

Usage Competition between Oilseeds and Biofuels: Impact assessment on the Brazilian Food Production

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Executive Summary:

The purpose of this paper is to present the impact on the availability of soybean for biodiesel in Brazil based on the trade-off between food and fuels, as well as establishing a model capable of estimating the offer of soybean. It can be seen that the states of Bahia and São Paulo are not capable of meeting any biodiesel production demand levels, the latter presenting a deficit reaching 387,296 tons of soy oil, which indicates its foreign dependency (other states) regarding soy oil. The states of Rio Grande do Sul (RS) and Paraná (PR), which in the first scenario would show up as suppliers to deficit-bearing states, lose such ability and are no longer capable of turning out any biodiesel amount above 20% at the current productivity and area rates. Even Mato Grosso do Sul loses that ability, unable to turn out any biodiesel amount above 50%. In face of such scenarios, we may point out that the competition of soy use for biodiesel-generation purposes, as a product resulting from the so-called agri-energy, is likely to take place if the current oilseed potential percentages, land structure and total area covered in comparison with other crops of the same seasonal character are maintained. To sum up, we may also point out the following results: a) the biodiesel demand for soy will probably compete with the food demand for soy; b) there is the need to develop new varieties capable of specifically meeting the biodiesel demand; c) the diversification in the production of oilseeds may become an alternative to soy for the Brazilian biodiesel program.

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Abstract: The purpose of this paper is to demonstrate the impact on the availability of soy for food in Brazil based on the trade-off between food and fuels, as well as establishing a model capable of estimating the offer of soy in terms of its main factors. We are able to point out the following results: a) the biodiesel demand for soy will compete with the food demand for soy; b) there is the need to develop new varieties capable of specifically meeting the biodiesel demand; c) the diversification in the production of oilseeds may become an alternative to soy for the Brazilian biodiesel program.

Keywords: Biofuels, Food, Competition of Use, Biodiesel, Soybean.

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Introduction

Experiments with renewable fuels are not new. Many studies started as early as the 1920s. One of the pioneering movements in this kind of study was the so-called “Chemurgy Movement”. It was motivated by the problems faced by North-Americans during World War I regarding lack of food and fuel. The word chemurgy is made up of two roots: chemi – chemistry and ergon-work. The chemurgy movement designates the study of chemical compounds designed to cater to the industry based on agricultural products. Chemurgists had three goals: a) to develop non-food uses for the existing agricultural products; b) to develop new commodities for intensive industrial use, instead of using the agricultural production surplus; c) to develop the economic use of agricultural refuse (FINLAY, 2004).

In 1935, the Ford Company already used 1 bushel of soy to manufacture the plastic components of its cars. That was made possible by the initiative of Henry Ford and Tomas Edison, who founded the “Edison Institute” in 1929. The institute's main goal was to find new uses for agricultural products. The crude oil industry took the liberty of “hiding” those projects during the cold war years.

In terms of the Brazilian energy matrix, from the 70s onwards there is the insertion of ethanol (sugarcane-based fuel), an initiative that has since been concentrated in the Southeast, especially in the state of São Paulo. More recently, there is the introduction of biodiesel (fuel obtained from vegetable oils) to this matrix via the issuance of Law 11.097/2005 on 01/13/2005, which provides for the optional addition of B2 until 2008 (2% of biodiesel in diesel oil), and mandatory as of 01/01/2008.

The prohibition to the sale of pure diesel oil as of early 2008 mobilized all the players that make up this chain of production, among them: farmers, cooperatives, vegetable oil manufacturing plants, fuel distributors, and others. An example of that is the implementation of 7 biodiesel manufacturing plants throughout Brazil since 2005, there being another 45 under construction.

Across Brazil, soy, sunflower and castor beans have been adopted as the oilseeds of choice for biodiesel production. However, the only variety yielding enough to supply the demand at the manufacturing plants going into operation is soy, reason why this paper focuses its analysis on this oilseed.

This entire mobilization also reflects the global awareness regarding the need to increase the participation of renewable energy sources in the world’s energy matrixes, a product of, among other factors, the worsening in pollution effects caused by fossil fuels.

However, it is possible to see the existence of barriers to the expansion of fuel production based on agricultural products. One of the main barriers results from the competition of use that converting agricultural products into fuel may force on the production of food. Furthermore, studies indicate that in certain countries the agricultural yield of a given product may be insufficient to meet the demand for fuel. One of those studies is by Hill *et al.* (2006), which states that if the United States of America (USA) used up all their 2006 corn and soy production for biodiesel manufacturing purposes, that production would be enough to supply only 6% of the country’s annual diesel demand.

This competition is a result from the relationship amongst farmers, crushing companies and biodiesel manufacturing plants, and the destination given to agricultural production, which

for those reasons is directly regulated by the laws of demand and supply. In that sense, we should clarify that selling means both an intermediary process between producer and consumer as well as making the goods and services produced available to consumers, at the shape, time and place the latter are willing to purchase them.

A major feature in this process arises from the biological nature of agricultural products, which imposes a seasonal supply associated to a constant demand, given that they are part of the human grocery list. In relation to that, the economic theory clearly explains that supply abundance and concentration cycles render products somewhat scarce at certain periods. Therefore, the association of that fact to a low elasticity in the demand for agricultural products ends up shifting the supply and demand curves, making the prices of these products drop at their harvest time, and even at periods close to their occurrence, there being an exactly opposite trend at in-between harvests periods (BRANDT, 1980).

A trend that may possibly alter this natural supply and demand behavior derives from the growing rates in the Brazilian soy supply availability over the past few years, associated to the impacts caused by the insertion of biodiesel into the energy matrix. As we said before, the production of this fuel will demand the supply of oilseed grains, soy being the grain of choice due to its scale. Considering the supply aspect, we see that over the past ten years the available offer of soy in Brazil has grown at an annual average rate of 4.3%. However, taking a look at the other aspect, i.e. the consumption of oil diesel– to which biodiesel is to be added, we see a higher growth rate at an annual 5.4%. In the event such trend is maintained, that difference will cause the decrease in soy availability for many and various purposes, such as human food (ABIOVE, 2007; ANP, 2006).

In light of that, it is evident that one of the main restraints that may take place in agri-energy chains of production would be the competition of use and the expansion limits between food and fuel. Therefore, we ask: how do we produce oilseeds for both food and fuel?

