ETHANOL’S IMPACT ON BRAZILIAN ENERGY SECURITY

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By

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To my parents, for making all of this possible
To Gabriel, Joao Pedro and Valentina, for bringing me endless joy

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Introduction

In recent years, energy security has become one of the top priorities of governments around the world. Concerns about diminishing and finite resources, scarcity conflicts, unstable supplies and climate change have led countries to increase their focus on energy security, scrambling to ensure that their energy needs are met to promote their economic growth.

In a world highly dependent on petroleum as an energy source, the quest for energy security becomes even more crucial. If the oil shocks of 1973 and 1979 weren’t warning enough, record prices in 2008 once again demonstrated the dangers of becoming overly dependent on one source - especially if a country is heavily reliant on imports. Because of the risks posed by potential market disruptions and the vulnerabilities of the globalized energy market, the issue of energy security is especially timely.

In the case of Brazil, it is impossible to talk today about energy security without talking about sugarcane ethanol. In the last 30 years, ethanol has become increasingly dominant in the fuels market, going from a byproduct of the sugar industry to an important component of the Brazilian energy matrix. Today, Brazil is the second biggest producer (24 billion liters) and exporter (5.1 billion liters) of ethanol in the world. The United States is currently the leading producer, with 34 billion liters.

The Brazilian government has made it clear that it believes that ethanol is one of the main pillars of its energy security and predicts that it will also comprise 75% of the light vehicle fleet’s fuel demand in the country by 2020, with gasoline only accounting for 17%. Currently, gasoline provides 50% of the total demand for fuel in Brazil.\(^4\)

The choice to embrace ethanol in Brazil was made in the 1970s when the first oil shock made evident the dangers of an economy overly reliant on oil and on a just a few suppliers. With prices skyrocketing, the Brazilian government launched ProAlcool, a national program to encourage the production and consumption of ethanol. While the program was discontinued in the 1990’s, Brazil had already seen that ethanol was a viable option for its fuel needs – it was domestically available and perceived as a more stable and inexpensive source. Between 1980 and 2003, even though the consumption of hydrated ethanol\(^6\), or ‘pure ethanol’, decreased significantly, the country maintained the mandatory blend of anhydrous ethanol in gasoline – therefore keeping the ethanol industry alive.

In 2003, the decision by Volkswagen to launch the first Flex-Fuel Vehicle (FFV) – which runs on any combination of gasoline and ethanol – in Brazil proved to be the boost that the national ethanol industry needed to once again become an important energy source for transportation. Since then, ethanol consumption has increased quickly and steadily. The fact that almost 90% of new cars sold last year in Brazil\(^7\) were built to run


\(^5\) Ibid

\(^6\) Hydrated ethanol can be used to fuel cars on its own, while anhydrous ethanol is used as a blend component in gasoline.

on flex fuel shows that for Brazilians the use of ethanol is likely to continue in the long
term.

Ethanol becomes even more appealing if one takes into account the fact that it is a
renewable substance and a low greenhouse gas (GHG) emitting source\(^8\). While for the
purposes of this paper climate-related issues will not be addressed, they are still important
to mention in the context of Brazil’s fuel choice since they raise interest in biofuels
regardless of more conventional market forces.

All of these factors show that Brazil seems invested in making ethanol its fuel
choice for the future. But just how much impact has ethanol had on Brazilian energy
security? In order to address this question, this paper analyzes the performance of ethanol
over the last 7 years (2003 to 2009) and compares it to gasoline using various measures.

The overall finding is that ethanol has had a positive impact on Brazil’s energy
security, helping the country develop its own sources of energy, reducing dependence on
oil and providing consumers with an affordable fuel source. Still, the Brazilian ethanol
industry faces a myriad of challenges if it is to establish itself as a superior long run fuel
choice for the country and its consumers.

**Hypothesis, Sub-Hypothesis and Methodology**

This paper’s hypothesis is that ethanol has had a positive impact on Brazil’s
energy security, demonstrating that it is a stable source that has diminished Brazilian

\(^8\) In 2010, the US Environmental Protection Agency classified the Brazilian sugarcane ethanol as an
advanced biofuels. This could mean an exponential increase in ethanol exports from Brazil, since the U.S.
will increase ethanol consumption to comply with EPA’s GHG emissions reduction.
dependence on foreign sources of oil. The paper’s sub-hypotheses will be based on comparisons with gasoline. They are as follows:

a) Ethanol has had a positive impact on Brazil’s energy security because its prices are lower and more stable than those of gasoline. In order to be a viable fuel choice for Brazilians, ethanol needs to be able to compete with gasoline in terms of cost at the pump, otherwise consumers will resist opting for biofuels. Because gasoline is more energy efficient than ethanol per volume (meaning a car needs less of it to run longer) this paper will adopt the ratio 1.0 to 0.70. According to this, ethanol prices should be no higher than 70% of the prices charged for the same volume of gasoline.

b) Ethanol has had an impact on Brazil’s energy security because its production has been increasing steadily in comparison to gasoline. This judgment is predicated on the assumption that increased consumption is indicative of the fuel meeting consumer needs in a way that bodes well for the future. For this to be true, this paper expects to see a higher growth ratio in ethanol production in comparison to gasoline, as well as no major incidents of ethanol shortage.

c) Ethanol has had an impact on Brazil’s energy security because its production is larger than gasoline’s. An increasing production is crucial for energy security because it means that the industry has the ability to provide consumers with the amount of energy necessary. For this to be true, the ethanol industry needs to show that it has consistently increased production from year to year, that production has been consistently higher than consumption and that there have been no major shortage incidents.
d) Ethanol has had an impact in Brazil’s energy security because it has diminished Brazil’s dependence on oil and on foreign supplies. As ethanol’s consumption increases, one would expect to see a decrease in gasoline import volumes. This measure assumes that if Brazil imports less gasoline, it is relatively more protected from price and supply fluctuations that occur outside its borders, making it more energy secure in the case of an oil crisis. Another important point is the fact that by using more ethanol, Brazil is less dependent on oil, which is considered a finite resource. Therefore, when/if oil runs out, Brazil will have a strong renewable fuel industry to rely on.

