The Brazilian biofuel alternative

Marcos Amatucci* and
Eduardo Eugênio Spers

Escola Superior de Propaganda e Marketing de São Paulo – ESPM,
Programa de Mestrado em Gestão Internacional,
R. Dr. Álvaro Alvim, 123, São Paulo, SP 04018-010, Brazil
E-mail: marcosamatucci@espm.br
E-mail: espers@espm.br
*Corresponding author

Abstract: Alternatives to fossil fuels require both appropriate technological development and subsequent adoption by consumers. While electric or hybrid automotives seem to be an international trend, the Brazilian automotive industry has instead pursued biofuels, i.e., ethanol and biodiesel. Notwithstanding its ecological advantages, certain negative elements may serve as a barrier to its widespread use, such as price, origin, and accessibility of both final product and raw materials. Using the new institutional economic framework, this study aims to identify factors that influence decision-making for the Brazilian economic agents. The study was conducted using document analysis and in-depth interviews with consumers, private agents, and experts related to biofuel production. We conclude that the Brazilian experiences with ethanol and biodiesel differ significantly from one another; the first has reached a mature level of sustainability, while the second is still dependent on institutional initiatives in order to develop fully. Implications and possible future generalisations of the Brazilian experience to other countries are discussed.

Keywords: automobile industry; biodiesel; biofuels; Brazil; consumer behaviour; consumer perception; ethanol; institutionalism; public policy.

Reference to this paper should be made as follows: Amatucci, M. and Spers, E.E. (2010) 'The Brazilian biofuel alternative', *Int. J. Automotive Technology and Management*, Vol. 10, No. 1, pp.37–55.

Biographical notes: Marcos Amatucci is Dean of the Business School and Coordinator of the International Management Post-Graduate program at ESPM-SP (www.espm.br/ppggi). His research fields are the automobile industry and subsidiary strategy.

Eduardo Eugenio Spers is a Professor at the International Management Post-Graduate Program at ESPM-SP. His research fields are agribusiness marketing and consumer behaviour.

1 Introduction

In the 90s, it became apparent that human kind needed to reduce carbon emissions and other pollutants associated with cars, mainly in large cities and metropolitan areas. Today, this remains a very tangible issue in public health, and one that can be measured in terms of hospital admissions due to respiratory problems, lost workdays, morbidity, and mortality (Miraglia, 2007).

The Brazilian Government, though it postponed the adoption of the S50 (50 parts per million of sulphur) diesel technology standard in metropolitan areas. The standard for São Paulo, the major metropolitan area in Brazil, is currently S500, but the diesel standard remains S2000 (respectively, 500 and 2,000 ppm of sulphur) in many parts of the country (Munhoz, 2008), has directly invested in emissions reduction through programs of incentive of biofuels production.

Biofuels are fuels obtained from vegetal renewable sources, such as sugarcane, maize, soybeans and several other types of seeds. The main biofuels used in Brazil today are ethanol and biodiesel. Ethanol is the combustible alcohol obtained from sugarcane (in Brazil) or maize (in the US); while biodiesel is a thick vegetable oil with combustible characteristics similar to those of the regular diesel, nevertheless, the present technology and supply allow only a partial use of this fuel, mixed with regular diesel.

Notwithstanding the fact that the use of biofuels such as ethanol and biodiesel offers proven results in terms of emissions reduction, consumer and producer behaviours apparently remain focused on short-term economic optimisation. When a citizen purchases any new ‘flex’ car, the owner receives a printed table that lists ethanol and petrol price combinations, in order to make a quick decision between the two fuels at any gas station. Several newspapers have also published such tables. The decision is made purely in terms of pricing and efficiency considerations. Similarly, producers react to breakeven prices of crude oil and alternative feedstocks.

In addition to the economic behaviour of the agents, various myths about the use of ethanol persist all across the world: its energetic and ecological balance, competition with food for land area, and potential food price hikes due to ethanol-related use of sugarcane in Brazil and of corn in the US. This study aims to discuss the material and psychological barriers that prevent economic agents from more effectively adopting less polluting biofuels, as well as the decision-making processes of these agents regarding biofuel adoption.

2 Institutional arrangements

In order to make better decisions and to better address the main questions regarding alternatives and sustainable products such as biofuels, it is important to first understand the dynamics and the behaviour of economic and institutional agents at both the macro and micro levels. A characterisation of the Brazilian biofuel institutional environment under formal (laws and rules) and informal (traditions, perceptions, and behaviours) constraints (North, 1990) allows us to understand the incentives for adoption of biofuel technology. Also, the extent to which these formal and informal institutional constraints interact, when influenced by institutional arrangements. Formal and informal institutions provide incentives to individuals engaged in economic activities, in different levels (Alston et al., 1998).

For North (1990), the main role of institutions in society is to decrease uncertainty. Formal and informal constraints can establish a stable, but not necessarily efficient, structure for individual and organisational strategies and interactions. Depending on the structure of the institutional environment (institutional arrangements), there may be incentives for production of sustainable forms of energy such as biofuels (ethanol and biodiesel). This is the case in Brazil and is the topic we wish to explore.

Threats to the environment have prompted a new era of consensus and increased research into new uses of natural resources to reach higher levels of protection and sustainability using human and global modelling techniques (Goldemberg, 2000). All too often, limited natural resources are used to satisfy human desires and needs that are unconstrained (Milaré, 1994). Therefore, we would argue that institutional arrangements must motivate the pursuit of sustainable strategies and activities.

The prefix 'bio' has been used in names of processes to denote characteristics related to future biotechnology improvements (Enríquez, 2003). Such processes transform biological raw materials for industrial development and final consumer use. In the agro-energy sector, Brazil is one of the most important international players, with economic advantages both now and in the future. While ethanol from maize produces only 1.7 energy units per unit spent on production, in sugarcane ethanol this proportion is eight to ten units, as shown below.

Notwithstanding its ecological advantages, there are concerns about price, origin, and accessibility, both for the final product and raw materials. This study aims to identify factors in the formal and informal constraints of the Brazilian institutional environment that influence decision-making among the Brazilian producers, government, and consumers, regarding biofuel technology adoption. We will also describe the Brazilian ethanol and biodiesel alternatives in the context of car engines. Our main goal is to characterise the successful acceptance of biofuel in the Brazilian market by summarising the reasons for its adoption. Regarding informal institutional environment constraints, our specific goals are to assess attributes such as price, accessibility, and origin from the perspective of Brazilian consumers.

This paper focus on the four elements that a sustainable strategy could guarantee: economic, social, technological, and environmental benefits. All four dimensions are based on the positive viewpoint of correcting market failures and on the negative viewpoint of creating and capturing rents.