This competition presents direct economic effects that may result in social impacts such as, for instance, people's well-being as they consume lower amounts of food due to prohibitive prices. An example of that has been taking place in the United States where, since President George W. Bush's announcement regarding the 20% decrease in gasoline consumption over the next 10 years, there has been an increase in land areas cultivating corn for the production of ethanol. It is estimated that, as early as 2007, there will be a 15% increase in corn-planted areas, which due to the competition of use should result in an approximately 11% decrease in soy-planted areas. That has been causing mark-ups in food prices, given that it decreases both the supply of corn, as it is used for the production of ethanol, and the supply of soy, as planted areas become smaller. All that considered, in North-American markets it is already possible to see mark-ups reaching 5% for both corn- and soy-based food (SERVICE, 2007).

Hence, keeping in mind the energy, economic and social issues, as well as the worldwide macro and microeconomic context trends, the purpose of this paper is to demonstrate the impact on the availability of soy for food in Brazil based on the trade-off between food and fuels, as well as establishing a model capable of estimating the offer of soy in terms of its main factors.

The methods employed consist of estimating some comparative statics scenarios based on an econometric model; they also use the MAVBB model developed by Benedetti (2006), which determines the required oilseed volumes to supply the Brazilian biodiesel program needs.

Theoretical Background

Agricultural Products Supply Model

According to the Microeconomic Theory, the supply of an item is defined as the amount of such item that producers are willing to take to the market, at different price levels, at a certain time, when the other relevant factors remain constant, such as the price of alternative products, input prices, technological levels, production costs, etc (PINDYCK and RUBINFELD, 1995).

One of the main problems regarding the empiric application of the microeconomic theory is establishing the relationship between theoretical concepts and the variables actually observed. In the production of any item, especially in agriculture, the decision about the use of inputs must be made well in advance to the production taking place. One supply curve estimation problem is related to the choice of the dependent variable. The supply theoretical function associates the planned production to the prices of products and inputs. As the production planned cannot be observed, the planted area has been used as an approximation for the production planned (OLIVEIRA, 2004).

The planted area presents the advantage of being under higher control by farmers, better representing their behavior towards price expectations - even considering that land is only one among the several inputs used, and its lack of homogeneity in terms of production yield (OLIVEIRA, 2004).

This study will use an econometric model to select which variables affect the supply of soy in two Brazilian states. The econometric model takes the following working configuration:

$$Y = \alpha + \tau_1\delta_1 + \tau_2\delta_2 + \tau_3\delta_3 + \tau_4\delta_4 + \dots + \tau_{i-1}\delta_{i-1} + \tau_i\delta_i + \varepsilon$$

Y= total soy area;
 δ_i = variables affecting soy supply;
 α_i and τ_i = parameters to be estimated.

One of the hypotheses of this study is that variables suffer regional influences, that is, for aggregation levels larger than the state, models lose their power to explain changes to dependent variables; in this instance, the supply of land for soy.

Some aspects related to time arrays, especially cross-section analyses, refer to the relationships between variables and the relationships between error terms. The main problems to be analyzed by the data arrays are: a) multicollinearity: linear relationship amongst explanatory variables in a model; b) self-correlation: correlation amongst data array information, or cross-section information (GUJARATI, 1995).

Main Conceptual Aspects connected to Agri-Energy

The purpose of this section is to present the different concepts mentioned when we talk about agri-energy chains, which are oftentimes used mistakenly as synonymous. Hence, it is our intention to approach the concepts of bioenergy, agri-energy, biofuels, biomass and biorefinery.

The first refers to any and all animal or vegetable organism capable of generating energy from nature substrates, that is: sun light, water, soil, and food, among others. The energy humans

synthesize by way of the food ingested, for the purposes of providing the operation of their several capabilities such as walking, is an example of biological energy, or bioenergy.

On its turn, agri-energy, or agricultural energy, according to the 2006-2011 National Agri-Energy Plan, is a less comprehensive concept than the previous one, and refers to the energy derived from agricultural products, such as: oilseeds, **roots**, and cattle raising, among others. We may explain agri-energy as the bioenergy obtained from agricultural, livestock and forestry products (MAPA, 2006).

Biofuels can be generically defined as fuels originating from energy cultures, or natural residues. Included in this group are: biomass – a fuel deriving from agricultural products and residues, forest residues, industrial and urban residues (fire wood, charcoal, ethyl alcohol or ethanol, and biodiesel, among others) and biogas, a biofuel deriving from the anaerobic biological decay of organic material contained in agriculture, livestock, agri-industry or urban area waste.

Biodiesel is one of the existing types of biofuels deriving from the so-called agri-energy and even a component of the so-called bioenergy. Biodiesel requires the addition of a vegetable oil to methanol or ethanol, having caustic soda as catalyst. This is the most widespread process used – called transesterification, and the preferred process in Brazil for obtaining biodiesel; however, we should mention that there are at least other 4 processes enabling its production. After the reaction, phases are separated into heavy and light; the first stage yields glycerin alcohol, glyceric residue and distilled glycerin; on its turn, the light process purifies the ester produced, which finally generates biodiesel.

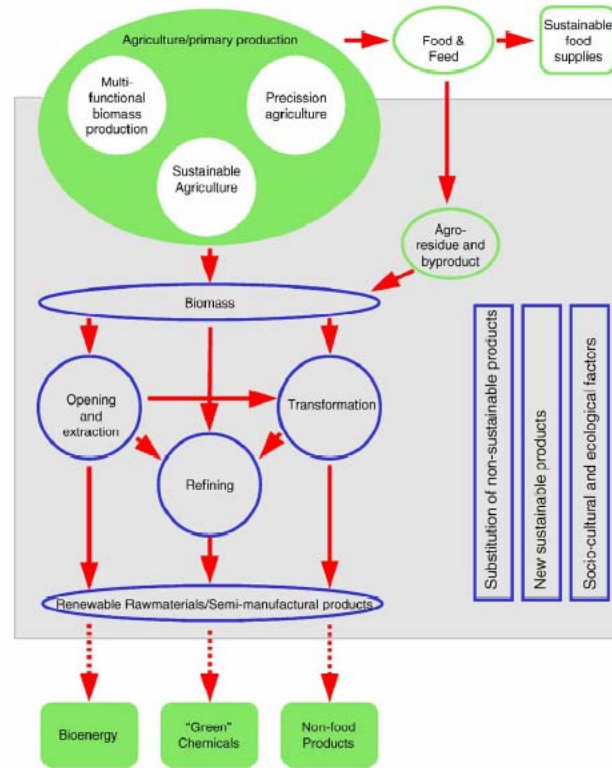
For the transesterification process to yield one (01) liter of biodiesel, it is necessary to add one (01) liter of vegetable oil to 100 milliliters of some oil, be it ethanol or methanol. We should mention that this process will also result in approximately 100 grams of glycerin, which must go through a purification method in order to be used commercially.

