A FEASIBILITY STUDY: CAN PARAGUAY LEARN FROM THE BRAZLIAN SUGARCANE ETHANOL PROGRAM?

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Abstract

This research investigates the feasibility of Paraguay developing a productive sugarcane ethanol sector, by drawing from the Brazilian experience with biofuels. Brazil is clearly a key case for examining whether there are certain lessons which can be extrapolated for other developing countries, such as Paraguay which have the factor endowment conditions to grow sugarcane and use it for the development of an ethanol industry. This study is framed around the following question: to what extent can the Brazilian ethanol program be replicated in Paraguay? This project's framework for analysis is based on three categories: political and institutional arrangements that govern the value chain of ethanol in Brazil and Paraguay. These categories include: an evaluation of the multiple stakeholder's intricately involved; the economic costs and benefits; and sustainability requirements which must be incorporated in order to credibly assess environmental gains and penalties associated with this renewable source.

Dedication

This project is dedicated to my wonderful parents, Marten and Diane Bradsen, who have supported me throughout my educational career. I thank you both from the bottom of my heart for making this all possible.

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1: Research Plan

1.1 Introduction to Biofuels

Finding a supply of renewable energy, mitigating the effects of climate change and peak oil are critical geopolitical issues discussed in international dialogues and forums. We sit in the midst of greenhouse gas emissions (GHG) accelerating exponentially, at a rate faster than ever before. We know as an international community that global warming is occurring. We are also aware that if we do not reduce GHG emissions by 2015, far below 1990 levels, that our world will surpass a threshold of no return. Accelerating temperatures, rising sea levels, 70% of our fish stocks eliminated, the selective destruction of biodiversity, starvation, deaths in the millions and hundreds of trillions of dollars in damage are just a glimpse of what the future is foreshadowing. Yet, it is not too late for countries to begin making strategic long-term choices, by taking action to reduce their dependence on fossil fuels and adopting cleaner sources of energy.

Approximately 80% of all energy in the world is derived from fossil fuels, represented by oil, coal, and natural gas. These sources of energy are the main contributors to environmental problems at the local, regional and global levels. With the price of crude oil in the world market escalating to more than US$140 in 2008, the quest for a renewable energy supply that is affordable and environmentally friendly is inevitable. Unlike fossil fuels, the advantages of renewable energy are enormous in terms of environmental gains and availability in the long-term. Given our current state of depleting fossil fuel reserves, environmental concerns and interests in energy security, there has never been a more advantageous time to create viable markets for the alternative energy sector, especially in the developing world. One of these newly emerging markets includes biomass, which can be extracted and turned into first generation biofuels for commercial consumption.

First generation biofuels are a promising source of energy because they are generated by the process of photosynthesis, where energy from the sun is captured and transformed into biomass to produce energy. Typically, this alternative source is renewable, as the carbon dioxide emitted into the atmosphere is recaptured by the growing crop in the next growth cycle. This has the potential to offset carbon dioxide emissions and act as one tool in mitigating the effects caused by climate change. Despite the multitude of benefits associated with first generation biofuels, the industry is frequently met with opposition. We often hear the media linking biofuels to increases in food prices and questioning their environmental benefits. However, what is rarely discussed in the media is that biofuels are not homogeneous in their abilities to abate carbon. They must be analyzed based on the type of feedstock used (which produce variable levels of environmental benefits), method of production and various other inputs which affect the sustainability of the end product. In the face of these debates, the literature clearly identifies that sugarcane used in production of ethanol is the most energy efficient in comparison with other types of feedstock varieties. Thus, the intent of this research is to concentrate on

Brazil, the world’s leader in sugarcane ethanol production. Brazil is a key case for examining whether there are certain lessons which can be extrapolated for other developing countries, such as Paraguay which have the factor endowment conditions to grow sugarcane and use it for the development of an ethanol industry.