The findings of this thesis will be based on quantitative comparisons of the following aspects of ethanol and gasoline markets: demand/consumption, price, production, and gasoline imports. Since there is no seminal energy security quantification model to draw from, the parameters used in this analysis were established based on the main factors cited by authors as pillars of energy security: Price, production, and diminishing dependence on foreign sources and oil.

Most of the data used here was drawn from governmental sources such as the Brazilian National Petroleum Agency (ANP), Ministry of Mines and Energy, Ministry of Agriculture, Livestock and Food Supply (MAPA), and sector associations, think tanks and institutes, such as the Brazilian Sugarcane Industry Association (UNICA) and the Agrarian Economy Institute (IEA) and the Renewable Fuels Association (RFA).

Comparisons between ethanol and gasoline from 2003 to 2009 will serve as a starting point for a more detailed discussion on which factors affect the ethanol industry
(such as crop yield, weather, competing industries), how they affect it and the extent of the impact they have. While this paper will try to use as up-to-date data as possible, 2009 and 2010 numbers may not have been available at this time, therefore some comparisons will be limited to 2008. After this discussion, it will be possible to draw policy recommendations and conclusions.

**Literature Review**

The production of ethanol has been widely discussed in Brazil and in other countries, be it from an economic point of view or from an environmental and sustainable development one. Much has also been written about on the success of the Brazilian national ethanol program, which was launched by the government in 1975 and has made the country the second biggest producer in the world. While the literature on ethanol fuel is extensive, to date there has been little focus on quantifying and analyzing ethanol's contribution to energy security.

The basis of my thesis will be the academic definition of what energy security is. For the majority of authors, energy security is based on the following two pillars: decreasing dependence on oil (considered a finite and unstable resource), and investing in domestic and/or stable sources.

These pillars have driven the international discourse on energy security, making their way into many countries’ national agendas (including Brazil.) The Brazilian

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10 Rothman, Greenshields and Calle, *The Alcohol Economy*.
National Energy Plan states among its main objectives that it intends to decrease dependence on foreign sources and increase biofuels’ participation in their energy matrix.

It is important to make a note that climate change has also been a factor behind the backlash on oil and other hydrocarbons. But for the purpose of this paper, this discourse will be only briefly addressed.

The assumption that oil is finite and unstable, and that domestic supplies make a country more energy secure has fostered a wave of renewable resource advocacy.\textsuperscript{12} This school of thought posits that renewable sources are the future of energy and, therefore, need to be explored by countries seeking to enhance their energy independence and security.

While this trend has certainly gained strength in recent years, not all are convinced of the evils of oil and the security that comes with renewables. In Pires, Fernandez y Fernandez and Bueno, the authors put in question the stability and adequacy of Brazilian ethanol supply, due to its dependence on the sugarcane market and the lack of an international future contracts market.\textsuperscript{13} Other renowned experts, such as Georgetown University professor Bruce Everett, argue that oil is not finite - that rather, oil reserves are more than adequate for many decades to come and that renewable energy sources have proven inadequate to supply the world’s energy-hungry economy.\textsuperscript{14}

A large part of this fear of the end of oil supply comes from the Peak Oil theory, created by Marion King Hubbert in 1956. The theory predicted the end of oil supplies in

\textsuperscript{12} Goldemberg, \textit{Energy, Environment and Development}.
\textsuperscript{14} Bruce Everett, http://bmeverett.wordpress.com/2008/08/18/myth-2-oil-is-a-dwindling-resource/
the U.S. and has been since used to analyze reserves and production. But while there is a
general belief that oil reserves will eventually run out, there has been no consensus
among academic and energy experts as to when that will happen. Some forecast that this
will happen by 2050, while others predict that it will take much longer.

Although renewable proponents latch on to peak oil to show why the world needs
to invest in more reliable sources of fuel, the reliability of renewable sources has also
been questioned. Jessica Tuchman Mathews in *Redefining Security*\(^{15}\) argues that if any
energy source is in danger of running out, it is renewables. “An important paradox to bear
in mind when examining natural resource trends is that [….] so-called renewable
resources can be finite.” Tuchman argues renewable sources can be destroyed, citing the
example of overfishing, which can destroy fish species. Theoretically, the same could be
applied to sugarcane if it was attacked by a plague. Therefore, the assumption that
biofuels lend themselves to better energy security simply because they come from
renewable sources is unreasonable, since those sources can still be imperiled by natural
and human occurrences.

**Energy Security Concept**

At its most basic, the concept of energy security addresses a country’s need to
guarantee enough energy supply to meet its demand at an affordable price.\(^{16}\) Energy
security is definitely not a new concept. Experts have pointed out that:

“Ever since the Industrial Revolution, energy and the need to secure its
supply have been fundamental to any position of power in the world”\(^{17}\)

But while it is not a new concept, energy security has evolved since its emergence, absorbing and addressing new challenges and threats faced by nations. In his article, “Ensuring Energy Security,” Daniel Yergin argues that energy security has evolved to include the rise of developing countries such as India and China, who also vie for an increasing share of the world’s energy sources. It also now takes into account exploration of new and less stable regions, notably Africa, and the threat of terrorism to energy assets.18

Yergin makes an important point when he highlights that although one can generalize the concept, energy security will always need to adapt to each country’s needs19. The view of Saudi Arabia on energy security issues will be much different than that of Brazil. One wants to ensure the demand for oil, while the other wants to diminish its dependence on it.