The previously mentioned chemical process for the generation of biodiesel (transesterification) refers us to another concept used in the literature, that is, the production site for chemical products derived from crops: biorefinery or bio-industry. The concept of biorefinery is essentially an interdisciplinary one, involving from civil engineering, chemistry, economics, management, agronomy, in short, all the disciplines involved in setting up and formatting such companies (DOELLE, 2003).

That concept is based on the rebirth of the biomass utilization to produce fuels, chemical products, and other materials. Such integration represents a new frontier, be it economic or even technological. This production dedicated to supply fuels and products has been organized with an eye towards economic and environmental balance. A biorefinery depends on the local supply of inputs to operate, and based on that organization it is capable of making agricultural production more dynamic and independent from price fluctuations, once that production ceases being a commodity to become an industrial input (DOELLE, 2003).

A first attempt to link the agri-energy chains of production to the already consolidated reference can be seen in figure 1. It shows the existence of complex connections that must be coordinated so that those chains can be effective. The challenges refer to technological, economic and social issues. The vertical integration, that is, the optimum design of the value chain combining food, energy and other products is required, once that type of arrangement involves chains that are more or less independent, and such arrangement will be effective if all product and residue flows are allocated so as to maximize the chain's overall value (VAN DAM et al, 2005).

Figure 1 – Connection between Food and Industrial Product Markets.



Source: VAN DAM, J.E.G et al. (2005).

A production arrangement based on a “biorefinery” does not represent a challenge solely in technological terms but also in terms of organizational structure (centralized and de-centralized units), in addition to the entire integration with agricultural production and the environment. The linking effects of industrial products manufactured from agricultural products and crop residues may come to replace petroleum, as long as it is possible to effectively integrate the industrial and agricultural productions (KROMUS et al, 2004).

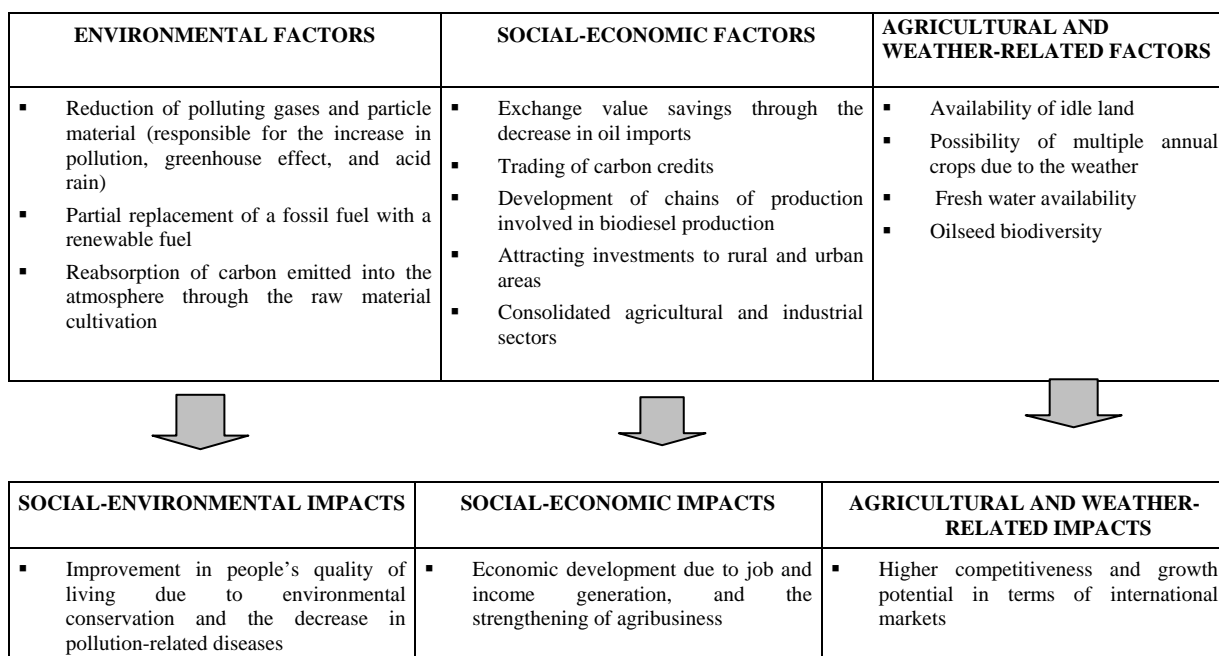
In short, the basic proposal of a biorefinery is to integrate the agricultural production and the chemical and pharmaceutical industries. The production of biodiesel, ethanol, or any other fuel deriving from agricultural production may be considered within that context (LEITSINGER, 2003).

Panorama and Set Up of the Brazilian Biodiesel Chain of Production

The insertion of the latest fuel deriving from the so-called agri-energy in Brazil took place via the publication in the Brazilian Official Gazette of Law 11.097, which authorizes the introduction of biodiesel into the Brazilian energy matrix as of January 2008. The mixture approved for optional utilization until 2008 is 2% biodiesel to 98% diesel oil; from 2008 onwards, that mixture will be mandatory, and a 5% mix will be optional.

We can point out that three groups of factors drove the implementation of biodiesel in Brazil as a State program: a) social-economic factors; b) environmental factors and; c) agricultural and weather-related factors. Those factors generate a series of impacts that tend to be generally positive, among which the main ones are economic development and improvements to people’s quality of living, according to figure 2.

Figure 2 – Factors driving the implementation of the biodiesel chain of production in Brazil.



Source: Adapted from Cânepa (2004) and MME (2005).

Hence, the government has been promoting the program so as to ensure, still in 2007, the required supply of 782 million liters of biodiesel per year. One of these promotion mechanisms are the biodiesel auctions, which have been engaging the production base across the country.

This is the mechanism used by the government to ensure the required biodiesel supply for compliance with the law; manufacturing plants are summoned, whether they are in operation or not, for the auctions, and they make sale offers of their biodiesel at a minimum price, falling unto ANP the determination of the winning company. As a result, we can see that the supply of 840 million liters of biodiesel has been ensured until 2007, showing that the supply for compliance with the law has probably been met for 2008 (ANP, 2005).

As we map the investments in biodiesel plants in Brazil, we can see the range of what has been going on in the country in terms of biodiesel, thus leading to the understanding that the goal ensuring the biodiesel supply for 2008 will actually be met. There are already 7 plants in operation in Brazil, with a production capability estimated at 91 million tons of biodiesel / year. Another 45 plants are either getting their papers in order or under construction, and as they go into operation, it is expected that they will supply approximately 1.9 billion tons of biodiesel a year.