3 Methodology

The study analysed institutional and economical documents and secondary data, in order to characterise the macro institutional level. These data are analysed through classical economic concepts (market theory). In order to investigate the actual behaviour of economic agents in the biofuel chain, two types of data collection were conducted.

First, a sample of 37 individuals was taken into an exploratory research. The goal was to identifying important values in the informal institutional constraints regarding final consumer. The respondents were mainly professional drivers who use ethanol or common diesel in their vehicles. The researchers approached these drivers at three gas stations in São Paulo, inviting them to participate. They were invited to answer a two-part questionnaire containing 28 questions. One section featured questions about personal and social characteristics, and the other half asked about the importance of each biofuel attribute (laddering). The laddering method (means and ends) links attributes consequences and benefits, trying to mapping the deep structure of the consumer behaviour (Gutman, 1982; Reynolds and Gutman, 1988).

This technique assumes that very specific product attributes should be related to increasing levels of abstraction. The approach reveals the associations that consumers make between specific attributes, their functional or psychological consequences, and their values (Wansink, 2000). Our study requires using qualitative interrogation techniques to establish the links between elements that influence, affect, or predict events or outcomes (Ennis, 1999). This method is appropriate because it makes it possible to link green products like biofuels to the motivation to purchase, consistent with the various perceived risks.

Second, in order to investigate the perception of private organisations, a study was carried through in-depth interviews with 33 economic agents analytic chosen (theoretic sample) according to their involvement in the biofuel chain, in order to cover all its phases: farm production, industrial processing, distribution, and related product and services suppliers. The respondents were the company’s owners or general managers. The companies’ sizes varies from medium to large, including multinational corporations’ subsidiaries; and the products and services provided included: Brazilian seeds oil production, machinery manufacturing and sales, ethanol integrated production (sugarcane plantation and industrial plant), animal grease oil production, agribusiness cooperatives, and energy investment societies. Many of them define themselves as ‘renewable energy business’, and many participate in both food and energy businesses.

4 Biofuel world market

The traditional oil market was estimated by the Organization of the Petroleum Exporting Countries (OPEC) to be worth 84.7 million barrels per day in 2006 (OPEC, 2008) or 30.9 trillion barrels a year, equivalent to approximately US$1.2 quadrillion a year at US$40/barrel. If the maximum amount of petrol were extracted from this fossil-derived oil, it would represent 605 trillion gallons (2.29 quadrillion litres) of petrol per year.

World ethanol production in 2007 totalled 52 billion litres (not all is used as fuel; see Table 2 for biofuel production figures), while biodiesel was recorded at 10.2 billion litres. Global maize production represents 711 million tons, and sugarcane 1.3 billion tons per year. With current technology, these represent a ‘potential’ ethanol production rate (i.e., if all maize and sugarcane were converted) of 284 billion litres and 91 billion litres, respectively, according to the Food and Agriculture Organization of the United Nations (FAO, 2008).

It is clear that the oil market is much larger than the biofuels market. We must look at the magnitude of these figures in order to understand how international oil prices can put pressure on investments in biofuel production, and how the instability of international oil pricing leads to investor insecurity, preventing the biofuel market from growing without institutional help.

FAO (2008) estimated the 2006 breakeven oil price for profitable production of maize ethanol at US$58/barrel, and around US$38/barrel for sugarcane ethanol (these breakeven points will vary according to feedstock prices as well, but the oil market exerts more important effects). Table 1 shows the hypothetical potential of ethanol-for-petrol substitutions from different feedstock. Table 2 shows the production of ethanol and biodiesel *used as fuel* for the 15 most significant countries in 2006.

Table 1 Hypothetical potential for ethanol from principal crops

CROP	*Global area*	*Global production*	*Biofuel yield*	*Maximum ethanol*	*Petrol equivalent*	*Supply as share of petrol use (2003)*
	(Million ha)	*(Million tonnes)*	*(Litres/ha)*	*(Billion litres)*	*(Billion litres)*	*%*
Wheat	215	602	952	205	137	12
Rice	150	630	1806	271	182	16
Maize	145	711	1960	284	190	17
Sorghum	45	59	494	22	15	1
Sugarcane	20	1300	4550	91	61	6
Cassava	19	219	2070	39	26	2
Sugar beet	5,4	248	5060	27	18	2
Total	599	-	-	940	630	57

Source: FAO (2008, p.21)

Table 2 Biofuel production, top 15 countries, 2006

Country		*Ethanol*	*Biodiesel*
		(billion, litres)	
1	USA	18.3	0.85
2	Brazil	17.5	0.07
3	Germany	0.5	2.8
4	China	1.00	0.07
5	France	0.25	0.63
6	Italy	0.13	0.57
7	Spain	0.4	0.14
8	India	0.3	0.03
9	Canada	0.2	0.05
10	Poland	0.12	0.13
11	Czech Republic	0.02	0.15
12	Colombia	0.2	0.06
13	Sweden	0.14	-
14	Malaysia	-	0.14
15	UK	-	0.11
World total		39.0	6.0

Source: REN21 (2008)

According to the FAO (2008) report, ethanol from sugarcane in Brazil is an exception in terms of world ethanol production due to its lower production costs. No other ethanol production effort could compete with oil without subsidies, even if oil prices were very high. However, factors such as technological developments and feedstock prices may alter this situation in the future.

5 Antecedents of Brazilian biofuel production

The automotive industry, one of the first industries to internationalise, arrived in Brazil early in its internationalisation process: Ford entered the market in 1919 and GM in 1925. After WWII, with Brazilian Government incentives, VW commenced local production in 1953, and Fiat followed in 1974.

In 1973, the oil crisis hit the Brazilian economy, which was already indebted, suffering from high inflation and exhibiting a weak currency. At that time, Brazilian oil production was far lower than demand, and the country had to rely on oil imports for consumption and growth. The military government, which maintained a nationalistic ideology with regard to homeland security, put forward the traditional idea (which can be traced back to the early Republic foundation period) of substituting petrol consumption with ethanol, instigating the PROALCOOL (*Pro-alcohol*) program, officially sanctioned in 1975. The PROALCOOL program aimed to drive the production of dehydrated ethanol (99.5% pure ethanol), adding it to petrol at a rate that would not require engine modifications (a proportion between 10% and 15% or E10 and E15, respectively). Later, research showed that it can reach up to 25% with minor adaptations in the engine project. Technically, the resulting fuel is called 'gasohol'. This approach remains in effect today; Brazilian petrol is currently 25% ethanol (E25) and has been since 2007.

Together with this process, long-term research aimed to deploy an engine exclusively powered by ethanol, specifically hydrogenated ethanol (94.5% pure ethanol, the rest being mainly water). Urbano E. Stompf, engineer at the Instituto Tecnológico da Aeronáutica (ITA), furthered the work of Eduardo Sabino de Oliveira and Lauro de Barros Siciliano to develop the first Brazilian modern prototypes of ethanol powered engines in the automotive industry (Inovaunicamp, 2009).

