to a rise in the share of this fuel in the sales of fuel distributors, from 18.2% of the total in late 2009 to 43.9% in 2014.



Graph 5: Projection of the Gompertz model to 2014 for the share of the sale of ethanol by distributors in Brazil

Source: ANP, 2009a. Graph devised by the authors.

One should highlight that, given Brazil's very large territorial size, the penetration of these new vehicles does not take place evenly across all regions in the country. Large consumer centers, located near the vehicle production plants, will have a greater penetration rate of flex fuel vehicles, meaning that demand for ethanol in these regions will also be greater.

The assumption underlying these projections was that the current and future investments of the sugar and alcohol industry will be able to meet this increasing demand, without this entailing any major changes in the price of ethanol that might make it less financially attractive than gasoline. This is so because most of Brazil's ethanol production is concentrated in the southeast of the country, which is the largest consumer of this technology.

5 FINAL THOUGHTS

This work presented the evolution of the production of vehicles with flex fuel technology, as well as the evolution of the consumption of ethanol as a fuel in Brazil, principally after the invention of flex fuel technology. This provides evidence of the impact that this technology has had on the entire ethanol production chain and on the distribution of this fuel throughout Brazil.

Available computer methods made it possible to extrapolate trends, both for projecting the share of automobiles with flex fuel technology in national production and the share of ethanol in the fuel consumption matrix of Brazil. For each projection, a different extrapolation model was used, due to the characteristics of the variables to be projected.

In the case of the share of domestically manufactured flex fuel cars, the Fisher-Pry model was used for the projection, since this technology has clear advantages over the conventional technology of single fuel engines, meaning that the conventional technology is replaced. To project the share of ethanol in the fuel consumption matrix in Brazil, the Gompertz model was used, since ethanol as a fuel has none of the technology substitution characteristics, because its use depends on other variables that are just as important, or even more so, than the technology itself, namely, the price of ethanol relative to the price of gasoline.

The projections indicated the likely state of both technologies by the end of 2014. The Fisher-Pry model projection indicated that the share of flex fuels automobiles should reach roughly 98.6%, reflecting growth of 0.325% a month relative to the October 2009 figure. For ethanol, the Gompertz projection indicated a 43.9% share of all the fuel sold by fuel distributors in Brazil, a growth of 0.415% per month during the projection period.

Finally, one should point out out that the Gompertz projection considers that the installed capacity of ethanol production in Brazil can keep up with demand without significant price changes. In other words, it is assumed that the historical performance of the ethanol to gasoline price ratio, usually less than 70%, is maintained.

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