As these plants are implemented, there will be a permanent need for available oilseeds for the production of biodiesel, that is, the chain of production must constantly and consistently ensure the supply of basic inputs (oilseeds). In that sense, soy should be the preferred oilseed for biodiesel production, given the fact that it accounts for 92.5% of this variety's total availability in Brazil (CONAB, 2006).

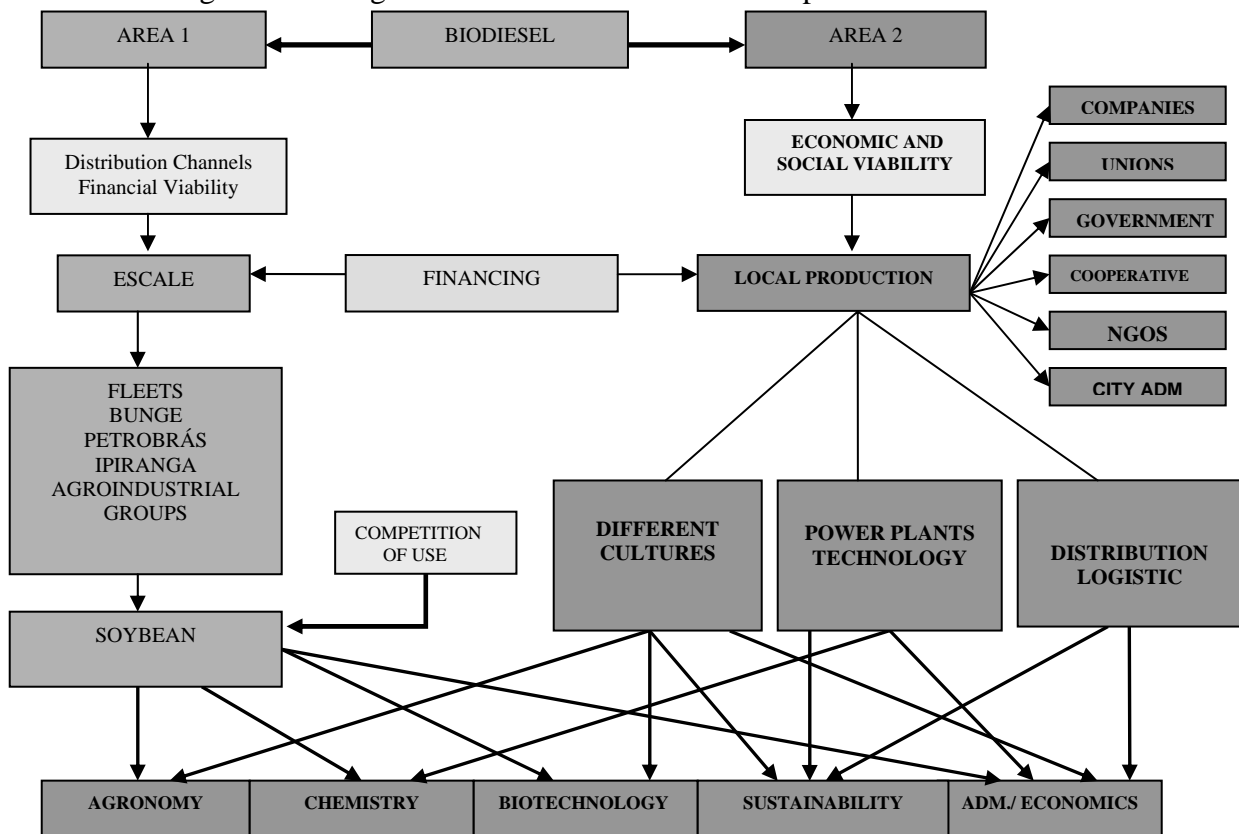
Regarding the configuration of the chain of production, we should point out that there are six major players in the chain, the first one being oilseed farmers. They deliver their products to a grain crushing company, which extracts the oil and delivers it to a transesterification plant. The latter completes its process from which biodiesel is the product, handing it over to a refinery or

authorized distributor, which are the only companies authorized to mix biodiesel into diesel oil. At the end, the end-product is finally taken to gas stations, where it is sold to end-users.

This chain has revealed the existence of two major organization modes among the players according to their “needs”, as seen in figure 3. One side of the chain (Area 1) reveals the large-scale production logic, represented by large agro-industrial companies, and soy oil and biodiesel manufacturers. In it, players see biodiesel as another alternative in their business portfolio, the economic factor being the one leading to their remaining in the activity.

On the other hand, there is another logic (called Area 2) that refers to small production volumes. In it, we must take into account different arrangements and different purposes, which may be represented by family farming and the small electricity power plants (isolated systems). Here the decision necessarily considers local development, and social factor plays a much bigger role than the economic one. In short, it is necessary to consider a sort of dual logic regarding the needs and organization of the biodiesel chain of production in Brazil, taking into consideration decisions that are qualitatively and quantitatively different, despite the existence of common needs and points.

Figure 3: Configuration of the biodiesel chain of production in Brazil.



Source: Prepared by the authors.

Methods and Procedures

The research conducted for this paper comprised the search for data related to the Brazilian agricultural production. Data was obtained from sources like the National Supply Company (*Companhia Nacional de Abastecimento* - CONAB), the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* - IBGE), the Getulio Vargas College (*Faculdade Getulio Vargas* - FGV) via the FGV-DADOS database, and the

database from the Brazilian Association of Vegetable Oil Industries (*Associação Brasileira de Indústrias de Óleos Vegetais- ABIOVE*). The data was updated to March 2007, utilizing as indicator the IGP-DI of the Economics and Statistics Foundation of Rio Grande do Sul (*Fundação de Economia e Estatística do Rio Grande do Sul - FEE*). The econometric model was set up with support from the statistical software SPSS, version 14.

The methods employed consist of estimating some comparative statics scenarios based on the econometric model. In addition, we will also employ the Model for the Brazilian Biodiesel Viability Analysis (*Modelo de Análise da Viabilidade do Biodiesel Brasileiro – MAVBB*) developed by Benedetti (2005), which determines the required oilseed volumes to supply the Brazilian biodiesel program needs and use of the land for biodiesel.

These models will be used to determine the impact to the grain production in Brazil, both in terms of demand and supply, and by so doing it may be possible to point out alternatives that could be used in the medium and long terms in an effort to answer the question posed by this paper.