Clearly, authors still diverge on what really constitutes energy security. Although there is not universal agreement, this paper will base its analysis on what it sees as the most common factors within the energy security concept: diversification, prices, production, and dependence on foreign supplies.

The first factor we will examine are prices. Most broad definitions of energy security stress the issue of reasonable20 or affordable prices.21 While authors acknowledge that this is a somewhat vague concept, this paper will assume that reasonable or affordable prices mean that these fuel sources will be in the reach of consumers and will present some sort of stability.

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18 Yergin, Ensuring Energy Security, 71
19 Ibid, 71
21 Yergin, Ensuring Energy Security, 70
The second factor is production. This goes back to the energy security concept, which stresses a nation’s goal of meeting its energy needs. In a 2007 report, the IEA highlighted the importance of “physical availability components”.\footnote{IEA, Energy Security and Climate Policy—Assessing Interactions, 2007, http://www.iea.org/textbase/nppdf/free/2007/energy_security_climate_policy.pdf} This is perhaps the most intuitive factor. In order to meet one’s energy needs, there needs to be enough supply. For a country that relies on foreign source, this means relying upon stable imports of fuels. For a country that can rely on its own sources, this means stable production.

The last factor we will investigate is diminishing dependence on foreign supplies and oil. This factor only makes sense for importing countries that have some significant domestic energy sources available to them, and Brazil falls into this category.

**Energy Security in Brazil**

Brazil is perhaps a blessed country when it comes to energy security. Its massive territory includes vast hydropower resources, large uranium reserves, extensive crop land, and considerable gas and oil reserves, among other resources. Recently, Brazil has discovered significant offshore oil fields, which could give the country one of the biggest oil reserves in the world. According to ANP, current reserves are forecasted to double Brazilian oil reserves, and could eventually triple or quadruple them.\footnote{Ministry of Mines and Energy, http://www.mme.gov.br/mme/galerias/arquivos/noticias/2009/10_outubro/Cartilha_prx-sal.pdf}

Unlike many other countries, Brazil has worked to develop all its energy sources – granted, some more than others – and today the country has one of the most renewable energy matrices in the world, as illustrated by Figure 1.
While the average non-renewable/renewable energy ratio in the world is 14% renewable to 86% non-renewable, in Brazil, it is almost half and half: 44% renewable and 56% non-renewable. This is significant because it shows that the country is already investing in diversifying its energy sources and working on energy self-sufficiency. Figure 2 shows the Brazilian Transportation Fuel Matrix.

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25 Ministry of Mines and Energy,
The figure shows that diesel oil still accounts for practically half of all transportation fuels used in Brazil, with a share of 49%. Gasoline comes in second, with a 23% participation and ethanol in third, with 18%.

But the Brazilian government seems committed to increase even further the participation of renewable fuels both in its energy and transportation matrices. A series of programs have been launched by the current Brazilian government with the intention of fostering the growth of alternative domestic sources of energy.

With regards to ethanol specifically, the government allocated additional budget to boost the expansion of the ethanol industry. This month, the government has launched its Accelerated Growth Program 2 (PAC-2), which concentrates investments in infrastructure. According to the program guidelines, R$1 billion will be invested in the
next years to “expand the participation of renewable fuels in the energy matrix”. The program specifically mentions investing in new mills.

Historical Background

The Beginning of the Biofuel Industry in Brazil

For centuries, sugarcane crops have been one of the most lucrative economic activities in Brazil. With plenty of productive land and amenable weather (the latter particularly in the mid-east and northeast regions), it was natural that the crop would flourish in the country. As such, sugarcane quickly became a vital industry.

While sugar remained the sole product extracted from sugarcane over several centuries, in the early 20th century scientists around the world started experimenting with the possibility of using the crop to produce alternative sources of fuel.

In 1933, the government started regulating the sugar sector, creating the Institute for Sugar and Alcohol (IAA). The Institute was a response to the crash of the New York stock market in 1929, which dealt a huge blow to the Brazilian sugar exports. The main objective of the IAA was to “control the production to maintain prices at an adequate level, protecting the Brazilian product in the global market. In order to achieve this, the IAA established a strict quota system, which was distributed between sugar mills”.

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30 Ibid
31 Ibid
Even if the IAA had nothing to with regulating the ethanol market, it forced sugar mills to cut production costs and become more efficient.\textsuperscript{32} Since sugar mills eventually started producing ethanol, this certainly becomes relevant in the development of the biofuel industry in Brazil.

\textit{Oil Shocks and Ethanol Boom in Brazil: The Creation of the ProAlcool Program}

One could say that 1975 was the pivotal year for ethanol in Brazil. Reeling from the oil shock in 1973, the Brazilian government decided to take action to guarantee its fuel supply. Taking advantage of its robust sugarcane industry, then president Ernesto Geisel created the Programa Nacional do Álcool (National Ethanol Program) or Proalcool. At first, the program stipulated that new mills be installed, and old ones modernized; and that ethanol should be added to gasoline.\textsuperscript{33} By 1977, Brazil was already adding 4\% ethanol into gasoline.\textsuperscript{34} But that still was not enough to help Brazil survive skyrocketing oil prices.\textsuperscript{35}

In 1979, President João Figueiredo declared that “ethanol was the Brazilian answer to the energy crisis. More than a solution to external contingencies, it is the biggest challenge of the 80’s that the nation will have face and overcome”. It was in Figueiredo’s government that the ethanol industry really began to flourish. In 1978, the government realized that it needed to increase the ethanol market and launched cars that could run on ethanol. By 1980, ethanol production reached 3.4 billion liters per year, up

\begin{footnotesize}
\textsuperscript{32} Ibid
\textsuperscript{34} National Petroleum, Natural Gas and Biofuels Agency (ANP), http://www.anp.gov.br/?pg=9215&m=&t1=&t2=&t3=&t4=&ar=&ps=&cachebust=1271386842833
\textsuperscript{35} Veja, “Coleções: Proálcool”.
\end{footnotesize}
from 600 million liters in 1976. So by then the ethanol industry had two fronts: one that was increasing the amount of ethanol blended in gasoline – which reached 22% in 86\textsuperscript{36} - and the one that created the market for pure ethanol as a fuel.

