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Biodiesel in Brazil: A Market Analysis and Its Economic Effects

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Abstract

The commercial production of biodiesel in Brazil began in 2005 and increased in such a way that the country has become one of the largest producers in terms of volume in 2012. This study aims to analyze the biodiesel market in Brazil and its socio-economic effects resulting from the mandatory addition of biodiesel in the distribution system of mineral diesel. This work is characterized as a qualitative and exploratory study. The technical procedures adopted include literature research and data collection from government agencies involved. It is highlighted that the *Programa Nacional de Produção e Uso de Biodiesel no Brasil* - PNPB ("National Program for Production and Use of Biodiesel in Brazil") was designed for the purposes of: promoting rural development; the growth of biodiesel production plants; and positively impact the environment. The survey showed the following results: i) significant increase in investment in renewable energy, especially biodiesel, ii) a high unused capacity in the biodiesel production plants; iii) a high dependence on soy for biodiesel production, iv) unfavorable prices of oilseeds; v) high concentration of the biodiesel market; vi) difficulty in standardizing the biodiesel auctions; vii) a small increase in inflation; viii) increased generation of income, employment and Gross Domestic Product (GDP) due to the presence of biodiesel in the energy market. It was found that by adding a percentage of biodiesel to diesel oil caused positive impacts on the national economy, contributing to improvement in employment policies, income distribution, environmental issues, technological and regional development.

Keywords: biodiesel, market, Brazilian, economy effects, regional development, PNPB

1. Introduction

Brazil has considerable potential for renewable energy, these include: solar (photovoltaic and thermal), biomass (wood, agricultural residues, biodiesel, ethanol and some vegetable oils), hydroelectricity, biogas (sewage, garbage and manure) and wind energy (Lund, 2009; Takahashi & Ortega, 2010; Visser et al., 2011; Marchetti, 2012; Padula et al., 2012; Alonso-Pippo et al., 2013).

Several studies into the use of renewable energy have been made in recent years motivated by fluctuating oil prices as well as by concerns about climate change and the social and environmental aspects (Arent et al., 2011; Rathmann et al., 2012; Souza & Seabra, 2013; Hertel et al., 2013; Hassan & Kalam, 2013).

Initially it was observed that the relationship between economic and social development with the energy matrix is extremely complex and poorly understood. In the twentieth century, fossil fuel, especially oil, has formed the main basis for the primary global energy supply because they were abundant and capable of various applications. However, currently there is a greater emphasis on renewable or alternative energies (Pousa et al., 2007; Dermibas, 2009; Rovere et al., 2011; Janssen & Rutz, 2011; Schaeffer et al., 2012; Pereira et al., 2012; Timilsina

et al., 2013).

Global warming and global concerns about the environmental have put the energy debate on the political agenda and have created opportunities for diversification of energy sources and new markets (Pinho et al., 2009; Yusuf et al., 2011; Miyake et al., 2012; Kaercher et al., 2013; Pacini et al., 2013; Souza & Seabra, 2013; Mata et al., 2013). On the one hand, the costs of fossil fuels have increased, especially in the face of speculation around the scarcity of oil reserves. On the other, world oil reserves are unequally distributed and concentrated in the Middle East, where the geopolitical outlook is quite uncertain. These aspects are sources of uncertainties and distort expectations about the future energy market (Demirbas, 2009; Harvey & Pilgrim, 2011; Perdiguero & Jiménez, 2011; Atabani et al., 2012; Silva Jr., 2013).

The uncertainties of the energy scenario motivate and drive countries in the pursuit and development of alternative energy sources (Hall et al., 2011; Lora et al., 2011; Matos & Silvestre, 2013; Pao & Fu, 2013; Nogueira et al., 2013). For example, Brazil established the current National Program for Production and Use of Biodiesel (PNPB), inserting biodiesel into its energy matrix. The PNPB differs from other energy programs in that it includes family farms in the energy chain, empowered by law and regulations (Garcez & Viana, 2009; Vaccaro et al., 2010; Shahid & Jamal, 2011; Nogueira, 2011; Watababe et al., 2012; Bergmann et al., 2013).

The feasibility of biodiesel requires the implementation of an organized structure in every link of the production chain in order to achieve competitiveness in potential markets (Dermibas, 2011; Lin et al., 2011; Gold & Seuring, 2011; Ong et al., 2012; Borugadda & Gould, 2012; Padula et al., 2012; Bryngelsson & Lindgren, 2013). In this context, this paper aims to analyze the biodiesel market in Brazil, as well as to investigate the economic and social effects of biofuel production.

2. Methodology

Given the complexity of this subject, we examined in detail data, information and opinions derived from studies and existing knowledge on the biodiesel market. Our analysis was exclusively documental research. We adopted predominantly qualitative, descriptive and exploratory procedures.

The research is a formal procedure, with a method of reflective thinking, which requires a scientific treatment and it is on track to meet the reality or to find partial truths. Therefore, in order to establish the best methodological path that led to the expected results, this study has adopted the methodological approach proposed.

Documental research consists of primary research (collecting data from companies belonging to the biodiesel industry and government agencies involved in the research), secondary research (industry information available on the Internet) and a review of the literature (use of books, scientific articles, dissertations, periodicals and theses).

Regarding the way to approach the problem, this research is characterized by qualitative to be possible to understand the context of the situation studied, enabling the capture and interpretation of phenomena and assign meanings to these (Marconi & Lakatos, 2008).

The qualitative research is part of larger issues for understanding the phenomena that take shape as work progresses, which requires the consultation on different sources for data collection. Regarding the objective raised in this article, this research is exploratory due to allowing an increasing familiarity with the problem raised (make it explicit) and to be more flexible and informal, allowing researchers to seek more knowledge on the subject in perspective. The technical procedures adopted in the researches classified as qualitative and exploratory are broad and versatile (Gil, 2009).