The first exclusively ethanol-powered passenger car produced in Brazil was the 147 model from Fiat, in 1978. A protocol signed in the same year by President Figueiredo and automotive industry representatives invited all the other automakers into the program.

The production of ethanol-powered vehicles reached its peak in the middle of the 1980s, when more than 90% of passenger car production focused on ethanol powered engines. In 1989, however, ethanol demand surpassed its supply, causing shortages. Long lines appeared at petrol stations, causing mass consumer abandonment. This history continues to influence consumer behaviour even today. Eventually, international oil prices dropped to 'normal' levels, eliminating the economic advantage of ethanol for the consumer's wallet.

As a result, sales of new ethanol cars dropped to 4% in 1994 and 0.56% in 1996. Some small shops offered 'reconverting' services to turn ethanol engines 'back' to petrol during this period. These macroeconomic factors, allied with technical issues characteristic of innovative processes (weaker performance than traditional engines, lower efficiency, difficulties with cold starts, corrosion problems, etc.), caused ethanol engines to be seen as inferior by consumers (Kremer and Fachetti, 2000).

Even years later, with a regular supply and fully-developed technology (enhanced kilometre per gallon rate, although, still 30% less efficient than today's petrol engines, and delivering more horsepower than an equivalent petrol engine), the market was hesitant to adopt the exclusively ethanol powered engines. Ethanol-only cars gradually lost value in the secondary market (used cars), costing less than their petrol peers, and they practically disappeared from assembly lines.

Using technology that had been available in the USA since the 1980s, the hybrid bi-fuel petrol-ethanol engines ('flex', as they are called in Brazil) were brought to Brazil in the 1990s, eliminating forever both the market's fears about fuel shortages and the inconveniences of international oil price fluctuations. The VW Gol 1.6 litre, powered with injection technology from Magneti Marelli, was the first hybrid produced in large scale in Brazil, and was rapidly imitated by other players (Marotti de Melo et al., 2005). The latest figures from March 2009 indicate that 87% of all new vehicle number plates are registered to cars with flex engines (Automotive Business, 2009).

This new technology changed the process of choosing between ethanol and petrol. Before the 'flex' engine, it was a one-time and long-term decision as to which type of car to buy; now, it is a decision of which fuel to fill the tank with, a daily and non-durable decision that carries no consequence in terms of vehicle depreciation or resale pricings. It is purely a matter of immediate price and sustainability.

Sugarcane is the major Brazilian ethanol feedstock. It has been cultivated in Brazil since 1532, first planted by the Portuguese colonisers, who brought plants from the Azores, where they had long-term experience with this plantation. This species adapted very well in Brazil, and it rapidly spread along the coastline during the colonial period. Today, sugarcane is cultivated in several Brazilian regions, but mainly in the Northeast region and in the São Paulo state (both of which are relatively near the Atlantic shore). Contrary to common beliefs, the Amazon rainforest climate (of the North and Northwest regions of the country) is not appropriate for sugarcane culture.

Sugarcane is now the third major Brazilian agricultural product, after soybean and corn; it is responsible for 13.5% of the Brazilian energy matrix, though accounting for only 9% of Brazilian agricultural land usage (BNDES, 2008). After the termination of the PROALCOOL program in the 1980s, the business grew by itself, without any government subsidy to producers, though ethanol usage carries better tax incentives than petrol usage, which is taxed at a 44% rate (Brazil Institute, 2007).

On the biodiesel side, the military government also planned a biodiesel program in 1975; however, it did not take off. This program aimed to revive research that had started in the 1920s and was continued during the Second World War. The effort was officially revived in 1983 as PROÓLEO ('Pro-oil'), aiming at producing biodiesel from vegetal sources (cotton, canola, sunflower seed, soy, castor oil seed, and other native Brazilian seeds such as babaçu and several types of palms), and from animal oils. The program suffered with the international downfall of oil prices, and was discontinued by 1985. At that time, ethanol powered cars represented 76.1% of total fleet; but international oil prices drop from US$40/barrel to US$20/barrel and even US$12/barrel at the lowest point. The investments on biofuels and the ethanol offer decreased, resulting in an ethanol supply crisis, which leaded to a lack of confidence in the PROALCOOL program, and consumer abandonment of ethanol-powered models in favour of a return to petrol.

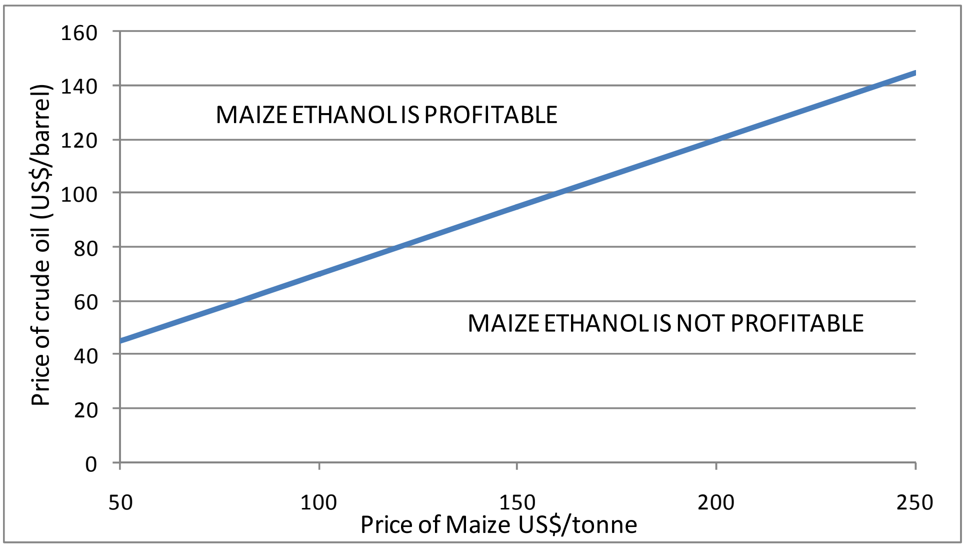
In the 1990s, the Gulf War raises the oil prices back to US$40.00/barrel; the Brazilian ethanol market is de-regulated, and in 1998 a minimum of dehydrated ethanol in petrol mixtures is regulated by law to 22% (maximum 24%).

In the 2000s, 'flex' technology is pushed ahead by Brazilian automakers, who try to benefit from the existing ethanol distribution channels. Ethanol market recovers. Te 'flex' fuel vehicles secure consumer confidence and the market share of ethanol vehicles skyrockets. On the other hand, E25 gasohol (petrol mixed with 25% of dehydrated ethanol) is established as a fuel standard for petrol in Brazil. In 2008, the price of a barrel of oil reaches US$ 130.00; and 'flex' fuel powered vehicles account for 85.6% of new cars.