In the next few years, the program ran full steam ahead. The government approved the installation of 292 new mills that would help fuel the growing ethanol car fleet. By 1981, one fourth of the car fleet in Brazil had an ‘ethanol-engine’\textsuperscript{37} and in 1983, 90% of car sales were for those ethanol-based\textsuperscript{38}.

In order to speed up the development of the program, the Brazilian government created the National Ethanol Council (CNAL) and the National Executive Commission for Ethanol (CENAL). Both state agencies would help translate government policies into practice and further develop the sector.\textsuperscript{39} In 1986, production reached a record 12.3 billion liters, surpassing by 15% the original target set by the government.\textsuperscript{40}

In 1985 and 1986, oil prices plummeted again, making gasoline a cheaper option than ethanol. Moreover, sugar prices were increasing, making it more attractive for mills to use their sugarcane crops to export sugar and not produce ethanol.\textsuperscript{41} Both oil and sugar prices contributed to two of the mains reasons the program ended.

The first reason was that in order to justify the production of ethanol and foster consumption, the Brazilian government decided to maintain the price of gasoline artificially high, while investing large amounts of money in the ethanol industry (via

\textsuperscript{36} ANP, http://www.anp.gov.br/?pg=9215&m=&t1=&t2=&t3=&t4=&ar=&ps=&cachebust=1271386842833
\textsuperscript{37} Ibid
\textsuperscript{38} Ibid
\textsuperscript{39} BiodieselBr, “PróAlcool - Programa Brasileiro de Álcool”, www.biodieselbr.com/proalcool/proalcool.htm
\textsuperscript{40} Ibid
\textsuperscript{41} Veja, “Coleções: Proálcool”
loans, tax credits, etc.).\textsuperscript{42} The second reason was that decrease in production led to a major ethanol supply crisis in the 1990s. In the next few years, the image that ethanol could solve Brazil’s energy supply problems was shaken. By the 1990’s, the program became unsustainable. By then it had consumed more than 10 billion reais and forced Petrobras into more than 600 million reais in debt to cover the cost of production.\textsuperscript{43} In the mid-1990s, the Brazilian government revised the program, discontinuing the heavy subsidies and price fixing.

Still, ethanol didn’t disappear altogether from the government’s agenda. Trying to coordinate its biofuels policies, the government created the Interministerial Council of Sugar and Ethanol (CIMA) in 1997,\textsuperscript{44} which works as a meeting place for various ministries, such as the Ministry of Agriculture, Cattle and Supply, Ministry of Development, Industry and Foreign Commerce, and Ministry of Mines and Energy.

**Data Analysis**

**Ethanol and Gasoline Demand and Consumption Comparison**

Even though ProAlcool did not survive, it showed the Brazilian government and both the car and the sugarcane industries that ethanol could be a viable fuel option for the country. Aware that this presented them with a potentially important possibility, automakers started developing a car that would be able to run on any combination of gasoline and ethanol, allowing consumers the freedom to choose which fuel they wanted,

\textsuperscript{42} Ibid
\textsuperscript{43} Ibid
\textsuperscript{44} BiodieselBr, “PróAlcool - Programa Brasileiro de Álcool”.

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and not being constrained by the type of car. In March 2003, Volkswagen launched its first FFV car\textsuperscript{45}, revolutionizing the fuel and car industries in Brazil.

Since FFVs were introduced in Brazil ethanol consumption has steadily increased while that of gasoline has remained somewhat stable. As Figure 3 shows, since 2003, ethanol consumption has practically doubled, going from 11 thousand cubic meters to 21 thousand cubic meters in 2008. Meanwhile, gasoline has shown a small increase from 17 thousand cubic meters to 19 thousand cubic meters in the same period.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{ethanol_gasoline_consumption.png}
\caption{Ethanol and Gasoline Consumption in Brazil}
\end{figure}

Since overall fuel consumption in Brazil has not remained stable, it is possible to infer that consumers have opted to use more ethanol than gasoline since 2003. But to understand the increase in ethanol consumption, one must look at the FFV industry in Brazil and how it has grown in the past seven years.

As Figure 4 shows, FFV sales have grown at a staggering rate, reaching almost 3 million new vehicles sold in 2009. Currently, ten automakers offer consumers FFV models.\footnote{National Association of Automakers (Anfavea), \url{http://www.anfavea.com.br/tabelas/autoveiculos/tabela07_producao.pdf}}

FFVs overcame technical issues normally associated with pure-ethanol run cars (such as difficulty starting in cold weather), which made them more alluring to consumers. But the real appeal of FFVs is that for the first time consumers did not have to buy a car that restricted their fuelling options, which could leave them vulnerable to shortages or price increases. This time, they could buy a car that would give them the power to choose which fuel they wanted at the gas station, based on price.