Categories and variables analyzed in this article were: investments in renewable energy, biodiesel market in Brazil, marketing of biodiesel, price of biodiesel by region and economic effects of the production of biodiesel in Brazil.

The main sources were: Ministério de Minas e Energia - MME (Ministry of Mines and Energy), Agência Nacional de Petróleo, Gas Natural e Biocombustíveis - ANP (National Agency of Petroleum, Natural Gas and Biofuels), Instituto de Pesquisa Econômica Aplicada - IPEA (Institute of Applied Economic Research), Fundação Instituto de Pesquisas Econômicas - FIPE (Economic Research Institute Foundation), Fundação Getlio Vargas - FGV (Getlio Vargas Foundation).

3. Considerations About the Renewable Energy Market

3.1 Renewable Energy and Biodiesel Markets

Traditional energy resources and fossil sources are increasingly in demand all over the world. However, there is

a much debate about the need for alternative energy sources in the face of global warming issues and energy security (Arent et al., 2011; Giraçol et al., 2011; Timilsina & Shrestha, 2011; Queiroz et al., 2012; Lucia et al., 2012; Linares & Pérez-Arriaga, 2013).

A summary of global investment in renewable energy, the average rates of growth in clean energy, the production of Brazilian and world biodiesel are presented. The levels of installed capacity and unused capacity, the biodiesel prices and trading, the ways in which biodiesel auctions are conducted in relation to the Brazilian market will also be examined.

3.2 Investments in Renewable Energy

It is important to highlight the amount of investment that was made in the world renewable energy market between 2004 and 2012. In 2011, there was an investment of 279 billion dollars in the sector, a 23% increase over the previous year, according to Figure 1. In 2012 there was a dramatic change, with only 244 billion dollars of investment, which represented a 12.5% decrease with respect to 2011. Europe and China were the most significant investors, together accounting for 60% of the world total in 2012, though it was the weakest year in Europe since 2009. The top ten (10) countries that invested in renewable energy were: China, with $ 64.7 billion, followed by United States (U.S. $ 34.2 billion), Germany ($ 19.8 billion), Japan (U.S. $ 16 billion), Italy (U.S. $ 14.1 billion), United Kingdom ($ 8.8 billion), India (U.S. $ 6.4 billion), South Africa ($ 5.7 billion), Brazil (U.S. $ 5.3 billion) and France ($ 4.6 billion) (REN, 2013).

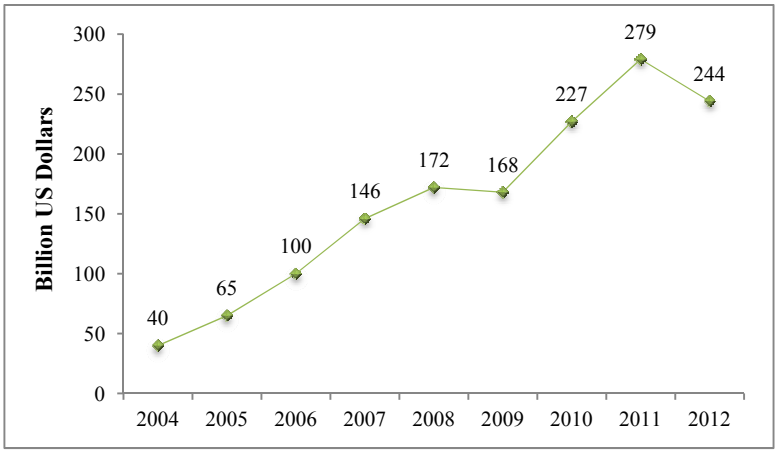

Figure 1. Investments in renewable energy in the world - 2004 to 2012 - billion US dollars

Source: Own elaboration based on: REN (2013).

The global market for renewable energy has been recovering after a global recession in 2008/2009, with growth varies according to advances in technologies, (Sorda et al., 2010). REN (2013) observed that the market for solar energy has shown consecutive increases in investment in the past five years. This same report showed a 0.5% and a 1.3% decrease in the production of ethanol in 2011 and 2012 respectively. Biodiesel grew by 16% in 2011, but in 2012 there was only a small increase of 0.4% (as shown in Figure 2) due to global agro-economic problems.

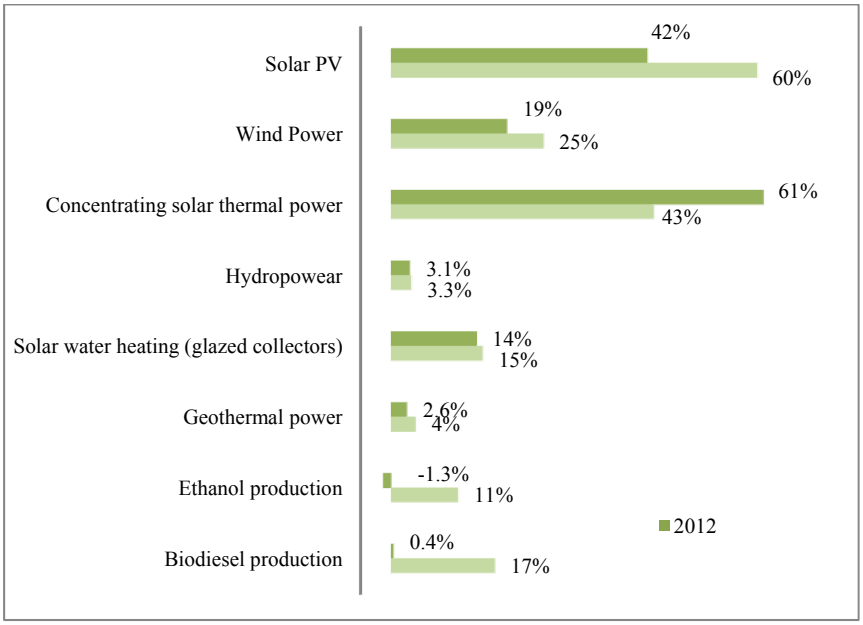

Figure 2. Average annual growth of renewable energy and biofuels, 2007-2012

Source: Own elaboration based on: REN (2013).