Scenarios and Discussion

Soy, soy oil, and biodiesel demand

As previously mentioned, biodiesel can be obtained from a wide range of oilseeds but subsidized governmental support is given primarily for castor bean-based production. The reason is that such crop is more labor intensive, thus generating an allegedly higher number of jobs in rural areas.

However, especially in Brazilian southern and southeastern states (Paraná, Santa Catarina, Rio Grande do Sul, São Paulo, Minas Gerais, Rio de Janeiro and Espírito Santo), experts point out that the preferred oilseed for biodiesel production should be soy. According to the experts, that is due to two factors: a) vocation and tradition in planting this grain, and; b) the castor bean supply capability across the country is much lower than what is required to immediately meet the demand of nearly 900 million liters of biodiesel a year, soy being the only oilseed whose scale is enough to meet such demand.

Even when there is oilseed availability, particularly soy in the case of Brazil, we can see there are barriers to the expansion of fuel production based on agricultural products. One of the main obstacles derives from the competition of use that converting agricultural products into fuel may impose on the production of food. Another barrier can be detected in terms of supplies, given that over the past ten years the soy supply available in Brazil has grown at an annual 4.3% average rate, while the consumption of diesel oil – to which biodiesel is to be mixed, has grown at an annual 5.4% average rate. In the event such trend is maintained, that difference will cause the decrease in soy availability for many and various purposes, such as human food (ABIOVE, 2007; ANP, 2006).

In terms of the Brazilian biodiesel chain of production demand, specifically concerning soy and its main food equivalent (soy oil), five of the main demanding and supplying states were chosen, namely Rio Grande do Sul, Paraná, São Paulo, Mato Grosso do Sul and Bahia.

First, we sought to ascertain the biodiesel production potential in those states by using a hypothesis that transformed the entire soy production available domestically into soy oil for the year 2006, as well as the respective demand for percentages B2, B5, B10, B20, B25, B50 and B100. As we can see in chart 1, São Paulo does not have enough supply to meet any biodiesel demand other than for B2, while Bahia does not have supply enough for the addition of B25, B50 and the production of B100. On the other hand, the states of Rio Grande do Sul, Paraná and Mato

Grosso do Sul present themselves as potential suppliers for the scarcity that should take place in other states, given that their production capabilities enable them to make biodiesel at any internal percentage, except for the 100% pure state (RS and PR), while MS is capable of meeting any scenario.

Chart 1: Biodiesel production potential scenario based on soy oil per state in reference-year 2006 (tons / year).

Estate	Soy Oil - Productive Potential in tons	B2 Demand	B5 Demand	B10 Demand	B20 Demand	B25 Demand	B50 Demand	B100 Demand
BA	394.277	38.598	96.495	192.991	385.981	482.476	964.953	1.929.906
MS	866.349	16.084	40.210	80.419	160.839	201.048	402.097	804.194
SP	310.721	177.237	443.092	886.183	1.772.366	2.215.458	4.430.915	8.861.831
PR	1.859.042	69.165	172.913	345.825	691.650	864.563	1.729.126	3.458.252
RS	1.488.683	47.574	118.936	237.871	475.742	594.678	1.189.356	2.378.711

Source: Calculations by the authors based on ABIOVE (2006). IBGE (2006). BENEDETTI (2006).

Next, we moved on to another scenario, that of the net biodiesel production potential based on soy oil per state in reference-year 2006. It is called thus for excluding the domestic consumption of soy oil, foreign demand for soy grains, transportation-related losses, and the Federal Government's regulating stocks. This scenario points towards a more realist picture of the effects generated by the insertion of biodiesel into the Brazilian energy matrix in terms of the competition of use, considering it includes the context of soy consumption for other purposes, such as human food.

It allows us to determine that the states of Bahia and São Paulo, in this context, do not have the ability to meet any biodiesel production demand; furthermore, the latter state would present a deficit of 387,296 tons of soy oil, which clearly points towards its foreign dependency (other states) regarding soy oil. The states of RS and PR, which in the first scenario would show up as suppliers to deficit-bearing states, lose such ability and are no longer capable of turning out any biodiesel amount above 20%. Even Mato Grosso do Sul loses that ability, unable to turn out any biodiesel amount above 50%.

We should mention that such scenario maintains the current soy productivity and land area occupation rates, but that may take place differently, that is, it is possible to expect that the crop may become more appealing due to the option of its sale for fuel production purposes.

Chart 2: Net biodiesel production potential scenario based on soy oil per state in reference-year 2006 (tons / year).

Estate	Biodiesel Potential (*)	B2	B5	B10	B20	B25	B50	B100
BA	6.862	38.598	96.495	192.991	385.981	482.476	964.953	1.929.906
MS	387.296	16.084	40.210	80.419	160.839	201.048	402.097	804.194
SP	-354.070	177.237	443.092	886.183	1.772.366	2.215.458	4.430.915	8.861.831
PR	619.359	69.165	172.913	345.825	691.650	864.563	1.729.126	3.458.252
RS	459.543	47.574	118.936	237.871	475.742	594.678	1.189.356	2.378.711

Source: Calculations by the authors based on ABIOVE (2006).IBGE (2006). BENEDETTI (2006).

(*) Excluding domestic consumption of soy oil, foreign demand for Brazilian soy grains, transportation-related losses, and public stocks.

In face of such scenarios, we may point out that the competition of soy use for biodiesel-generation purposes, as a product resulting from the so-called agri-energy, is likely to take place if the current oilseed potential percentages (oil content), land structure and total area covered in comparison with other crops of the same seasonal character are maintained.

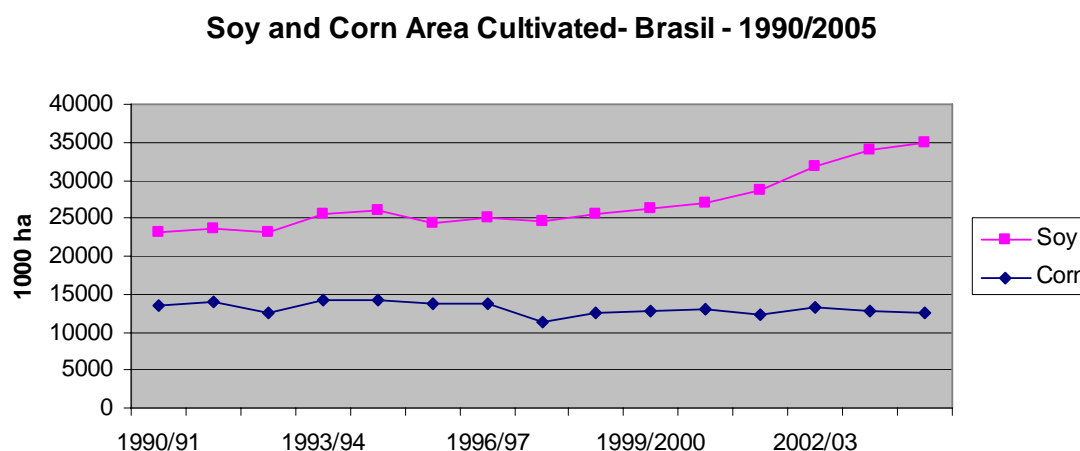
Agricultural Supply for Biodiesel

Backdrop

In the previous section, we discussed the oilseed demand for biodiesel production. In this section, our purpose is to analyze the determining factors of soy supply, taking into consideration the competition against sugarcane and corn.