6 Basic biofuel decision-making by economic agents

Available data suggest that the economic behaviours of producers and consumers are mainly driven by prices, and not by sustainability concerns. On the production side, producers decide to produce either biofuels or food based on the substitutability of fossil fuels, which will depend on international oil prices. Figure 1 shows the break-even levels for ethanol production in the USA based on the price of oil. Governmental subsidies for ethanol production would pull the curve down.

Figure 1 Breakeven prices for maize and crude oil in the USA (see online version for colours)

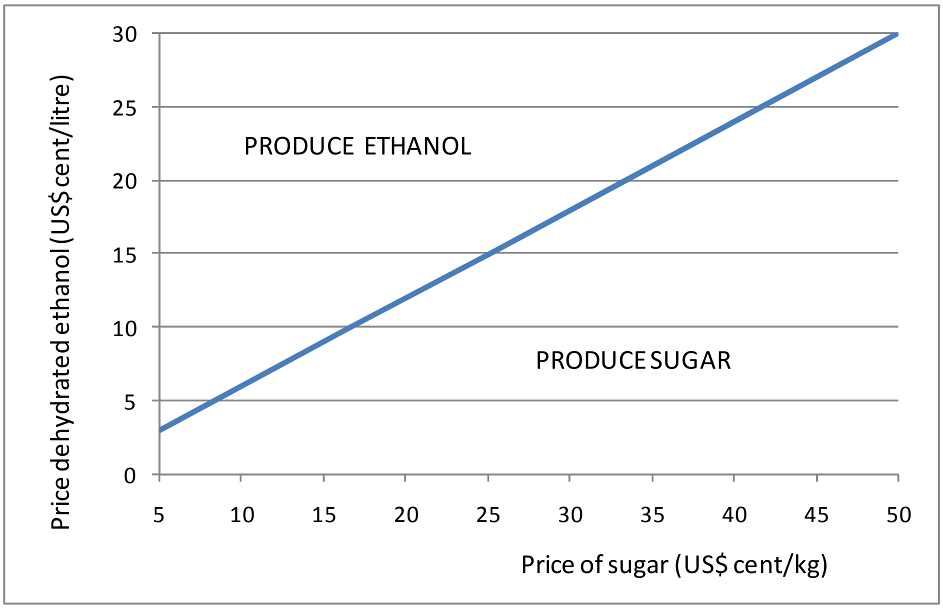


Source: FAO (2008, p.37)

In Brazil, producers decide between sugar and ethanol at production time, according to ethanol prices in the business-to-business market, which is also, influenced by government policies and in particular the levels of government security stocks. The indifference curve is shown in Figure 2.

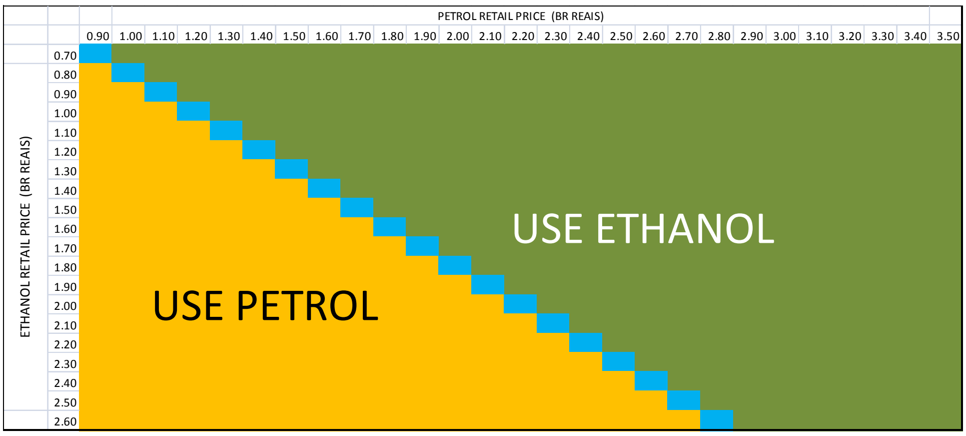
In other words, the decision to produce ethanol is influenced by crude oil prices and by competing feedstock prices.

Figure 2 Indifference prices for dehydrated ethanol and sugar production in Brazil (see online version for colours)



Source: Banco Nacional de Desenvolvimento Econômico e Social – BNDES (2008, p.55)

Figure 3 A consumer decision table intended for use at the petrol station (see online version for colours)



Source: Based on a General Motors do Brasil's table distributed to flex car owners.

The consumer who buys a 'flex' engine can decide which fuel to use at the pump, and there are variations within Brazil in both ethanol and petrol prices. Figure 3 is a copy of a standard table that is distributed by automakers (this one is based on a General Motors do Brasil's example) and newspapers in order to facilitate consumer decision-making, which are mainly economic (but anecdotal data suggest some inertia acquired by habit, i.e., a consumer may take some time to respond to changes in prices).

The international crude oil price that permits the economic production of ethanol in Brazil is currently around US$40.00 per barrel (Barbosa et al., 2009).

We note that the entire chain makes decisions according to traditional economic parameters, maximising utility. The parameters themselves are impacted by market forces (surplus or shortages in total production, consumption volumes and stocks), as well as the influence of governmental policies, such as subsidies to producers (in the USA) or petrol tax management in Brazil, which keeps petrol and diesel prices artificially high. Such governmental efforts aim to minimise the impact of international oil price variation on investors' decisions regarding the opening of new plants, the development of existing plants, and the promotion of technology research in this area.

Because this market is hugely sensitive to international oil prices, the very survival of the biofuel business in Brazil relies heavily on formal and informal institutional constraints. These are discussed below.

7 Formal institutional environment constraints: biofuel main characteristics in Brazil

The world demand for energy may increase at a rate of 1.6% per year until 2030, according to the International Energy Agency (IEA, 2009). At the same time, increases in production and the development of new energy alternatives are directly influenced by climate impacts. The challenge for national economies is to create an institutional environment that will increase the role of renewable and less polluting options such as biofuel. Bio-organic products can be used as energy resources, since they are derived from a natural biological process that relies on solar energy at its foundation.

Brazil has 850 million hectares of land, in addition to abundant solar irradiation and water resources to produce biofuels. Excluding the Amazon region and other areas, the available agricultural land area covers more than 300 million hectares. Only 70 million hectares are used for crop production. Sugar cane production, the main source of ethanol biofuel, accounts for less than 9% of the total agricultural land area, and thus, the potential for sustainable expansion is significant. Productivity may also increase and costs could decrease through investments in technology and logistical efficiencies.