In 2012, ethanol and biodiesel production globally was 83.1 billion and 22.5 billion litres, respectively, as shown in Figure 3 (REN, 2013). There were consecutive increases in ethanol production during the period 2000-2010, but this decreased in 2011 and 2012 due to issues of investment post the 2008/2009 crisis combined with unfavorable weather and high world sugar prices, and other effects (Rajcaniova et al., 2013; Gorter et al., 2013).

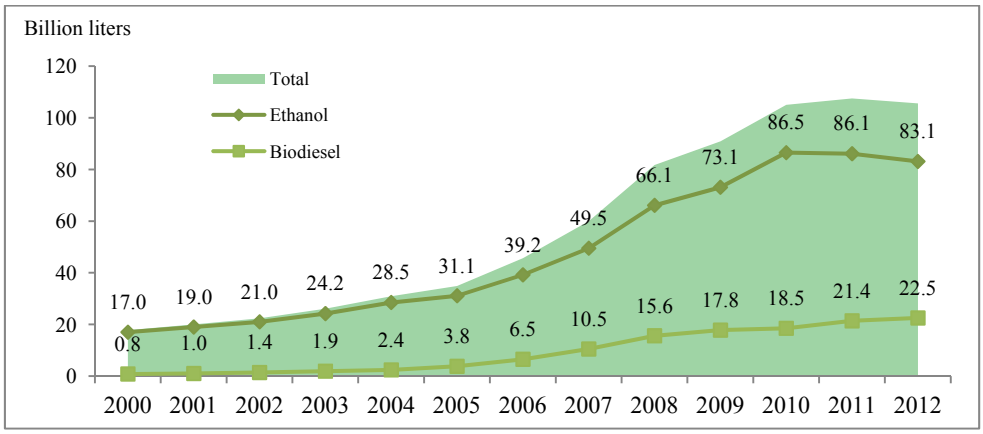

Figure 3. Global production of ethanol and biodiesel, 2000-2012

Source: Own elaboration based on: REN (2013).

With strong growth in the last twelve years, biodiesel production stands out on the world scene with an increase in production of 2,812%, thus growing on average 235% per year as shown in Figure 3. The five largest producers of biodiesel in 2012 in rank order were: United States, Argentina, Germany, Brazil and France (REN, 2013).

3.3 The Status of Brazilian Biodiesel

The Decree 5297 on December 6, 2004 (BRAZIL, 2004) provided the definitions of "biodiesel", "Producer or Importer of Biodiesel" and the institution of the *Selo Combustível Social* – SCS ("Social Fuel Seal"), granted by the Ministério do Desenvolvimento Agrário – MDA ("Ministry of Agrarian Development"), for biodiesel producers who purchase seeds and ensure technical assistance and training to farmers. The main advantages are:

lower federal taxes (PIS/COFINS and PASEP) varying according to the seeds purchased and the region; commercial incentives and financing, and participation in the auctions related to 80% of the volume. 20% of the auctioned volumes are also intended for plants that do not have the SCS. In return, the producer makes commitments to purchase a minimum percentage of raw material from family farmers or their respective cooperatives, and ensure training and technical assistance to contracted farmers.

In summary, the SCS is an identification mechanism granted to biodiesel producers to promote regional development tied to improving social inclusion through the generation of employment and income for family farmers or their cooperatives in the *Programa Nacional de Agricultura Familiar* - PRONAF ("National Program for Family Agriculture").

Established by Normative Instruction No. 01 of 5 July 2005 (MDA, 2005) SCS was the result of a joint effort between the government, represented by the MDA ("Ministry of Agrarian Development") and different institutions linked to family farmers. This allows the biodiesel plants to participate in the auctions promoted by the Agência Nacional de Petróleo, Gás Natural e Biocombustíveis – ANP ("National Agency of Petroleum, Natural Gas and Biofuels") and Petrobras.

In the period 2005-2012, several changes were made regarding the compulsory minimum percentage of acquisition and the requirement of raw material from biodiesel production plants with SCS as shown in Table 1 below.

Table 1. Minimum percentages for compulsory acquisition of the purchase of raw materials for the Brazilian region

Brazilian Regions	***NI 05/05/2005***	***NI 09/02/2009***	***NI 06/20/2011***	***Ordinance 06/09/2012***
	2005	**2009**	**2011**	**2012**
Northeast	50%	30%	30%	30%
Southeast	30%	30%	30%	30%
South	30%	30%	30%	30%[3] / 40%[4]
North	10%	10%[1]/15%[2]	15%	15%
Midwest	10%	10%[1]/15%[2]	15%	15%

Source: Own elaboration based on: MDA (2005); MDA (2009); MDA (2011a); MDA (2012);

Notes of period harvest: [1] 10% to the 2009/10; [2] 15% to the 2010/11; [3] 35% to the 2012/13; [4] 35% to the 2013/14.

In Brazil, currently (as of October 2013) there are 59 plants authorized to produce and commercialize biodiesel through the sales system of auctions. In the 8 years since the effective implantation and execution of the PNPB in 2005 several features in performance of this program can be observed. First, it should be emphasized that the program almost instantaneously led to the birth of the Brazilian biodiesel industry. In this short period, the program achieved the establishment of an industrial playground with an installed capacity of 7,243 billion liters per year (as of April 2013), as shown in Figure 4. 86% of this capacity is from companies that have the Social Fuel Seal (MME, 2013a).