We can initially see (according to figure 4) the total supply of land for soy and corn production. In it, we see an increase in the area planted with soy in Brazil and the decrease in corn, which derives, among other factors, from the increasing profitability and demand for soy to the detriment of corn (MAPA, 2006).

Figure 4 – Total area planted with soy and corn in Brazil.



Source: CONAB (2007).

Furthermore, according to IBGE data (2007), Brazil has 90 million hectares available for agriculture, representing nearly 59% of the estimated total of Brazilian land, which is 152 million hectares.

However, it is expected that these areas will not be totally taken up by biodiesel-oriented soy production, and we point towards a soy land occupation projection of approximately 6 million hectares to support biodiesel production, considering a percentage of 20% of biodiesel added to diesel. According to Benedetti et al. (2006), that fact indicates that the biodiesel production evolution must be parallel to an increase in soy productivity dedicated to the production of biodiesel. As a solution, the same authors indicate that we need to have two soy varieties available: one with higher bran content, and one with higher oil content.

At first, we will not conduct an evaluation based on production data from northeastern states in Brazil, given their low soy yield in comparison to other Brazilian states. Although there are big projects for biodiesel production in those states, their agricultural production is still insufficient to meet the demand. In addition, the lack of more concrete data makes it impossible to estimate soy production.

Regional Analysis of Soy Supply in Brazil

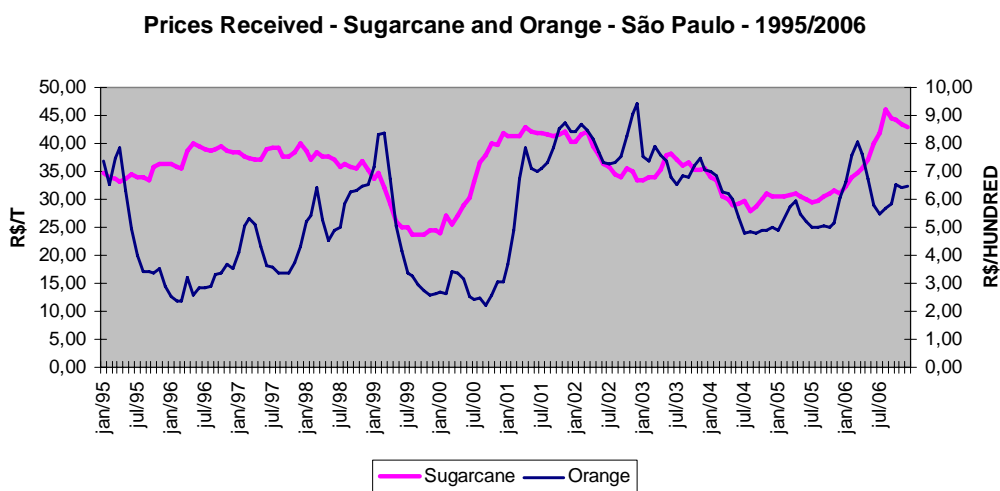
This section will analyze soy supply conditions, so as to complement the analysis made on the demand in Brazil. In addition, we will present an estimate regarding the land supply for soy crops in the states of Mato Grosso do Sul and Rio Grande do Sul; we should mention that those states were selected due to their soy production levels. Furthermore, the data available enabled us to set up a few estimates, which was not possible for other states. On its turn, the state of São Paulo will be analyzed for its relevance regarding the national economic backdrop and for the existence of biodiesel production units in the state.

Analysis on the state of São Paulo (SP)

The state of São Paulo has a production base relying primarily on sugarcane. Over the past few years, sugarcane production has developed new varieties that yield higher crops, and therefore has been increasingly gaining space in international markets through the sales of either sugar or ethanol. Figure 5 shows the variation in sugarcane prices in São Paulo, allowing us to see that such prices have increased in recent years despite the volatility presented by the entire data array.

Sugarcane crops have their own dynamics making them independent from factors that impact biodiesel production. From this analysis of the data array, we can see that, despite taking part in the biodiesel chain, ethanol production has its own adjustments mechanisms that take into consideration the prices of sugar and ethanol in the domestic and foreign markets. However, despite its independence, it still manages to impact other economic activities.

Figure 5 – Evolution of Sugarcane and Orange Prices in SP (1995-2006).



Source: FGV-Dados (2007).

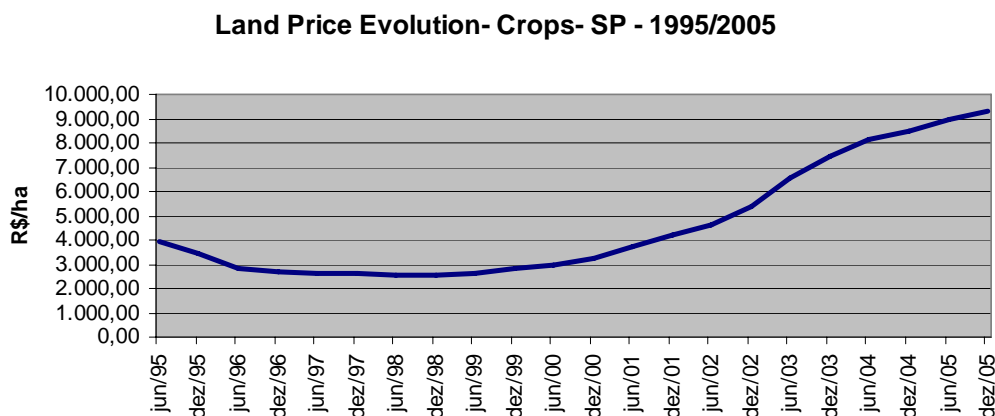
* Updated by IGPDI-FEE. March 2007.