1.2 Introduction to Brazil

In Brazil, ethanol is produced from sugarcane. As a champion of biofuel use, Brazil is currently the world’s second largest producer. For over 30 years, the Brazilian government’s support of research and development in biofuels has been a key factor in achieving economic growth. Brazil has saved more than $100 billion in foreign exchange, both in reduced import costs and service payments on the debt that would have been incurred from larger oil imports (Rothkopf 2007). Over three million jobs in Brazil’s periphery depend, directly or indirectly, on the ethanol and sugar production chain. The domestic growth in labour, such as contributing to improved employment rates, is also marked by interdependent linkages between the industrial and agricultural sectors. The current successes of Brazil’s ethanol program are driven by two main factors: the mandatory blending of ethanol to gasoline; and the expansion of the Fuel-Flex Vehicle market (FFV’s). [1] All gasoline is blended with 20% to 25% anhydrous ethanol, and approximately 80% of all vehicles sold are FFV’s (Petrobras 2008).

[1] A Flex-fuel vehicle is an alternative fuel vehicle with an internal combustion engine designed to run on more than one fuel, usually gasoline blended with either ethanol or methanol fuel. B oth fuels are stored in the same common tank. Brazilian technology exists to allow ethanol FFVs to run on any mixture of gasoline and ethanol, from pure gasoline to 100% ethanol (E100). North American and European flex-fuel vehicles are optimized to run on a maximum blend of 15% gasoline with 85% anhydrous ethanol (called E85 fuel).

Currently, there are approximately 33,000 service stations in the country which have a minimum of one pump dedicated to pure hydrous ethanol (E-100), which illustrates the accessibility of the market for consumers that purchase FFV's (Petrobras 2008). These domestic gains have been the real measures of the program's strengths and sophistication.

An additional strength of this program is that sugarcane, a source of feedstock to produce ethanol, is significantly more energy efficient than other types including: corn, grain, rapeseed, barley (Brandao 2007; Macedo and Nogueira 2007; WorldWatch Institute 2007; De Almeida and De Souza 2008, Kojima and Johnson 2006). The literature highlights a consensus that the utilization of sugarcane ethanol in Brazil's energy matrix has decreased aggregate levels of GHG emissions to 1990 levels. Notably, decreases in carbon output are associated with cogeneration capabilities, which are harnessed from bagasse, a biomass (sugarcane) co-product. Cogeneration offers a uniquely sustainable energy instrument, which provides the power to operate the production facilities in a self-sufficient manner (WorldWatch Institute 2007, 166-167).

There are three explicit pillars which work interdependently within the framework of the Brazilian ethanol program: 1) political and institutional arrangements that govern the value chain of ethanol in Brazil; 2) the financial costs and economic benefits of the current program; and 3) sustainability requirements which evaluate the environmental gains and or penalties associated with sugarcane ethanol. By investigating these categories, this research seeks to highlight if there are potential lessons for other developing states to replicate growth in the production of ethanol. In order to have a greater understanding of whether there are certain components of the Brazilian ethanol structure which could be transferable to other developing countries, this research project will evaluate the extent to which the Brazilian ethanol program can be replicated in Paraguay. It would be an outrageous claim to identify the Brazilian experience in large-scale ethanol production as a template for new producer countries, as many mistakes were made in the past and there are still many problems to be solved. Arguably, Brazil does possess unique political and economic characteristics that many smaller developing economies do not have and thus complete replication is unlikely to materialize. Nevertheless, the Brazilian experience is clearly the key case for studying the possibilities, costs and benefits for other countries seeking to develop a sustainable industrial policy based on the production of sugarcane ethanol.

1.3 Framework for Analysis

This study's framework for analysis will be based on the following three categories: political and institutional arrangements that govern the value chain of ethanol in Brazil, including: an evaluation of the multiple stakeholders intricately involved; principal economic factors in regards to the costs and benefits of the Brazilian program; and sustainability requirements which the environmental literature emphasizes are required in order to credibly assess environmental gains and penalties associated with this renewable source (De Almeida 2007; Smeets 2007; Morreira and Noguiera 2005; Kojima and Johnson 2006).

The impetus for choosing this framework is driven by what the literature conveys are the strategic ingredients for producing a cost-effective, viable and sustainably enriched ethanol program. In summary, what this project is investigating is whether the Brazilian experience with ethanol is an isolated case in achieving real domestic gains and what, if anything, Paraguay can learn from this program.