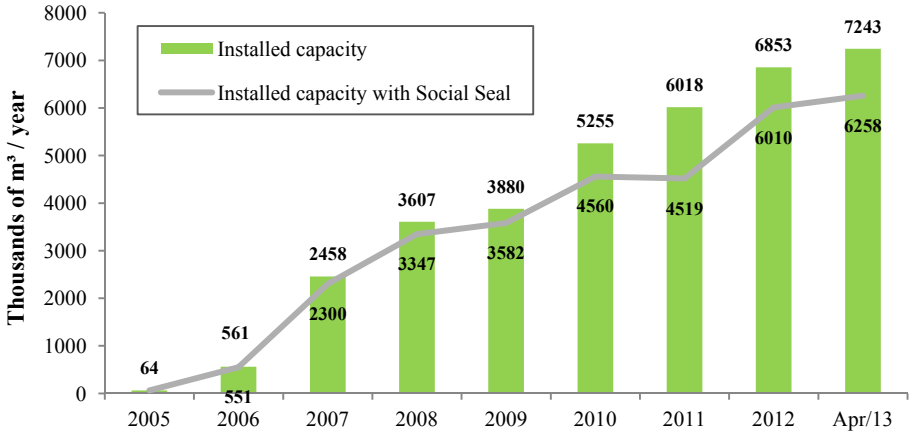

Figure 4. Installed capacity of biodiesel production in Brazil

Source: Own elaboration based on: MME (2013a).

Since January 2005, with law 11.097/05 (BRAZIL, 2005), refiners and distributors were allowed to add 2% biodiesel to diesel (B2), as illustrated in Figure 5. In January 2010, given strong pressure from agents and producers, the government revised the blend to B5, creating an average demand of about 2.5 billion liters of biodiesel per year (ANP, 2013a).

Figure 5. Timeline of the introduction of biodiesel into the Brazilian energy matrix

Source: ANP (2013a).

4. Results and Discussion

4.1 The Structure of the Biodiesel Market in Brazil

With the increasing demand for B5, Brazil has become one of the largest producers and there is no threat of supply shortage in the short term, provided the legal conditions prevail. On the contrary, to date there has been excess capacity of approximately 55%, 56% and 40% in 2010, 2011 and 2012, respectively, as shown in Figure 6. It should be noted that these indexes reflect the very heterogeneous reality in this industry, as there are few plants recording high rates of use, some below 30%, and many plants have not produced anything yet, approx 35 plants (MME, 2013b).

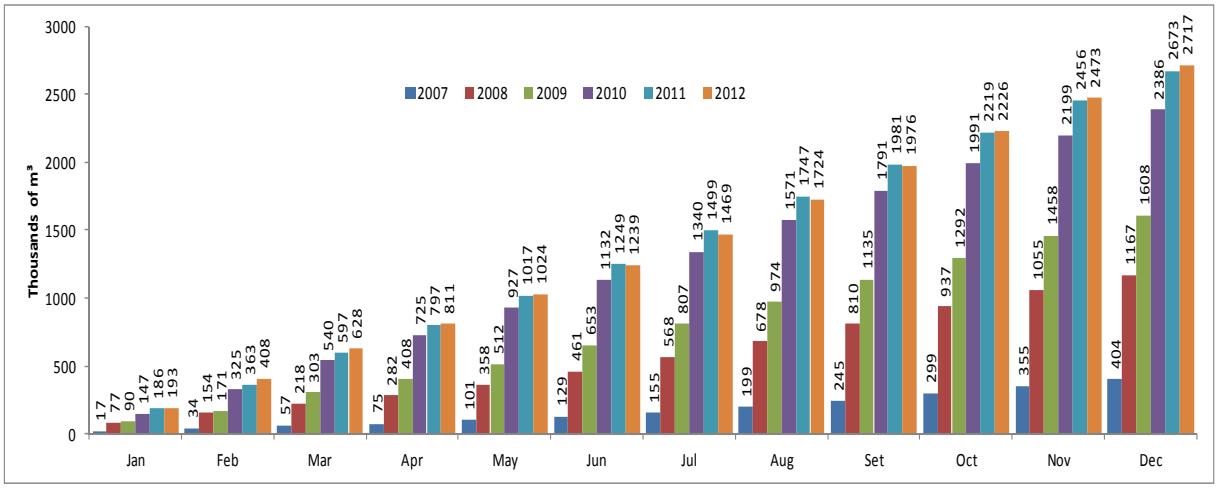

Figure 6. Cumulative Production of biodiesel from 2007 to 2012 (thousand m^3)

Source: Own elaboration based on: MME (2013b).

According to data from April 2013, regional production was distributed as follows: Midwest (41.9%), South (33%), Southeast (10.6%), Northeast (11.7%) and North (2.7%) (MME, 2013a). These results are due to the location of plants in Brazil because 87% are in regions of the Midwest (CO), Southeast (SE) and South (S) and while the North and Northeast, with 3% and 10%, respectively, as shown in Figure 7 (MME, 2013a).

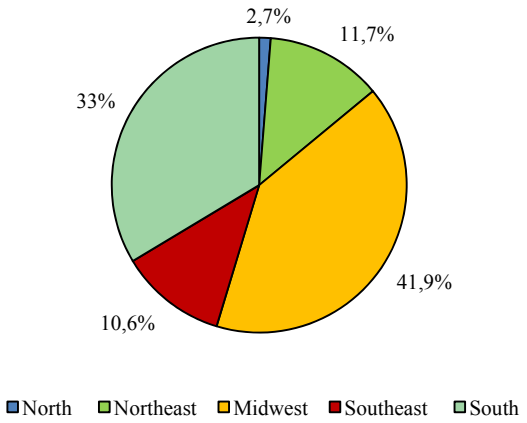

Figure 7. Participation in the production of biodiesel (%): Regions (April 2013)

Source: Own elaboration based on: MME (2013a).