In terms of crude oil production, Brazil became self-sufficient at the start of the 21st century. Today the nation produces an average of 2.25 million barrels per day. Brazil exports its petrol surplus; however, it depends on imports to meet the national demand for diesel.

7.1 Biodiesel in Brazil

In 2003, the Brazilian Government created a new program, the *National Program for the Production and use of Biodiesel* (PNPB), which required the mandatory addition of biodiesel to mineral diesel from 2007 on. The program initially required a 2% additive framework, with plans for gradual increases consistent with growth in national production (Masiero and Lopes, 2008). Half a year after the new mixing regulations were implemented, in August 2008, Brazil became the third largest world producer, after

Germany and the USA, with 41 operating plants and 52 in the process of being brought online by the government's National Oil Agency, the ANP (Inova Brasil, 2009).

The implementation and consolidation of biodiesel supply chains in Brazil is a result of incentives offered by the government. Operational management of the program is conducted by the Ministry of Mines and Energy. The main goal of the PNPB is to economically and sustainably promote the production of biodiesel. The stability of the institutional arrangement is guaranteed by several government acquisitions, and diversification in terms of raw materials is a key strategy moving forwards.

Initially, the program was designed to focus on small farmers who would supply a wide range of different raw materials for the vegetal oil production. This characteristic of the program was intended to provide 'social sustainability', according to the government definition of it. However, this goal was soon challenged by the inconsistent availability of these sources and by disagreements over contracts (mainly price-related). Consequently, the program was refocused on traditional and abundant sources like soybeans. The government has nevertheless expressed a preference to purchase biodiesel raw materials from small farms that are certified by the Social Fuel Seal.

The federal government has promised to purchase 315 million barrels of biodiesel fuel in the second half of 2009 in order to meet resolution number two of the National Council of Energy Politics. This legislation mandates a 3% addition of biodiesel to regular diesel for sale to consumers, increasing to 5% by 2013.

The challenge is to better explore the regional potentialities that are mainly produced by small farmers. Some examples of traditional cultures are peanut, sunflower, castor, palm, pequi, macauba, among others. In May 2009, the rate of biodiesel source from soybean was 81.3%.

We conclude that the Brazilian biodiesel program has not yet achieved true economic sustainability. Therefore, the government needs to provide several formal constraints to guarantee an increase in the amount of biodiesel that gets mixed with traditional diesel. There is also a gap in terms of achieving social sustainability. Technological efforts will likely continue to improve efficiency in the production of raw materials. Finally, the environmental sustainability benefits are related to a decrease in CO_2 emissions. In order to achieve the B20 (20% of biodiesel mixed with common diesel) target in Brazil, it would be necessary for 12.8 million hectares of agricultural land to be redeployed to produce raw material for 8 billion litres/year of biodiesel. In our view, this is a reasonable goal in the medium term.

In contrast, the FAOs (2008, p.51) simulation of the effect of the removal of all 'trade distorting' policies for biodiesel suggested that Brazil could enjoy a positive balance in favour of biodiesel, unlike all other tested countries.

7.2 Ethanol in Brazil

According to projections from the Brazilian Ministry of Mines and Energy, Brazil will increase its ethanol production by 150% by 2017, becoming the world's primary exporter of this product. According to this projection, Brazilian ethanol production will reach 64 billion litres, of which 8 billion will be exported. Over this period, planned investments in biofuels will total US$23 billion (compared with US$146 billion in oil and natural gas and US$83 billion in electric energy).

Differently from the biodiesel policy, ethanol production remains a capital-intensive process, relying upon technological investments and achieving production scale. The social benefits of ethanol production are associated with job creation and not, as in the biodiesel case, with focusing on small farmers. Sugar and ethanol together currently account for around 765,000 directly-related jobs, 93.8% of which are protected (UNICA, 2005).

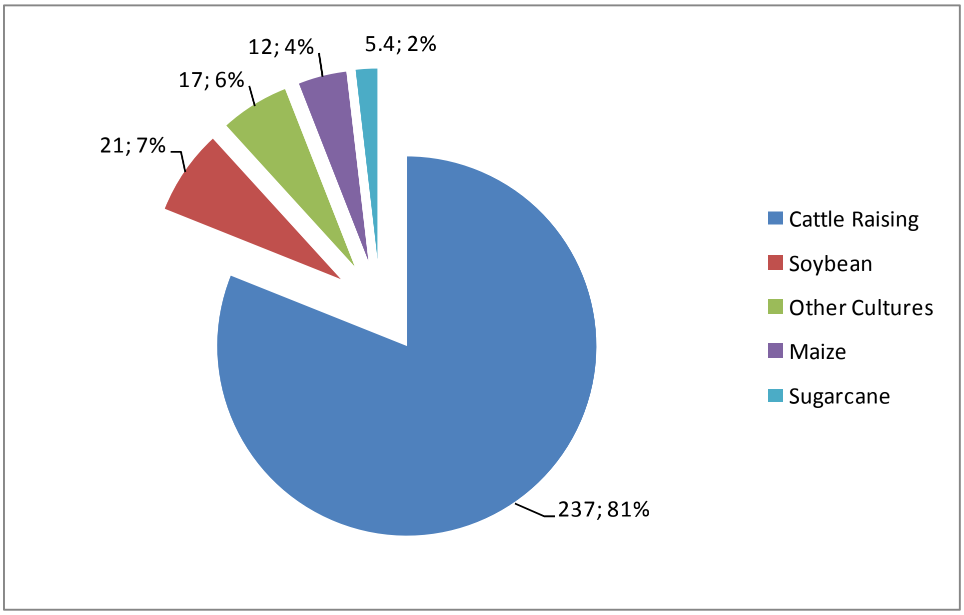
The ethanol value chain in Brazil has reached a maturity level that provides business competitiveness. The products and services provided by Brazilian enterprises along the supply chain support the creation of new businesses for ethanol production.

7.3 Four myths about Brazilian ethanol

Four issues are generally raised in discussions regarding Brazilian sugarcane plantations and ethanol: the risk of deforestation due to increasing sugarcane production, the food security problem; the greenhouse gases (GHG) balance of the ethanol value chain; and the peculiarities of the Brazilian experience that may make such scenarios non-generalisable abroad.

The total area dedicated to sugarcane production is currently less than 1% of Brazil's total land mass, or less than 9% of its cultivated grain land area. Sugarcane production is distributed as follows: 81.7% of all plantations are in the Centre-South region (Sao Paulo, Mato Grosso do Sul, Mato Grosso, Goiania, Minas Gerais and Espirito Santo), of which 60% are located in Sao Paulo, and the Northeast part of the country accounts for a further 18% of all plantation area. Therefore, 99.7% of sugarcane plantations are thousands of kilometres away from the rainforest.