In the last seven years, the majority of Brazilians have chosen to fuel their cars with ethanol, pushing biofuels sales, which now surpasses gasoline. As Figure 5 shows,\footnote{Brazilian Sugarcane Industry Association (Unica), \url{http://www.unica.com.br/dadosCotacao/estatistica/}}
ethanol (anhydrous and hydrated) sales grew from 12 thousand cubic meters in 2003 to practically 20 thousand cubic meters in 2008. Meanwhile, gasoline sales have shown little increase, going from 17 thousand cubic meters to little over 18 thousand.

Figure 5: Ethanol and Gasoline sales in Brazil

Source: National Petroleum, Natural Gas and Biofuels, Statistical Yearbook 2009

Overall, ethanol consumption has increased significantly in the last years, fuelled by the increase of the FFV fleet. The success of these cars in Brazil created the market for ethanol to grow in the country. As the sales numbers show, consumers in Brazil now prefer ethanol to gasoline. This is important for the energy security debate, because it shows that Brazil has created a stable supply for the consumption of ethanol, allowing consumers to choose without fear that they will face fuel shortages.

Ethanol and Gasoline Production Comparison

As the section above established, the demand and consumption of ethanol has steadily grown in Brazil, fueled by the rapid increase in the FFV car fleet in the country.
In order to be a secure fuel, ethanol production needs to meet the growing consumption; otherwise ethanol could face the same problems it did in 1989 when acute ethanol shortages damaged consumers’ faith in the fuel.48

As Figure 6 clearly shows, ethanol production has increased dramatically over the years, while gasoline has shown a smaller growth.

![Ethanol and Gasoline Production in Brazil](image)

**Figure 6: Ethanol and Gasoline Production in Brazil**

Ethanol sales (anhydrous and hydrated) went from 14.47 thousand cubic meters in 2003 to 27.12 thousand cubic meters in 2008. Hydrated ethanol displayed the biggest increase, from 5.6 thousand cubic meters to 17.56 thousand cubic meters, tripling its numbers. As shown previously, this accelerated increase was pushed by the sales of FFVs in the country. Meanwhile, gasoline production ranged from 19 thousand cubic meters to 21 thousand cubic meters. This shows that while gasoline production is still growing, ethanol production has increased at a much faster pace.

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48 BiodieselBr, [http://www.biodieselbr.com/proalcool/pro-alcool.htm](http://www.biodieselbr.com/proalcool/pro-alcool.htm)
To corroborate the figure above, one can compare growth in consumption and production. In a more stable energy source, one would expect to see higher production than consumption – the bigger the difference between them, the better, since it leaves a margin for increase in demand without much tightening of supply.

As Figure 7 shows, beginning in 2003 and until 2008, ethanol production remained steady and consumption increased significantly, indicating that the industry has not only been able to respond quickly to a rise in demand, but also that it has space for an even bigger increase. In 2008, Brazil produced 27 thousand cubic meters of ethanol while consuming 21 thousand cubic meters.

![Ethanol Production and Consumption](image)

In 2009, however, ethanol production in Brazil was threatened because of problems with the 2009/2010 sugarcane crop. Due to an especially intense rainy season which impacted the beginning of the processing,\footnote{Marcos Savaya Jank, “A Alta dos Precos do Acucar Estimula Novos Investimentos da Industria Brasileira?”, Única, March 23, 2010.} annual production decreased from 27 thousand cubic meters to 24 thousand cubic meters\footnote{Ministry of Mines and Energy, Energy Balance 2009, www.mme.gov.br}.
This sudden decrease, which was not expected\textsuperscript{51}, impacted sales and ethanol prices\textsuperscript{52} and highlighted an inherent weakness of the ethanol industry: The fact that it is completely dependent on the output of its raw material base, sugarcane. If there is not enough sugarcane, or if its Total Recoverable Sugar (TRS) concentration is not high enough\textsuperscript{53} then ethanol production can be threatened.

In comparison to the oil industry, sugarcane production is much less certain. Oil producers know how much oil they have in a field, and barring any natural or man caused catastrophe, they can predict how much they will be able to extract from year to year. Sugarcane producers on the other hand, depend on many factors to have a good crop. Soil, climate and so on play a role from year to year to determine what the sugarcane crop will be like. Depleted soil, too much rain or too little rain will have an impact on the quality or quantity of sugarcane. Obviously there are measures producers can take to minimize these factors, but at the end of the day, they can never be sure of how the harvest will turn out. So while the industry can make informed forecasts, there is no guarantee that they will be fulfilled.

The crop of 2009-2010 is proof of that uncertainty. The Brazilian Sugarcane Industry (Unica) had forecasted that mills would process 580 million tons of sugarcane, but the actual number was 537 million tons, a 43 million ton drop\textsuperscript{54}. TRS yield was also below the expected, dropping the forecasted 141.3 kg per ton to 130.5 kg per ton\textsuperscript{55}. This

\textsuperscript{51}Jank, A Alta dos Precos do Acucar Estimula Novos Investimentos da Industria Brasileira?  
\textsuperscript{52}According to UNICA, prices variation showed a 113\% amplitude from the 13\textsuperscript{th} week of 2009 until the second week of 2010.  
\textsuperscript{53}TRS is a measure used to determine how much sugar can be extracted a produce. The higher the number, the more energy it will produce.  
\textsuperscript{54}Jank, A Alta dos Precos do Acucar Estimula Novos Investimentos da Industria Brasileira?  
\textsuperscript{55}Ibid.
meant that on top of harvesting less sugarcane, the crop had a lower TRS, which meant that less energy could be produced from it.

Since ethanol is completely dependent on sugarcane harvest yields, it is critical to assess if the sugarcane industry has invested in expanding its crops and if it has managed to increase its productivity. Since 2003, sugarcane crop areas have increased from 5.38 million hectares to 8.92 million hectares, a 1.6 fold increase in six years. Sugarcane production has increased from 389.85 million tons in 2003 to 648.85 million tons in 2008, which also represents a 1.6 fold increase. The expansion of sugarcane crop area compared to the increase in sugarcane production also shows that the productivity has increased in the last few years. From 72.58 tons per hectare in 2003, the industry grew to 77.52 tons per hectare in 2008 – a 1.06 fold increase.