Most biodiesel in Brazil is produced from soybean oilseeds, which accounted for 75.2% of the total production 2012. The other raw materials used to produce biodiesel in 2012 were animal fat, cotton and other fatty substances, representing 17.2%, 4.5% and 3%, respectively, as shown in Figure 8 (MME, 2013a). From January to April 2013, the three main raw materials were: 69.3% (soybean), 21.1% (animal fat) and 4.0% (cotton), as shown in Figure 8 (MME, 2013a).

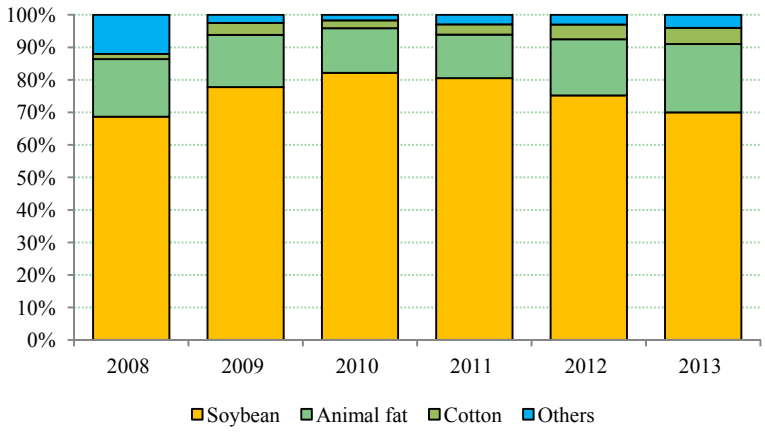

Figure 8. The raw materials used for production of biodiesel

Source: Own elaboration based on: MME (2013a).

According to data from the *Instituto de Pesquisa Econômica Aplicada* - IPEA (Institute of Applied Economic Research) (2012) in 2011 the 10 largest companies in the industry with the Social Fuel Seal produced 74.5% of total production. This data shows a strong market concentration, considering that the top 20 companies accounted for 94.9% of the total biodiesel offered in the Brazilian market from 2008 to 2011. Most of these companies belong to agribusiness soy and beef tallow (IPEA, 2012).

The use of soy as the primary oilseed designated for biodiesel production is in line with the supply chain already established in the country, as well as all the defined logistical complexes from production to marketing which have existed for several decades. The Southeast region of Brazil is home to 18% of the nation's cattle and was responsible for producing 80% of biodiesel from beef tallow. Most companies have a vertical production chain model (ANP, 2013c).

However, as shown by Padula et al. (2012), plans to diversify the raw materials used for the production of biodiesel and also to improve production in the poorest regions of Brazil have failed to prosper as projected at the start of the program. Additionally, on a global level, several authors have evaluated the life cycle of biodiesel from soybeans and have concluded that soybeans are not the most sustainable product in all circumstances considered. This is because the energy produced from the life cycle depends on various climatic conditions, technological processes and agro-processing (Cavalett & Ortega, 2010; Milazzo et al., 2013). According to IPEA (2012), soybean has a high homogeneity and availability which are factors of great importance. However, it has a low oil yield (only 19% of the total mass), and it does not encourage regional distribution nor promotes socio economic development (IPEA, 2012).

The increase in soybean production and the consequent increase in grain crushing results in more production of bran, a compound widely used as animal feed. The oil extracted from the crushed soybean oil is edible. This suggests that the production of biodiesel can compete with the market of soybean oil destined for the food industry (Rathmann et al., 2010; Ajanovic, 2011; Borzoni, 2011; Murphy et al., 2011; Bankovic-Llic et al., 2012; Nogueira & Capaz, 2013; Garrett et al., 2013).

4.2 Marketing of Biodiesel in Brazil

The commercialization of biodiesel is carried out through auctions which are promoted and monitored by the ANP between the producer, refiner and distributor. One purpose of the auction is to ensure for the sale of biodiesel produced by the plants in a competitive market. A plant can produce its product knowing how much it can sell it for, reducing risk and therefore providing lower prices for the final consumers (Locatelli, 2008).

The auctions are set up in such a way that the ANP establishes a *Preço Máximo de Referência* - PMR (Maximum Reference Price) and the plants and/or distributors bid increasingly lower than the PMR. The winner of the lot at the auction is determined by who offers the lowest price.

By October 2013, 33 auctions had been held auctioning approximately 14,437,642 m^3 of biodiesel (ANP, 2013c). The data can be seen in Table 2.

Table 2. Summary of biodiesel auctions in Brazil conducted by ANP - 2005-2013

Year	Auctions	Volume Auctioned (m^3)	Optional Step up 2%	Mandatory blend			
				2%	3%	4%	5%
2005	1º (11/23/2005)	70,000	X				
	2º (03/30/2006)	170,000	X				
2006	3º (07/11/2006)	50,000	X				
	4º (07/12/2006)	550,000	X				
	5º (02/13/2007)	45,000	X				
2007	6º (11/13/2007	304,000		X			
	7º (11/14/2007)	76,000		X			
	8º (10/04/2008)	264,000			X		
	9º (11/04/2008)	66,000			X		
	10º (08/14/2008)	264,000			X		
2008	11º (08/15/2008)	66,000			X		
	12º (11/22/2008)	330,000			X		
	13º (02/27/2009)	315,000			X		
	14º (05/29/2009)	460,000				X	
2009	15º (08/27/2009)	460,000				X	
	16º (11/17/2009)	575,000					X
	17º (03/01/2010)	565,000					X
	18º (05/27/2010)	600,000					X
2010	19º (09/02/2010)	615,000					X
	20º (11/17/2010)	600,000					X
	21º (02/16/2011)	660,000					X
	22º (05/24/2011)	700,000					X
2011	23º (08/24/2011)	700,000					X
	24º (11/21/2011)	647,000					X
	25º (02/27/2012)	679,400					X
	26º (04/06/2012)	768,939					X
2012	27º (09/18/2012)	773,324					X
	28º (12/06/2012)	496,308					X
	29º (01/02/2013)	517,357					X
	30º (04/05/2013)	488,532					X
2013	31º (06/07/2013)	515,400					X
	32º (08/05/2013)	524,836					X
	33º (10/29/2013)	521,546					X
Total – 1º to 33º		14,437,642					

Source: Own elaboration based on: ANP (2013c).