Figure 4 Distribution of agribusiness land area in Brazil (millions of hectares) (see online version for colours)



Source: Lopes (2008a, p.20)

Figure 4 shows the distribution of land use in Brazil, including cattle production but excluding forests and urban areas. The primary land use remains the rearing of cattle (Brazilian cattle raising is traditionally 'extensive', i.e., the animals live loose occupying large areas). However, evidence shows that cattle raising is slowly going through an 'intensification' process (i.e., more animals are being raised in smaller areas): in Sao Paulo, livestock grew from 13,154,649 heads raised on 10,288,887 hectares in 2001 to 14,072,447 heads raised on 10,010,491 hectares in 2005, an increase in land area efficiency of 11%.

Sugarcane is the third Brazilian feedstock in terms of importance. However, it only occupies 5.4 million hectares, a relatively small area compared with other Brazilian agribusiness activities, namely cattle breeding.

Over the last eight years, most crop cultivation areas have grown, with the exception of corn (see Table 3), which has decreased as US production has increased.

Table 3 Crop cultivation evolution

Country	*Crop*	*2000*	*2004*	*2008*	*Average annualised growth*
Brazil	Sugarcane	4.6%	5.3%	7.0%	5%
	Soybean	13.5%	21.4%	21.0%	6.6%
	Maize	9.8%	9.5%	9.6%	(–0.7%)
USA	Wheat	25.3%	24.2%	25.6%	(–0.1%)
	Soybean	30.1%	30.5%	30.3%	(–0.7%)
	Maize	32.2%	32.8%	34.8%	1.6%

Source: Lopes (2008b, p.23)

Regarding energy-based and GHG balance equations; the net results are now positive and trending upwards as technology and the institutional environment improve. Table 4 shows the current energy balance as compared with 2002 and a projection for 2020. Table 5 shows the GHG balance, again compared with historic and projected data. The Macedo et al. (2008) study follows the FAO (2008, p.56) methodology used to analyse biofuel production balance. The resulting data are often cited in Brazilian economic reports as a reference (e.g., BNDES, 2008).

The total GHG emissions from ethanol production were calculated (by Macedo et al., 2008) as 401 kg CO_2 eq/m^3 for anhydrous ethanol in 2002 (436 in 2005/2006) and as a projected 345 kg CO_2 eq/m^3 for 2020. Hydrous ethanol accounts for approximately 97% of these emissions. These totals take into account fossil fuel-derived emissions from the ethanol production process (around 50%), waste incineration (to be eliminated by 2020), and soil emissions. The main pollution sources are waste incineration and the use of nitrogen-based fertilisers. However, there is a huge potential for technology development in the reduction of waste disposal and diesel use as well, in terms of making this process more environmentally acceptable.

We note that incinerating plant material after harvest ('waste burning' in the above study or 'queimada' in Portuguese) is a major problem in sugarcane plantation management that creates excessive GHG emissions. Despite the fact that this is not specific to ethanol production (since it has been a practice for more than 300 years in the traditional Brazilian sugar production process), it was precisely with the advent of ethanol production and its environmental associations that the institutional context began to change in this respect. Brazilian Law 11.241/2002 establishes that all sugarcane plantation burning will be suspended until 2021 in areas that can be mechanically harvested (terrain with slopes lower than 12% and no major irregularities), and all burning activity must be eliminated by 2031. In addition, a major Sao Paulo producers' association, UNICA, has signed a protocol with the state government to bring forward these deadlines to 2014 and 2017, respectively, in the state of Sao Paulo (Bouças, 2008). In Sao Paulo, 46.6% of sugarcane production is already mechanised, avoiding waste burning; the short-term goals are to reach 50% in Sao Paulo, and 35% in the Centre-South region by 2010.

Table 4 Energy balance and external flows (MJ/ton)

	2002	*2005/2006*	*2020 projection*
Sugarcane transport	201.8	210.2	238.0
Ethanol processing	49.5	23.6	24.0
Total input from crude oil sources	251.3	233.8	262.0
Ethanol production	1,921.3	1,926.4	2,060.3
Bagasse surplus	168.7	176.0	0.0
Electricity surplus	0.0	82.8	972.0
Total Renewable output	2,090.0	2,185.2	3,032.3
Renewable output/crude input:			
a Ethanol + bagasse	8.3	9.0	7.9
b Ethanol + bagasse + electricity	8.3	9.3	11.6

Source: Macedo et al. (2008, p.590)

Table 5 Avoided emissions (kg CO_2 eq/m^3)

	2002		*2005/2006*		*2020 projection*		
	Ethanol	*Gasohol*	*Ethanol*	*Gasohol*	*Ethanol*	*'Flex'*	*Gasohol*
Total avoided emissions	2,190	2,401	2,181	2,323	2,763	2,589	2,930
Use of biomass surplus	141	145	143	150	0.0	0.0	0.0
Electricity surplus	0,0	0,0	59	62	784	784	819
Use of ethanol	2,049	2,256	1979	2,111	1,979	1,805	2,111

Source: Macedo et al. (2008, p.591)

8 Informal institutional environment constraints: consumer perceptions of biofuel

Consumers see products in different ways, and develop positive or negative attitudes consistent with advertising and product information (Karsaklian, 2000). The adoption of an innovation such as biofuels is no different. Some innovations are rapidly adopted, while others take more time to gain acceptance (Sheth et al., 2001), depending, i.e., on relevant economic or environmental advantages.

To address the consumer perception and acceptance of biofuels, we assessed four of the attributes related to production and commercialisation. The first attribute was ethanol's contribution to pollution reductions as compared with diesel sourced from crude oil. For each attribute, we created an analytics diagram similar to that shown in Figure 5 (which represents the first attribute), based on consumers interviews using laddering technique (Gutman, 1982; Reynolds and Gutman, 1988). The diagram shows environmental concerns and their impact on future generations and their quality of life. It also emphasises the importance of knowledge about alternative fuels as organic products that are tied to nature preservation as well as to job creation in Brazil. We consider that a lack of information about environmental preservation is less problematic. Of course, the non-availability of less polluting products and a lack of consumer acceptance of biodiesel are inhibitory factors in its commercialisation.