Another potential source of instability for ethanol is the fact that of the 426 mills, 249 have mixed production, meaning they produce both ethanol and sugar. While on average 60% of the sugarcane production is directed to ethanol, there is not a mandatory minimum ‘production mix’, as the division is called in Brazil. Mills are then free to allocate sugarcane to whichever final product they deem more profitable. Since they are private enterprises, the government has no control over how they allocate their production.

A clear example of this allocation question is that by September 2009, 43.33% of the year’s sugarcane harvest had been destined to sugar production, representing a

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56 Ministry of Agriculture, Livestock and Food Supply, www.mapa.gov.br
57 Unica, WWW.unica.com.br
23.44% increase in comparison to the same period of last year. Some argued that this increase in sugar mix was pushed by the increase in sugar prices in the last year. True or not, this choice clearly shows a vulnerability of the ethanol production in Brazil, in comparison to gasoline.

Overall, this section has shown that while in general terms ethanol production in Brazil has increased since 2003, surpassing gasoline and meeting the growing consumption, it is still vulnerable to some risks. Inherently, ethanol depends on the sugarcane harvest, which is susceptible to uncontrollable factors such as climate. Brazil also faces a challenge with regards to a lack of mandatory ethanol production, with mills deciding how much they will allocate to each production every year.

*Ethanol and Gasoline Price Comparison*

Now let us discuss the factor of price. As previously discussed, energy security is based on the availability of reasonably priced fuels, therefore, ethanol needs to show that its prices are competitive in comparison to gasoline.

As the Figure 8 shows, while ethanol has consistently maintained a lower price than gasoline since 2003, its prices have increased from R$1.40 to practically R$ 2.00 in 2008. Meanwhile, gasoline rose from R$2.00 in 2003 to R$2.50 in 2008.

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It is important to notice that gasoline prices have remained stable since 2006, while ethanol has showed a greater variation. This can perhaps be explained by the increase in ethanol demand and consumption shown previously, which puts pressure on production. Gasoline demand and consumption, on the other hand, have not shown as great an increase in the last years.

But it is not enough to have simply compared prices of ethanol and gasoline. Because gasoline is more efficient than ethanol (meaning a car fuelled with gasoline will run longer than a car fuelled with the same amount of ethanol), it is important to observe if, taking this into consideration, ethanol is still more competitive. According to the industry, ethanol becomes less competitive if its ratio of comparison with gasoline surpasses 0.70.

As the Figure 9 shows, until 2008 ethanol remained more competitive than gasoline, staying below the 0.70 threshold. In 2008, as prices began to rise, ethanol became for the first time less competitive than gasoline. According to ANP, one of the
reasons for the price increase was ethanol shortage in the Northeast region of Brazil, which forced the Southeast region to redirect some of its production. 

Figure 9: Ethanol and Gasoline Price Ratio

While there is no official average available for 2009 and 2010, ethanol prices continued to rise, surpassing gasoline in some states. As this paper has explained before, the 2009-2010 sugarcane crop failed to meet the forecasted output, causing a decrease in supply and consequently an increase in prices. According to Unica, from the 13th week of 2009 to the second week of 2010, hydrated ethanol prices in the Center-South region of Brazil displayed a 113% price variation. As a result, sales went drastically down, as consumers opted to fuel their cars with gasoline. From roughly 1.4 billion liters of hydrated ethanol in December 2009, sales went down to little over 0.7 billion liters in February 2010.

61 Since the region is the biggest producer and consumer of ethanol, according to UNICA, price and sales changes there are representative of the Brazilian market as a whole.
62 Jank, A Alta dos Precos do Acucar Estimula Novos Investimentos da Industria Brasileira?
63 Ibid
When talking about ethanol prices, one of the recurrent issues mentioned is an influence factor for sugar production and prices. As mentioned before, many mills in Brazil produce both sugar and ethanol. Therefore, they may be susceptible to price changes on either product. If sugar prices are much higher than ethanol, then it becomes more profitable for them to produce more sugar, putting a strain on the production of ethanol, which, in turn, leads to an increase in the price of the biofuels.

But while the connection can appear to be clear, there is no consensus in the industry of how much impact the price of sugar has over ethanol. The decrease in ethanol production and price increase in the second semester of 2009 and the beginning of 2010 highlighted the lack of agreement. Media coverage of the increase in ethanol prices pointed record prices for sugar in the international market as an important driver of ethanol price increase.

“When you have a sugar market that is more appealing, it is natural that mills give preference to the production of sugar, reducing ethanol supply.”64

In this instance, sugar became more appealing due to the crash of sugar production in India, caused by the lack of rain, which pushed sugar prices to record levels65. Since India is a major producer, its low production impacted the international market, putting pressure on supply to meet the growing demand.

“The harvest crash in India that forced it to import 2 million tons of sugar, was reflected in price increase, which reached a 28-year high. Since Brazil allocated

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64 Priscila Dal Poggetto, *Saiba os Motivos da Alta do Preço do Álcool Combustível*. SAIBA+OS+MOTIVOS+DA+ALTA+DO+PRECO+DO+ALCOOL+COMBUSTIVEL.html
more sugarcane to produce sugar, this led to a sugar price increase and an ethanol price increase.”