The empirical analysis of biodiesel auctions is difficult because of their particularities. Firstly, there have been several drastic changes in the way they are carried out. For example: the 1st to 7th and 17th to 25th auctions were conducted online. From the 8th to 16th personal attendance was required and currently the suppliers make their bids online using a specific electronic system for this purpose. It is common for adjustments to occur for

each new auction because of the very development of the system, changes to the bidding rules, the regulation of the auction, the delivery schedule and other items of negotiation.

By the 25th auction biodiesel had been commercialized in two steps. The first, conducted by ANP, the biodiesel plants offer the B100 to Petrobras refineries and Alberto Pasqualini Refinery - REFAP, which is a subsidiary of Petrobras itself, i.e. sales concentrated on two buyers. Then a re-auction occurred, that is, the reverse auction between cited refineries and distributors of diesel in the country.

From the 26th auction, decree nº 276/2012 (MME, 2012) eliminated the re-auction from the refinery. Therefore, as of the middle of 2012 (26th auction), the commercialization of biodiesel started being done directly between plants and distributors. Currently distributors may choose which plants they want to buy biodiesel from. It is believed that this change it will reduce the costs of transport because diesel distributors can choose the best conditions in terms of logistics

In the 30th auction held by the ANP, in March 2013, to supply the market during the third quarter of 2013., 44 plants were accredited by the ANP to offer bids according to "maximum reference prices" (PMR), with a total amount of 750,300 m³. In the next phase of the auction 488.5 thousand m³ were sold from 38 production plants at the national average price of R$ 1.98 per liter, without considering the purchaser margin of R$ 0.05 per liter, already included in federal taxes (PIS/COFINS and PASEP). Financial transactions from this auction were of the order of almost R$ 1 billion (MME, 2013c).

The total volume traded in this auction of 480,300 m³ liters will be supplied by plants possessing the Social Fuel Seal, which is exactly 98.3% of total sales. Figure 9 below shows the traded volume and average selling prices grouped by region within Brazil (MME, 2013b).

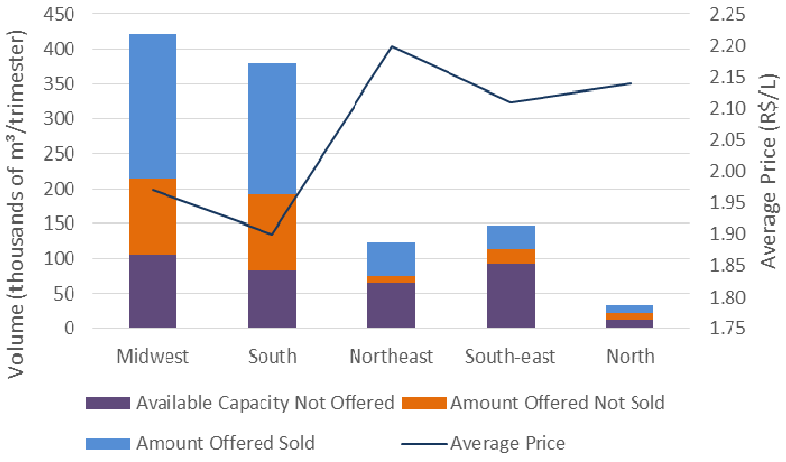

Figure 9. Volume and average price of biodiesel by region

Source: Own elaboration based on: MME (2013b).

According to IPEA (2012) there are some major problems to be overcome in biodiesel production in Brazil. These are the low level of diversification of the raw materials and the high cost of the raw materials currently used. Vegetable oils account for around 80% to 85% of the cost of production. Observing the international prices of major vegetable oils, shown in Figure 10, the average price for soybean oil is in the order of R$ 2.00/liter, canola oil R$ 2.30/liter, sunflower oil R$ 2.70/liter and palm oil around R$ 1.50 / liter. However, palm oil is not on a sufficient production scale to meet current regulations (MME, 2013a).

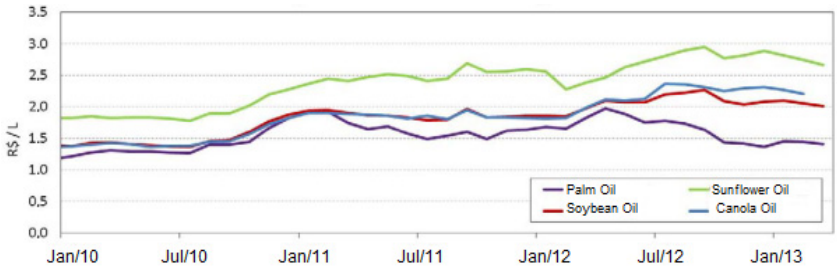

Figure 10. International prices of vegetable oils

Source: Own elaboration based on: MME (2013a).

From the data presented it should be said that the biodiesel market in Brazil is undergoing many difficulties, among them financial issues, because most of the international prices of vegetable oils (per liter) are higher than the prices per liter of biodiesel charged at auctions. This can be explained briefly as follows: i) the volatility of fluctuations in the commodities market with constantly varying yields and prices, ii) the existence of competition from large integrated industry players; iii) biodiesel plants are operating at a loss due to inefficient business plans iv) and above all the regulation pressure of the operation of the Social Fuel Seal and the mandatory delivery of the product offered in the auctions because the plants need to comply with agreements in order not to be penalized or disaccredited by the ANP.