Paraguay was chosen for this comparison study due to a variety of factors including Paraguay's proximity to Brazil and Paraguay's 100% dependence of imported fossil fuels. Further, developing an ethanol industry has the potential to bring the combined benefits of enhancing energy security and reducing high foreign currency outlay (which is the result of paying for oil imports). Paraguay also possesses the agricultural requirements for growing sugarcane and thus has a natural competitive advantage. The country has substantial availability of land and therefore the potential to expand in areas which do not threaten its natural environment. Moreover, agriculture is an extensive portion of both economies in Brazil and Paraguay and thus technological transfer is possible in vital areas such as research and development. Generally, in Paraguay there is an acute need for new sources of employment and income mobility. One way of generating this could be by establishing industrial linkages between the ethanol market and the agricultural sector, which was particularly successful in the Brazilian case. Paraguay is also in a position where it could optimize its trading relations with the EU by integrating environmental certification procurement into its production methods, and access one of the largest future markets for biofuels (Rothkropf 2007). Finally, Paraguay has an emerging biofuel sector, yet at this writing, it is unclear to what level of political support the government is committed to.

The following sections of this chapter will commence with a general literature review, illustrating why the three categories to guide this study were chosen for this analysis. Subsequently, the conceptual framework for this project will be presented, which supports my central questions for evaluation within each of these three categories. The final section will include a section on qualitative methods utilized; and it will provide the questions our research team asked key stakeholders involved in the Paraguayan ethanol value chain. I will conclude with a discussion of primary and secondary literary sources which have guided this study.

1.3.1 Research Question

To what extent can the Brazilian ethanol program be replicated in Paraguay? As the Brazilian state's policies were instrumental in the success of this particular ethanol program, what central institutional requirements that organize the value chain would be required for Paraguay to adopt? Further, what were the economic costs and benefits of the Brazilian model? A feasibility study of this nature will also need to evaluate sustainability requirements that any successful biofuel program must incorporate. This analysis will answer two critical questions for replication of Brazil's experience in Paraguay. First, at what point will Paraguay be able to enter the ethanol market, in comparison to the Brazilian experience with sugarcane ethanol? And second, without systematic support from the state during the infant stages of growth, is it realistic to expect Paraguay to be successful in developing a medium-scale production of sugarcane ethanol?

1.3.2 Structure of Document

Chapter 1 will outline the framework for analysis, the central research question, a general literature review and the conceptual framework. Chapter 2 will investigate the Brazilian model in further detail and address the questions which were asked to the Paraguayan interviewees. Through providing answers to these questions in reference to the Brazilian case, I then can make observations in terms of the feasibility of Paraguay adopting a sustainable industrial policy based on the production of sugarcane ethanol. In Chapter 3, this study will investigate the current status of Paraguay's ethanol sector, and address each of the hypotheses that are outlined in the end of Chapter 1.

1.4 General Literature Review

As noted, this project's framework of analysis is based on three categories: (1) political and institutional arrangements that govern the value chain of ethanol in Brazil; (2) economic factors including the costs and benefits of the Brazilian program; and (3) sustainability requirements which seek to mitigate the effects of complete dependence on fossil fuels.

1.4.1 Political and Institutional Requirements

As this alternative energy sector is relatively new, the literature that discusses political and institutional requirements for a viable ethanol program tend to draw reference from the Brazilian experience. Much of the literature emphasizes that the single most important factor driving the original expansion of the Brazilian sugarcane industry was the Proalcool program (Programa Nacional do Alcool), Brazil's national alcohol program (Brandao 2007; Kojima and Johnson 2006; Rothkopf 2007; BNDES and CGEE 2008). The program was created to reduce dependence on oil at a time when over 80% of oil consumed was imported and Brazil was reeling from the major oil price rises of the 1970s. Initiated in 1975, as a government mandated program to regulate the fuel alcohol content in gasoline, the Proalcool program was ultimately responsible for the expansion of sugarcane production and the development of two types of ethanol: hydrous alcohol for used in pure alcohol vehicles and anhydrous alcohol for blending with gasoline (Morreira and Noguiera 2005).

Since its inception, the Proalcool program has served to dampen the effects of increases in crude oil prices. The program provided incentives for greater use of fuel alcohol when oil prices were high or for reducing the ethanol content in the gasoline blends when ethanol supplies were low in the face of rising international sugar prices and exports.