Perhaps as a result of this high profitability situation, the production of orange, cattle, soy and other crops has lost space to sugarcane. Hence, such as in the case of soy in Rio Grande do Sul, maybe the return expected is higher for sugarcane given the increasing value of ethanol, deriving both from its higher demand as well as higher prices in Brazil. The possibility to export

to Europe and the United States has encouraged investments in ethanol production plants in Brazil, especially in the state of São Paulo.

Given such context, the evolution of prices paid per hectare dedicated to agriculture in the state of São Paulo has seen a pronounced increase over the past few years (figure 6). This increase is likely due to the sugarcane profitability, which may have been the cause for the transfer of cattle raising activities and soy crops to other states, particularly Mato Grosso and Goiás.

Figure 6 – Agriculture Land Prices in the State of São Paulo.



Source: FGV- Dados.

* Updated until March 2007 by IGPD-FEE.

Given the relative weight of sugarcane in the state of São Paulo, biodiesel production in the state will probably depend on imported soy and other oilseeds because, as seen in Chart 1, São Paulo has a deficit in the production of B2 biodiesel.

Thus, biodiesel represents a production alternative. Given the state's dynamic industrial and agricultural production, implementation decisions will be made considering same-profitability alternatives. In the event biodiesel is unable to establish a competitive level, be it for the management of the supply chain, be it for the reduction of direct costs, biodiesel plants in the state will probably transfer to other states.

The hypothesis of their staying is due to their geographical location in terms of major soy oil and, therefore, biodiesel, consumer centers, which decreases final product transportation costs; however, such hypothesis may be overridden by the competition against other areas, especially the Brazilian Northeast and South, in addition to the competition of use for human and animal food.

Despite ethanol being part of the biodiesel chain of production and the state of São Paulo having a suitable production of this fuel, new production alternatives currently being analyzed for their technical and economic viability in other states that do not have a tradition in this type of product may make the biodiesel production in those states more efficient in terms of the reduction in ethanol transportation costs. In other words, a new dynamics will be introduced to the production of ethanol and biodiesel in Brazil.

Perhaps in São Paulo and the other soy producing states there is a configuration of energy-related agricultural clusters, that is, an agricultural production oriented towards energy generation that holds highly specific assets, a fact that will impose new risks on agricultural production

considering oilseeds will have to be adapted to generate energy as, for instance, soy yielding 40% of oil instead of the current 20%.

Analysis on the state of Mato Grosso do Sul (MS)

Considering the model proposed for this paper, we see that the estimate for the state of Mato Grosso do Sul was more consistent. The model below presents the parameters for the equation estimating the area to be planted in the state. Like in Rio Grande do Sul, the results of the variables are valid for the model proposed. These estimates become rather inconsistent as we add data from the regions and even from Brazil, because the tests refuse the parameters and model's adjustment is relatively frail Brazil-wise. That is due mainly to the lack of updated, consistent statistics.

The model below does not present serial self-correlation or multicollinearity. The model's R^2 was 95.9%. There is a local logic for the behavior model of the soy-occupied area. In the state of Mato Grosso do Sul, the relevant variables are the varying cost of corn, varying cost of soy, corn sale price, and soy sale price, with the values in parentheses representing standard deviations for the variables. The Mato Grosso do Sul model has the following working configuration indicating that the variation in total soy area behaves positively in relation to the varying cost of corn, negatively in relation to the varying cost of soy, and positively in relation to corn and soy prices. That indicates the automatic character in terms of the replacement of soy with corn in Mato Grosso do Sul and vice-versa.

$$AT_S = 26,283.61 + 11.724CV_M - 6.992CV_S + 1,499.812P_M + 4,668.919P_S,$$

(11,206.578)
(4.033)
(6.682)
(3.389.689)
(2,037.776)

Where:

AT_S = Total Soy Area

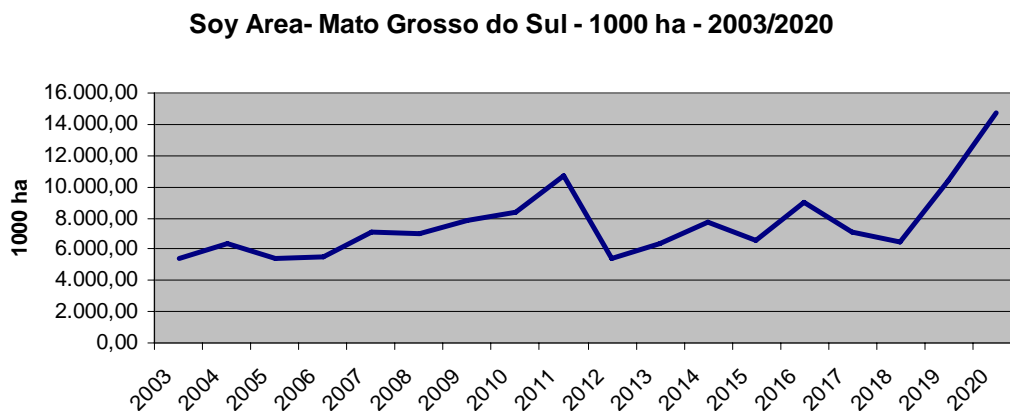
CV_M = Varying Corn Cost /Ha

CV_S = Varying Soy Cost /Ha

P_M = Corn Sale Price /60 kg sack

P_S = Soy Sale Price /60 kg sack

Figure 7 – Evolution of Soy Area in the State of Mato Grosso do Sul.



Source: Calculations by the authors.

Figure 7 simulates data for the variables selected. This is a purely theoretical behavior that requires new simulations. The production estimated for the state exceeds 14 million hectares for 2020, an amount above 100% of the current cultivated area. The state of Mato Grosso do Sul will probably be a soy “exporter” for the states of São Paulo and Minas Gerais, and given the low fuel needs and the relative proximity to the soy and oil export modals, the state may be capable of supplying its fuel needs.

On the other hand, the impact on food will probably not be felt within state limits the same way they are found on a national level and in major consumer centers. Finally, we should mention that there are large-scale plants being installed in the area, in an effort to establish themselves close to the production-oriented input supply.

Analysis on Rio Grande do Sul (RS)

In Rio Grande do Sul, agricultural production comprises primarily soy, wheat, rice and corn. The state does not yet produce commercial-scale sugarcane to supply the ethanol market, for example. With the introduction of biodiesel into the energy matrix, the state received 4 large biodiesel manufacturing projects. These companies are located mostly in soy production areas.