4.3 Economic Effects of the Production of Biodiesel in the Brazilian Economy

Brazil's challenge is how to avail the opportunities of an environment conducive to the expansion of the biodiesel program. However, it should be emphasized that the biodiesel market provides positive and negative externalities for the Brazilian economy. A study by the *Fundação Instituto de Pesquisas Econômicas* - FIPE ("Economic Research Institute Foundation") in 2012 demonstrates the increase in inflation as the main negative effect resulting from the increase in the price of the product having an effect on the subsequent chain. However, research conducted by Fundação Getúlio Vargas - FGV identified no significant impact on inflation due to the process of adding biodiesel to diesel because they found only a small impact on consumer inflation projections with respect to the biodiesel blend up to B20 (FGV, 2012). There is also a positive effect on the development of the Brazilian agro-industry for biodiesel production, which directly replaces imported mineral diesel. However, according to Rathmann et al. (2012) from the viewpoint of reducing the outflow of currency, due to the potential demand for imported diesel, the option to import methanol instead of producing ethanol will cause an imbalance.

At this juncture, results and losses are integrated into the production system of biodiesel on a large scale, so it is important to check what socioeconomic impacts have been generated in recent years since the inclusion of the biodiesel blend (Santos & Rathmann, 2009). The study by FIPE (2012) analyzed the following impacts: inflation, reduction in oil imports, increase in soybean meal production, reduction in soybean oil, the financial effect on the Gross Domestic Product (GDP) and employment, as per Table 3 below.

Table 3. Impact on GDP (in millions of R$, 2011) and employment (in equivalent/man/year), 2008-2011

Year	Biodiesel Content	Increase in inflation	Impact of inflation on GDP	Reduction of diesel imports	Increased production of soybean meal	Reduction of soybean oil	Total effecton GDP	Jobs
2008	2.43%	0.030%	-1,408	2,278	2,192	-635	2,427	24,660
2009	3.38%	0.056%	-2,417	1,991	1,360	-2,414	-1,480	22,890
2010	4.54%	0.051%	-2,563	3,099	4,654	-1,221	3,969	60,130
2011	4.90%	0.037%	-2,153	4,155	5,894	-736	7,159	86,112

Source: Own elaboration based on: FIPE (2012).

First, the impacts on GDP were analyzed by calculating the benefits to agro-industrial development. The results showed that in 2011 an increase in GDP of R$ 7.16 billion was obtained taking into account a rate of inflation of

0.037%. In addition, there was an estimated increase of more than 86 thousand direct and indirect jobs as a result of the agro-industrial production of biodiesel in the same year. These results are due to the low reduction in aggregate demand and the low rate of inflation (0.037% in 2011) caused by the increased mandatory percentage of biodiesel in mineral diesel. But again, according to Rathmann et al. (2012) their analysis showed that the generation of jobs in the agricultural sector has been much lower than expected.

Second, the cumulative impact on GDP during the 4 years (2008-2011) was estimated at more than R$ 12 billion. Only in 2009 the result was negative, considering that in this period there was a decrease in the crushing of soybeans causing a reduction in supply to the market. In general, the economic point of view is that increased percentages of biodiesel in diesel have a small effect in reducing aggregate demand due to inflation. Additionally, increases in GDP are the result of decreases in imports of diesel and the additional production of soybean meal.

A scenario of gradually increasing the percentage of biodiesel in diesel to a goal of the B20 blend is vital to building the foundations of the industry's growth in the coming years. Determining a target volume is relevant to the development of the whole production chain, especially in relation to the volume of investment necessary, as well as increased production of raw materials. A larger volume of biodiesel production will result in increased investment. This will improve the perception of the return on investment and reduce the perception of risk on the part of all the links in the chain.

Some future prospects for FIPE (2012) were also analyzed by making simulations for the same items surveyed, but considering higher levels of biodiesel blend including from 7.0%, 10.0% and 20.0%. Significant results were found for the scenarios presented. With the use of B20, the increase could generate up to 460,000 new jobs with an increase in GDP of R$50 billion, according to Table 4 below.

Table 4. Impacts on GDP (in millions of R$, 2011) and employment (in equivalent/man/year), 2013, 2015, 2020

Year	Biodiesel Content	Increase in inflation	Impact of Inflation on GDP	Reduction of diesel imports	Increased production of soybean meal	Total effect on GDP	Jobs
2013	7.00%	0.053%	-3,316	6,398	10,374	13,456	132,642
2015	10.00%	0.075%	-5,113	9,863	15,972	20,722	204,615
2020	20.000%	0.161%	-12,316	23,064	38,303	49,051	459,690

Fonte: Own elaboration based on: FIPE (2012).

FGV (2012) published a study on the *Análise do Impactona Inflação do Aumento da Mistura de Biodiesel no Diesel* (Analysis of the Impact on Inflation with the Increase in Biodiesel in the Diesel Blend) in 2012 and analyzed the direct and indirect inflationary impacts caused by increasing the percentage of biodiesel in the diesel blend sold to end consumers in Brazil. They performed several simulations of the impacts of increasing the percentage of biodiesel in mineral diesel up to the value of 20% (B20) with respect to the main inflation indices including the IPCA (Note 1), IPA (Note 2), IGP-M (Note 3) and Transport Services (Note 4). The results are summarized in Table 5 below.