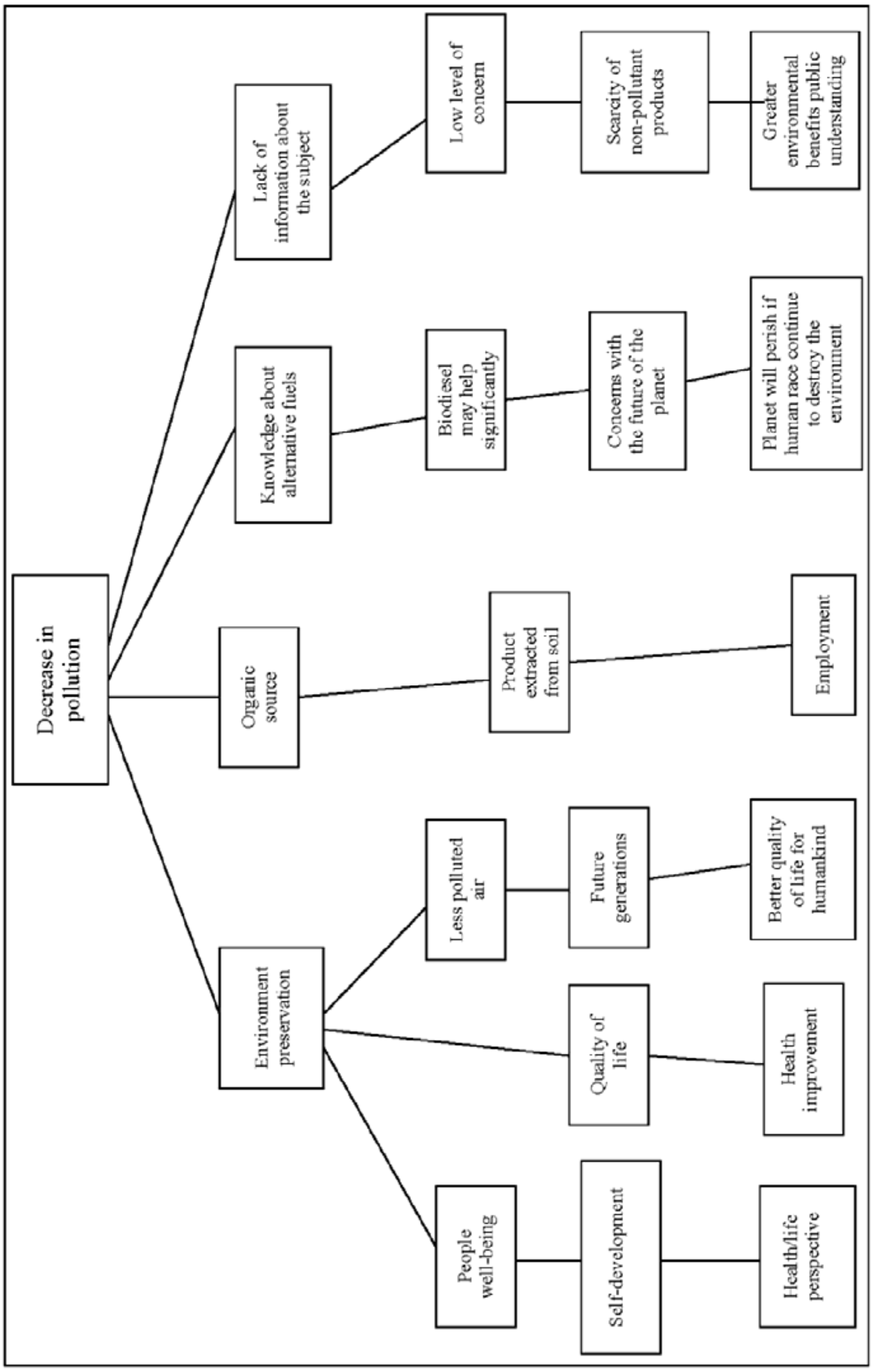
The second attribute analysed was Brazilian economic development due to the production and commercialisation of biodiesel. Most consumers will consider biofuels because of economic development, job creation, and improved quality of life standards for the Brazilian people. The wealth of the nation, cost savings, and superior consumer purchasing power are also related to the need for biodiesel, especially given the current global economic crisis.

Job creation in several economic sectors may benefit future generations in terms of fewer vicissitudes due to national development, better opportunities, and improved wealth creation and distribution. Consumers focus on general quality of life improvements for Brazilian society, and in particular for those undergoing economic hardship.

The fourth attribute relates to technological advances in biofuel production. This attribute is linked with Brazil's economic and social development, as well as tax reductions. Having biodiesel as an alternative to oil may also impact job creation and social development. Consumers believe that better technologies will lead to new vehicles, and an improvement in Brazil's global status. It may also lead to increased exports and better jobs creation, more affordable fuels, general economic improvement, and improved purchasing power and societal welfare. On the other hand, consumers are often concerned about abandoning diesel made from crude oil because it is a means of generating revenue for Brazil. This is true even though the main beneficiary is the government, due to the high taxes charged on oil derivatives.

We note a discrepancy between consumer statements (environment-driven) and actual practice (driven by economic factors). However, we only interviewed a few consumers in a qualitative manner, and our conclusions should be treated accordingly. Nadin et al. (2009) used the terminology 'rational' (saving money) and 'irrational' (personally contributing to pollution reduction) to describe these phenomena. In their quantitative study of natural gas adoption in Italy, they concluded that irrational thoughts are important; consumers want to feel proud about using natural gas because they are helping the environment.

Figure 5 'Means and ends' diagram for pollution reduction



We interviewed several experts, and learnt that perceived negative impacts of the production and commercialisation of biofuels may include food price hikes, technological challenges, high transaction costs or taxes imposed by the National Oil Agency (ANP), potential environmental damage caused by production inefficiencies, inadequate government surveillance and law enforcement, and a lack of planning and R&D investment. Positive comments focused on a reduction in diesel imports (which may be as high as 20% in the future), energy autonomy and security, improvements in the robustness of the economy, reductions of pollutants and GHG, accelerated R&D and innovation, and the potential to receive credits in the carbon market as made possible by the Kyoto Protocol.

9 Conclusions

We conclude that Brazil's biofuel industry faces two different phenomena – namely biodiesel and ethanol – with different dynamics and different levels of maturity that therefore require separate analyses.

Ethanol strategy is based on stable institutional constraints that promote economic, social, technological, and environmental sustainability. Brazil's biofuel value chain is fully developed, and Sao Paulo should be considered an ethanol cluster.

We believe that biodiesel still needs more intensive government intervention to motivate economic agents to invest appropriate resources into production.

Our informal perspective and analysis indicates that end consumers will always need economic incentives to buy a sustainable product. Our 'means and ends' (or laddering) approach helped us to identify certain values that are related to the attribute benefits of ecological fuels. We recommend further exploration of these ideas in the context of a public or private marketing strategy, using a more significant sample.

What part of the Brazilian experience can be 'exported' to other countries? There are several other countries with significant sugarcane production (currently, more than 100 countries could potentially produce sugarcane ethanol, some of which actually do), many of them with available lands for crop expansion and the ability to develop technology (such as India, China, Pakistan, Mexico, Colombia, and several African countries). 'Perhaps, the challenge to export the Brazilian sugarcane ethanol institutional experience depends upon a real positive signalling from buyer countries. Market signalling could involve both officially listing the use of ethanol among the measures to face GHG emissions; and reducing trade barriers for ethanol import, which are currently high in Europe and in the US.