From an analytical point of view, the supply of soy in the state of Rio Grande do Sul presented relevant results. The estimated elasticity for the variables selected presented a behavior similar to what is theoretically expected. The model was run in logarithms so as to obtain parameter elasticity, which coincided with the signs of the model provided below. This first test gives us a useful result for future research in the area.

The model estimates the occupation of over 25 million hectares in 2013. Considering an average productivity of 3000 kg/hectare, there will be an offer of 75 million tons of soy in Rio Grande do Sul, generating approximately 15 million liters of soy oil.

The model estimated for Rio Grande do Sul had a 99% R², and the model’s parameters are valid and statically different from zero. There are no indications of serial correlation or multicollinearity in the model. The gross margin represents the difference between the total income per hectare minus the varying cost per hectare, with the values in parentheses representing standard deviations. In the state of Rio Grande do Sul, the relevant variables are the varying cost of corn, varying cost of soy, corn sale price, soy sale price, and the gross margin of soy per hectare. The model for Rio Grande do Sul has the following working configuration indicating that the variation in total soy area behaves negatively in relation to both the varying cost of corn and the total corn area, as well as in relation to the price of corn. In addition, it behaves positively in relation to soy, which does not indicate the automatic character in terms of the replacement of soy with corn in Mato Grosso do Sul and vice-versa.

The working configuration for Rio Grande do Sul is as follows

$$AT_S = 26,424.802 - 3.199AT_M - 56.76CV_M - 926.276P_M + 6,668.69P_S - 139.609M_S$$

(11,758.523) (0.890) (12.190) (127.003) (716.938) (15.128)

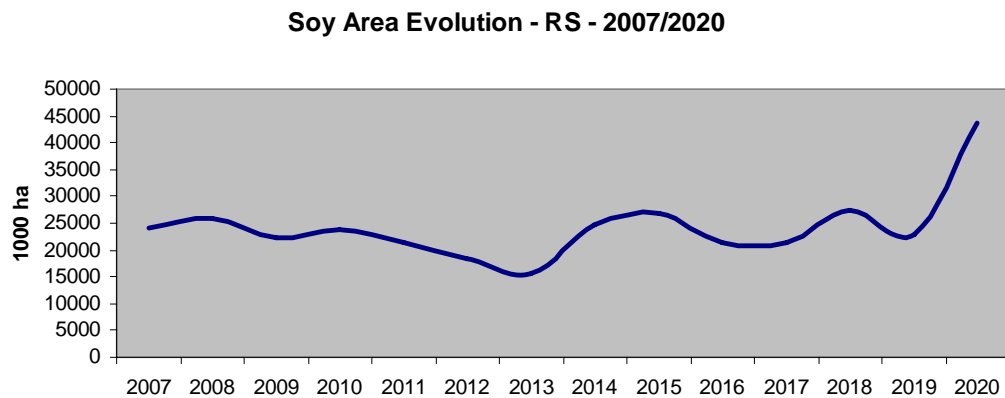
Where:

- AT_S = Total Soy Area / Ha
- CV_M = Varying Corn Cost /Ha
- AT_M = Total Corn Area / Ha
- P_M = Corn Sale Price /60 kg sack
- P_S = Soy Sale Price /60 kg sack
- M_S = Gross Soy Margin /Ha

Soy prices are largely more influential in determining the area, given the relative weight of its coefficient in the equation. This result shows that a local dynamics, and therefore a more local analysis, is more efficient in terms of the validity of the models.

In 2005, Rio Grande do Sul planted 12 million hectares with corn and 22 million hectares with soy. In the event the soy area should expand, there would be a decrease in corn area to soy. Figure 8 simulates that evolution. We considered variations for the corn area at 10% above and below, alternatively; for 2013 the area remained constant and the soy sale price varied above. Finally, it is possible to conduct many simulations but they all indicate an inverse relation among the areas, and positive relations between soy prices and the total area to be planted. Such data will be the subject of new research on the behavior of the variables selected, so that new adjustments may be made to the model currently under development.

Figure 8 – Evolution of the area planted with soy in Rio Grande do Sul (2007-2020)



Source: Calculations by the authors.

Given the soy production and export, as well as the state’s need in terms of fuel, it is likely that the food demand may suffer some fluctuations in the prices paid. Biodiesel may be considered an alternative for farmers and the companies setting up operations there. The law is still timid in terms of encouraging the production in the area but the auctions have fostered plant installations.

Final Considerations

From the answer given to this study’s objective, which was to show the impact on the availability of soy for food in Brazil based on the trade-off between food and fuel, we see that the concern for a possible food scarcity is pressing.

That fact requires the attention from the various players in the production chain, as well as from the government, to the need of developing alternatives that would enable that issue to be mitigated. Such situation entails challenges to be faced in the coming years, both in technological as well as economic and social terms.

Among them is the need for vertical integration, that is, the optimum design of the value chain combining food, energy and other products is required, once that type of arrangement involves chains that are more or less independent, and such arrangement will be effective if all product and residue flows are allocated so as to maximize the chain’s overall value (DAM *et alli*,2005).

One of the paths points towards the probable need to develop grain varieties such as soy with higher oil content, thus allowing a dual logic for each agricultural product: working as an input for human food and for fuel production.

As we compare the supply and demand required to meet the food and fuel needs, we find evidence that confirms on a provisory basis the hypotheses in this study. As we consider the land availability in Brazil, we are not considering the costs of soy transportation to consumer centers, for example. Perhaps those factors associated to the logistics and distribution may result in a slightly lower evolution estimated for the models, considering biodiesel has presented itself to be expensive in comparison to petroleum when it is produced far away from major consumer centers.

Another point to be considered is the Brazilian position in the worldwide soy market. In the event the USA lose space to Brazil in the supply of soy, especially regarding soy bran and oil, there will be a higher international demand for such products, thus renewing the competition and, even if soy supply levels expand enough to meet current and future biodiesel demands, causing changes to the international scenario that may alter the partial balances estimated by this study.

This debate must go on so that new arrangements may be efficiently set up, thus establishing a stable supply for food and fuel. We understand that many are the challenges faced by this chain of production currently being implemented in Brazil and other parts of the world; nevertheless, we must develop ways to organize and distribute the production that are capable of catering to the multiple uses presented by agricultural production.

It is possible to sum up the results of this paper in the following issues: a) the biodiesel demand for soy will probably compete with the food demand for soy; b) there is the need to develop new varieties capable of specifically meeting the biodiesel demand; and c) the diversification in the production of oilseeds may become an alternative to soy for the Brazilian biodiesel program.

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