Table 5. Average Direct Impact on the IPCA, IPA, IGP-M and Transport Services

	Price in distributor (R$/liter) diesel	Impacton IPCA	Impacton IPA	Impacton IGP	Services of transport
B5	1.990	-	-	-	-
B6	2.000	0.00063%	0.01373%	0.00934%	0.11756%
B7	2.010	0.00063%	0.01366%	0.00929%	0.11696%
B8	2.021	0.00062%	0.01359%	0.00924%	0.11637%
B9	2.031	0.00062%	0.01352%	0.00920%	0.11578%
B10	2.041	0.00062%	0.01346%	0.00915%	0.11520%
B11	2.051	0.00061%	0.01339%	0.00911%	0.11463%
B12	2.061	0.00061%	0.01332%	0.00906%	0.11406%
B13	2.072	0.00061%	0.01326%	0.00902%	0.11350%
B14	2.082	0.00060%	0.01319%	0.00897%	0.11294%
B15	2.092	0.00060%	0.01313%	0.00893%	0.11238%
B16	2.102	0.00060%	0.01306%	0.00888%	0.11184%
B17	2.112	0.00060%	0.01300%	0.00884%	0.11129%
B18	2.122	0.00059%	0.01294%	0.00880%	0.11076%
B19	2.133	0.00059%	0.01287%	0.00876%	0.11023%
B20	2.143	0.00059%	0.01281%	0.00871%	0.10970%
Cumulative impact		0.00911%	0.19911%	0.13538%	1.71681%

Source: Own elaboration based on: FGV (2012).

The cumulative impacts are estimated for the various scenarios: the consumer price index (IPCA) changes 0.00911% and the transport services index increases 1.71681%

In summary, the study demonstrates that the scaling of increases in the blend, (scheduled over 15 years), will cause a smoothing of inflationary impacts annually. That is, IPCA would be in the range of 0.01% per annum and IPA would be slightly less than 0.03%, per year. The values for the IGP-M would range between the two above-mentioned indicators.

Based on the values studied, the FIPE research concluded that the increases outlined for the participation of biodiesel in the blend will not produce significant direct impacts on inflation.

5. Conclusion

The main drivers for bioenergy use are sustainability and security of energy supply. Secondary drivers can also be identified such as rural employment and new economic opportunities. Sustainability is mostly focused on mitigation of climate change and thus on reducing Green House Gas (GHS) emissions in comparison to fossil alternatives (Internation Energy Agency, 2012).

From the point of view of sustainability of the PNPB market, there are guidelines that are admirable, including the production of biodiesel through a variety of raw materials with the objective of promoting the inclusion of farmers in the biodiesel production chain, especially in the Northeast and Semi-arid Regions. However, the biodiesel industry is confronted with a huge unused capacity due to its high market concentration.

From the data presented it can be observed that the biodiesel market is undergoing strong acceleration which presents positive and negative scenarios. With respect to the points mentioned in the overall analysis, the following adjustments are required: it is necessary to i) diversify the raw materials used in production so as to exploit regional comparative advantages and greater regional integration in the biodiesel production chain, ii) regionally spread production, preferably using plants that are not related to the food sector with producers located closer to consumer centers, iii) improve the supply chain, logistics and technical service of oilseed production so as to improve viability of these raw materials for biodiesel production, iv) utilize the unused

current capacity, promoting a legal framework to expand the mandatory mixture of B5 to B10 and to B20 at some point in the future v) significantly increase investments in renewable energy; vi) improve the efficiency of commercialization via auctions.

As a result of this detailed research which specializes in various areas of knowledge, it was noted that there are other effects as well as other elements which should be addressed in future work.

Indirectly Brazil is already an important supplier of biodiesel (or feedstock) through re-export of soy biodiesel from the US to the EU. However, this does not seem to be the way of the future. Direct Brazil/EU trade of biodiesel or feedstocks must be a goal for the near future.

With the 6th largest GDP in the world, in the coming years Brazil will be developing its own biodiesel infrastructure and market that will demand large quantities of raw materials. Apart from soybeans, most of the biodiesel production options require more time to be developed, even though much progress has already been made, such as with Jatropha and Castor oil production.

Despite the potential in Brazil for oleaginous cultivation, and consequently feedstock for biodiesel production, there are challenges for setting up and consolidating a wide program of biodiesel use as fuel. The principal challenges and considerations focus on the technological, agronomic and infrastructure areas.

Technological perspectives

(*i*) Develop new processes of transesterification (heterogeneous catalysts, ethylic route, etc.), with the possibility of reducing by-products and costs with separation and purification of biodiesel

(*ii*) improve the product stability with the use of additives

(*iii*) optimize the industrial plants to obtain better control of continuous processing

(*iv*) improve the quality standard of biodiesel to avoid motor and environmental damage

(*v*) investigate new uses for glycerin

(*vi*) evaluate and control the quality of vehicle emissions in engines using biodiesel as fuel.

Agro-economic perspectives

(*i*) Plan and execute an ecologically sustainable agricultural zoning of oleaginous cultivation

(*ii*) Assure supply of raw material with minimal costs to the producer

(*iii*) Establish financial support to expand the cultivation of oil plants

(*iv*) Develop research to select new varieties and systems of tilling with low environmental impact

(*v*) Intensify the search for genetic improvement of oil plants, with the purpose of increased productivity and oil yields for biodiesel

(*vi*) Develop technology to use the acidic castor bean and soybean as animal feed.

Infrastructure perspectives

(*i*) Improve transport and distribution infrastructure

(*ii*) Improve the connections in the production chain.

Environmental perspectives

(*i*) Reduce the emissions of harmful species (*e.g.* CO, particulate matter, sulphur compounds and toxic compounds);

(*ii*) Make a clear diagnosis on the environmental impacts of biofuel production and uses, along with its advantages and benefits.

Although it is clear that public pressure is already relevant for biodiesel distributors, at this moment there are no specific demands on the sustainability of biodiesel in Brazil. It can be argued that the official sustainability demands will focus heavily on GHG performance of biofuels as this is a primary driver for the existence of biofuels in the EU.

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Notes

Note 1. *Índice Nacional de Preços ao Consumidor Amplo* – IPCA (Broad National Consumer Price Index), produced by the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* - IBGE).

Note 2. *Índice de Preços ao Produtor Amplo* – IPA (Producer Price Index).

Note 3. *Índice Geral de Preços - Mercado* - IGP-M (General Price Index – Market).

Note 4. Prices of transport services (urban transport and freight).