These are just two examples of how Brazilian media portrayed increase in sugar prices and production as a driver of ethanol prices growth in the last months. ANP also mentions sugar prices as one of the main factors responsible for the decrease in ethanol production. According to a report published in March 2010, “the elevation of sugar prices in the international market also contributed to the growth of ethanol prices for Brazilian consumers. This is due to the sugarcane harvest crash in India, which reduced the country’s production from 26 million tons to 15 million tons.”

But while the media and ANP used sugar prices to explain increase in ethanol prices, the Brazilian Sugarcane Association has stressed that sugar prices are not the main factor pushing ethanol prices up. According to a recent report, “the current increase in sugar production by mills was not a determining factor in the reduction of ethanol supply and consequently the increase in its prices. Excessive rain and financial crises were the main factors.”

In the report, the Association stressed that the reallocation capacity of mills, meaning, diverting sugarcane from ethanol production to sugar production, is limited.

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68 Jank, A Alta dos Precos do Acucar Estimula Novos Investimentos da Industria Brasileira?
Also, mills used their sugar stocks to increase their exports, which shows that they didn’t need to reduce their ethanol production to meet increased sugar demand.\textsuperscript{69}

Unica argues that unusually intense rainfall in 2009 delayed the process of grinding sugarcane and lowered TRS concentration, meaning that while more sugarcane was harvested, it contained less sugar than in previous years.\textsuperscript{70}

The Association also highlighted the fact that the financial crisis left many mills without capital flow, therefore, many opted for selling their production quickly, decreasing fuel stock the period after the harvest. Because of that, by the end of the year the volume of stocked ethanol was significantly lower.\textsuperscript{71}

So when it comes to ethanol and gasoline prices, overall ethanol has remained a cheaper option for Brazilians, even if one takes into account the fact that it is less fuel efficient. But the increase in prices in the second semester of 2009 shows that ethanol is highly susceptible to climate factors.

With regards to the impact of sugar prices over ethanol’s, it is not possible for this paper for ascertain how closely connected they are, since there are many conflicting anecdotal accounts and the numbers shown here have not made a connection obvious.

\textit{Decrease in Oil and Foreign Sources Dependence}

The last part of this analysis will look at whether ethanol has been able to decrease Brazil’s dependence on oil and also on foreign sources. These are two important

\textsuperscript{69} Ibid
\textsuperscript{70} Ibid
\textsuperscript{71} Ibid
factors because as explained previously, energy security is based on the ability of a country to have stable energy sources. With a foreign source, countries have a limited if any control over it. But with domestic sources countries have the ability to control their own supply, taking measures to ensure that it is stable and capable of meeting demand. Reducing dependence on oil is also vitally important. With predictions that oil will run out in the future, countries are turning away from finite resources to renewable ones.

Figure 10 shows ethanol (divided in hydrated and anhydrous) and gasoline imports until 2008.

![Figure 10: Fuel Imports in Brazil](source: Ministry of Mines and Energy, Energy Balance 2009)

As the figure shows, all fuel imports have decreased dramatically. Both anhydrous and hydrated ethanol have not been imported in the last years, while gasoline maintains an insignificant amount of imports.

According to Claudio Ishihara, Director of the Department of Fuels at ANP, the volume of gasoline imported in the last years corresponds to special types of gasoline and
to trade agreements with other countries. Therefore, the imported gasoline has not been used to supplement gasoline demand. “Brazil is a net exporter of gasoline. The numbers shown in imports correspond to special products and lots.”

But the decrease in ethanol production in the second semester of 2009 forced the Brazilian government to import gasoline for a few months, in order to avoid fuel shortages, since the demand for gasoline increased so far 2 million barrels were bought by Petrobras, the Brazilian national oil company. The government has said that this is a temporary situation and that imports will decrease once ethanol production is normalized. “Once ethanol production is normalized, Brazil will not have the need to import gasoline anymore,” according to Ishihara.

The fact that Brazil was forced to import gasoline to meet its fuel demand shows that while ethanol has allowed the country to diminish its dependence on foreign sources, it still shows signs of instability. If every time the ethanol supply does not meet supply Brazil is forced to turn to foreign sources, this diminishes the impact the biofuel has on the Brazilian Energy Security.

The need to turn to imports to meet fuel demand also highlights another problem with both the ethanol and gasoline industry: lack of proper fuel stocks. By maintaining a proper fuel stock a country is ensuring that it can face short term decrease in fuel production, without having to resort to imports. In this case, Brazil clearly showed it has not amassed the proper amount of fuel stock.

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72 Claudio Ishihara, interview with author, April 2010
74 Claudio Ishihara
While there is not official numbers on how large the ethanol or the gasoline stocks are, anecdotal accounts say they are insufficient. According to Alexandre Pires, producers are reluctant to maintain a stock because of its costs. “The best scenario is to have a stock of fuel for three months, but nobody does it because a stock means money.”

With regards to ethanol’s ability to help decrease Brazil’s dependence on oil, a finite source, one must look at the transportation fuel matrix. As Figure 11 shows, ethanol has increased its participation in these last years, while gasoline’s had decreased.

Figure 11: Brazil Transport Fuel Matrix for 2008

While this is a good sign, it is possible to see that other oil based fuels still have a significant share of the Brazilian transport fuel matrix.

It is important to mention here that the recent pre-salt oil discoveries in Brazil, mentioned previously in this paper will allow the country to keep heavily using oil based

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75 Paula Pacheco, *Petrobrás Volta a Importar Gasolina*. 

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fuels. Even though ethanol might be doing its part by decreasing gasoline consumption, this trend is not seen with other fuels.