The main lesson of the Brazilian ethanol experience is that it is possible to build an artificial market with institutional support that is sustainable, competitive, and profitable. However, not all potential sugarcane ethanol producers can afford developing the ethanol offer supported only by internal demand, as Brazil did. Regarding the technological capabilities of most of these countries, the uncertainness in demands prevents the public and private agents of investing in the sector.

In the automobile industry, the institutional analysis approach seems to be useful to generate insights for public policies and private strategies, and this type of approach could be used to analyse the formal and informal constraints associated with other types of alternative car energy adoption, such as electricity and hydrogen.

References

Alston, L.J., Eggertsson, T. and North, D.C. (1998) *Empirical Studies in Institutional Change*, Cambridge University Press, United Kingdom.

Automotive Business (2009) 'Veículos flex representam 86.7% dos emplacamentos', 10/03/2009, Internet document, available at http://www.automotivebusiness.com.br/noticia_det.asp?id_noticia=3026 (accessed on 20/03/2009).

Barbosa, M.Z. and Sachs, R.C.C., et al. (2009) *Mercado para Biocombustíveis*, Instituto de Economia Agrícola, Textos para discussão, TD-IEA no. 3.

BNDES (2008) *Bioetanol de Cana-de-Açúcar – Energia para o Desenvolvimento Sustentável*, Banco Nacional de Desenvolvimento Econômico e Social Report, BNDES, Rio de Janeiro.

Bouças, C. (2008) 'Mecanização ganha terreno na colheita de São Paulo', *Valor Econômico Especial – Energia para o Mundo*, Mai, p.34.

Brazil Institute (2007) *The Global Dynamics of Biofuels*, Brazil Institute Special Report, April, No. 3.

Ennis, C.A. (1999) 'Theoretical framework: the central piece of research plan', *Journal of Teaching in Physical Education*, pp.129–140.

Enríquez, J. (2003) 'A hora da bioestratégia', *HSM Management*, January, No. 36, pp.64–69.

FAO (2008) *The State of Food and Agriculture – Biofuels: Prospects, Risks and Opportunities*, Rome, Food and Agriculture Organization of The United Nations.

Goldemberg, J. (2000) 'Energia', in Trigueiro, A. (Ed.): *Meio Ambiente no Século 21: 21 Especialistas Falam da Questão Ambiental nas suas Areas de Conhecimento*, pp.173–180, Sextante, Rio de Janeiro.

Gutman J. (1982) 'A means-end chain model based on consumer categorization processes', *Journal of Marketing*, Vol. 46, No. 2, pp.60–72.

IEA – International Energy Agency (2009) April, available at http://www.iea.org/Textbase/stats/index.asp.

Inova Brasil (2009) 'Cadeia produtiva do biodiesel já é a 3ª maior do mundo, 15/08/2008, Internet document, available at http://inovabrasil.blogspot.com/2008/08/cadeia-produtiva-do-biodiesel-j-3-maior.html (accessed on 20/03/2009).

Inovaunicamp (2009) 'Motor a àlcool', Internet document, available at http://www.inova.unicamp.br/inventabrasil/caralc.htm (accessed on 02/03/2009).

Karsaklian, E. (2000) *Comportamento do Consumidor*, p.11 e 42–44, Atlas, São Paulo.

Kremer, F.G. and Fachetti, A. (2000) 'Alcohol as automotive fuel – Brazilian experience', SAE Technical Papers, 2000-01-1965, June.

Lopes, F. (2008a) 'Áreas voltadas á pecuária agora possuem canaviais', *Valor Econômico Especial – Energia para o Mundo*, Mai, p.20.

Lopes, F. (2008b) 'Protecionismo e segurança alimentar na ordem do dia', *Valor Econômico Especial – Energia para o Mundo*, Mai, p.23.

Macedo, I.C., Seabra, J.E.A. and Silva, J.E.A.R. (2008) 'Green house gases emissions in the production and use of ethanol from sugarcane in Brazil: The 2005/2006 averages and a prediction for 2020', *Biomass and Bioenergy*, Vol. 32, No. 7, pp.582–595.

Marotti de Mello, A., Vasconcellos, L.H.R. and Marx, R. (2005) *Estariam as Montadoras Abrindo Mão de Suas Competências Essenciais no Desenvolvimento de Motores? – Um Estudo de Caso do Primeiro Veículo Nacional Bicombustível*', ENANPAD. Anais do XXIX ENANPAD.

Masiero, G. and Lopes, H. (2008) 'Etanol e biodiesel como recursos energéticos alternativos: perspectivas da América Latina e da Ásia', *Revista Brasileira de Política Internacional*, Vol. 51, No. 2, pp.60–79.

Milaré, E. (1994) *A Participação Comunitária na Tutela do Ambiente*, Terragraph, São Paulo.

Miraglia, S.G.E.K. (2007) *Health, Environmental, and Economic Costs from the Use of a Stabilized Diesel/Ethanol Mixture in the City of São Paulo, Brazil*, Cad. Saúde Pública, Rio de Janeiro, Vol. 23, Sup 4:S559-S569.

Munhoz, F. (2008) 'Acordo adia redução de enxofre no diesel por quatro anos', São Paulo, Eco-Finanças, 04/11/2008. Internet Document, available at http://ef.amazonia.org.br/index.cfm?fuseaction=noticia&id=290768 (accessed on 5 January 2009).

Nadin, G., Savorgnani, G.T. and Besana, M. (2009) 'The environmental awareness of car owners: the case of natural gas vehicles in Italy', *Int. J. of Automotive Technology and Management*, Vol. 9, No. 2.

North, D.C. (1990) *Institutions, Institutional Change and Economic Performance*, Cambridge University Press, p. 152.

OPEC (2008) *World Oil Outlook*, Organization of the Petroleum Exporting Countries.

REN21 (2008) *Renewables 2007 Global Status Report*, Paris: REN21 Secretariat and Washington, DC: Worldwatch Institute, Copyright© 2008 Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH.

Reynolds, T.J. and Gutman, J. (1988) 'Laddering theory, method, analysis, and interpretation', *Journal of Advertising Research*, Feb/Mar, pp.11–31.

Sheth, J.N., Mittal, B. and Newman, B.I. (2001) *Comportamento do Cliente*, Atlas, São Paulo.

UNICA (2005) 'Como e por que o álcool combustível melhora a vida do planeta', *União da Indústria de Cana-de-Açúcar/Globo Editora*.

Wansink, B. (2000) 'New techniques to generate key marketing insights', *Journal of Marketing Research*, Summer, Vol. 12, No. 2, pp.28–36, Chicago.