So while ethanol has significantly contributed to the decrease of Brazilian dependence on foreign sources, by providing the country with a domestic source capable of meeting national demand, the country needs to invest in fuel stocks. This will allow it to withstand short term fuel production decreases, without having to resort to imports. But with regards to decreasing Brazilian reliance on oil, ethanol seems to have have a smaller impact. While the biofuels has certainly shown that its participation in the fuel matrix is increasing, mainly substituting gasoline, the Brazilian transport matrix is still heavily reliant on oil-based fuels.

**Policy Recommendations**

The analysis provided by this paper has shown that ethanol has had a positive impact over Brazil’s energy security but that it still faces many challenges if it intends to ensure a stable future for the biofuels. Since the ethanol industry is a private one, this paper acknowledges the difficulty of the state to control production without nationalizing it. The challenge for Brazil is to put in place mechanisms that allow the industry to keep control and their profits, while also ensuring that it will always meet Brazilian strategic needs.

- **Ethanol Stock:** If the ethanol production decrease in the last semester has proven anything for the ethanol industry and the Brazil government, is that the importance of having adequate fuel stocks. Had Brazil had fuel stocks it is highly likely that it would not have had to resort to gasoline imports. Since mills can be
pressured into selling their production quickly to ensure cash flow, it is the
government’s duty to take action. As of now, the government has two choices: It
can either assume all the costs of stocking ethanol or it can give producers
attractive fiscal incentives to do so. So far, neither producers nor the government
have been able to reach an agreement of how ethanol stocks will put in place. But
as an strategic product, it is imperative that these actions are taken quickly, before
more shortages damage consumer’s faith in ethanol.

- **Mandatory Minimum Ethanol Production:** Even if the ethanol industry argues
  that sugar prices have not been the major cause of the current production
decrease, the fact is that both sugar and ethanol are connected from the moment a
mill produces both and has the capacity – however limited – to reallocate
production to increase their profits. One solution would be for the government to
establish a mandatory minimum ethanol production, guaranteeing that ethanol
production will not decrease past a certain amount. Once again, the government
will have to offer the ethanol industry incentives to do so, since producers may
lose money by not being able to allocate the amount they see fit for each
production.

- **Increasing refining capabilities:** If Brazil is to keep meeting its ethanol demand,
it is critical that the industry and the government focus on expanding refining
capability. As mentioned previously, the government has allocated funds to
building new mills. The ethanol industry has also expanded in the last five years.
Since 2005, more than 100 new mills\(^\text{76}\) have been built in the country. But some
specialists argue that this is not enough. According to Alexandre Mendonca, from

\(^{76}\) Jank, *A Alta dos Precos do Acucar Estimula Novos Investimentos da Industria Brasileira*?
MB Consultoria, the growth of the number of FFVs is Brazil is much higher than the rate of new mills construction. Therefore, it is imperative that the ethanol industry focuses on expanding its production capabilities, be it with the construction of new mills, or expanding already existing ones.

- **Diversifying ethanol raw material:** If Brazil argues that it is a bad thing to be overly dependent on oil, then being overly dependent on sugarcane is also equally bad. Therefore, it is important that the Brazilian government keeps fostering the research of cellulosic ethanol (which uses different sources, such as switchgrass). By diversifying the sources that produce ethanol, the government will ensure that it is able to increase its production, without depending completely on one raw material.

**Conclusion**

Overall, this paper has shown that ethanol has had a better record than gasoline in the last few years. Its consumption has gone up, pushed mainly by the popularity of FFVs and lower prices, while gasoline has remained at roughly the same level. Until 2010, ethanol prices were consistently lower than gasoline’s, despite a steady increase over the last seven years. Production-wise, ethanol has also shown an increase, not only in total numbers but also in productivity, with more sugarcane being produced out of each hectare of sugarcane.

These factors combined, increase in consumption, pushed by lower prices and maintained – so far – by an increase in production – have had a significant impact on

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77 Luiz Silveira, “Gasolina Abastecerá mais Carros Flex que Etanol”, *Brasil Economico*, March 24, 2010
Brazil’s gasoline’s imports. By becoming a more popular fuel choice, ethanol has allowed Brazil to maintain a practically inexistent gasoline import rate.

It is possible to say, then, that over the time period analyzed in this paper, ethanol has had a positive impact on Brazil’s energy security. It provided Brazil with an alternative and renewable domestic source, lowering Brazil’s dependence on oil and foreign exports.

Although so far ethanol has had a positive impact on Brazil’s energy security, it is important to observe its weaknesses. While many defend the biofuels source because it is a renewable one, unlike oil, this can be a threat to fuel supply. As shown in this paper, sugarcane crops are susceptible to natural occurring factors such as rain (excess and lack thereof,) heat and cold waves. Therefore, while it is a renewable source and unlike oil does not incur the risk of running out, it brings its own set of challenges due to its plant-based origins.

Another worrying trend for Brazil is that the country foresees that ethanol participation will increase to 75% in 2020. While for the ethanol industry this is a resounding victory, Brazil needs to be able to secure production and prices. Recent stumbles in ethanol supply pushed the prices up, with Brazilians turning to gasoline to fill their tanks. But once gasoline loses even more ground, this could lead to a fuel supply crisis like the immensely disruptive oil shocks of the 1970s. It doesn’t make sense to turn from overreliance on one source to another. Diversification is important here, as a means to guarantee that a country isn’t held hostage by energy supplies.
This paper has also shown the importance of the creation of solid fuel stocks. By letting the market dictate when it is more interesting for mills to sell their production, Brazil becomes vulnerable to any decrease in supply, as 2009 has shown. It is imperative that the government either creates its own fuel stocks, or gives the industry incentives to do so.

Everything seems to indicate that Brazil is aware of its challenges with ethanol and is working to address them. The development of new sources of ethanol, investment in infrastructure, and continued growth of the FFV fleet seem to indicate that ethanol will have a long and solid future in Brazil.


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