The literature categorizes Brazil's ethanol development into two phases (Hira and De Oliviera 2008; Kojima and Johnson 2005; Brandao 2007). The first is the period between oil shocks from 1973-1979, in which the government created incentives to boost ethanol production from sugarcane and introduced mandatory blending of ethanol with gasoline at a rate of 10% (Petrobras 2008). In the second phase, during the periods of 1980-1990, a new set of incentives for both carmakers and car buyers allowed the development of an ethanol-dedicated car market. In 1988, almost 100% of passenger cars produced were ethanol-based (De Almeida 2007, 14). However, the decrease in oil prices in the mid-1980's and price spikes in the international sugar market adversely affected ethanol economics. The collapse of the ethanol-dedicated car market resulted in a reduction in ethanol production in Brazil.

After 2001, ethanol production entered a new phase of expansion, related to three main factors: an oil price increase, the recovery of the Brazilian ethanol market; and international demand for ethanol (De Almeida 2007, 15; Brandao 2007; Rothropf 2007). The recovery of the Brazilian ethanol market is largely attributed to the introduction of FFV's, which now represent 80% of all light vehicles sold. In summary, what the literature highlights is that during the aforementioned phases of development, the state's interventionism was one of the most influential aspects in the success of this program. Hira and De Oliviera (2008) summarize the Brazilian state's interventionist policies during the industry's various phases of development:

- Establishing and supporting the market during the primary stages of development and during times of economic crises;
- Investing huge amounts of capital into infrastructure building, including key aspects of innovation and research leading to the efficiency of the markets; and
- Deregulation once the industry maintained stability.

There are several secondary sources which go beyond the historical explanation of the various phases of political development. The report *Sugarcane-Based Bioethanol*, produced by BNDES and CGEE (2008), provides a logistical and detailed account of the intra-institutional workings that govern the ethanol value chain. The study stresses "…the crucial role played by a legal and institutional infrastructure created along the process, which has paved the way for this alternative source to become a vital component of the Brazilian energy matrix" (BNDES and CGEE 2008, 145). Another key report, *Biofuels for Transport, Development and Climate Change*, by Noguiera and Morreira (2005), provides additional nuances to the discourse of the politics behind ethanol. Noguiera and Morreira elaborate on the instrumental leadership role played by the Brazilian government (at both the federal and state levels) which provided incentives and facilitated the creation of a clear institutional framework. This role included the setting of technical standards, support for the technologies involved in ethanol production and use, financial advantages, and market conditions (Noguiera and Morreira 2005, 29).

An integral aspect of the institutional framework includes the participation of the oil sector. As Kojima and Johnson (2006) discuss, it is only through facilitating linkages with key stakeholders in the oil industry, such as Petrobras, Brazil's state-owned oil conglomerate, that it is possible to distribute a blended liquid fuel (3). However, one area of contention is that this sector also has powerful economic interests which could likely be threatened by the widespread adoption of biofuels over petroleum. This is a focal point of reference to the Paraguayan case that will be discussed in great detail in the third chapter.

In light of this, institutional coordination from various ministries of industry and agriculture should theoretically work under a harmonized framework. Biofuels production should be organized and managed like all energy sectors, but, unlike the electric and oil industries, many players are required in the biomass market. Biofuels go through various phases which require specific actions both from the public and private spheres. For example, sugarcane is grown and harvested; it is then distilled at the plants; blended with gasoline; brought to market and distributed to a variety of entities which sell it for domestic consumption. There are a variety of ministries involved in each of these processes of production. Each of these ministries should have coordination and communication channels open, so that the product is produced within a system of checks and balances. In this sense, government and the other key stakeholders involved in the value chain of biofuels must play an active role, especially in developing countries such as Paraguay where the political and economic climate often lacks transparency.

1.4.2 Economic Costs and Benefits to the Brazilian Ethanol Program

Since the 80's, there have been substantial cost reductions in Brazilian sugarcane based ethanol (Kojima and Johnson 2006; Goldemberg 2008b; Hira 2009b). This trend accelerated further after the 1999 currency devaluation. This effect, plus the increase in the cost of oil since 2000, has made Brazilian sugarcane ethanol cost-competitive with that of gasoline.

In fact a great majority of the economic literature highlights that Brazil has the lowest production cost of ethanol in the world and is so far the only country where biofuels are strictly competitive vis-a-vis oil derivatives (BNDES and CGEE 2008; Goldemberg 2007, 2008, 2009; Kojima and Johnson 2006; De Almeida 2007). The financial cost of ethanol production in Brazil is estimated to be in the range of US$0.35-0.40 per litre (or US $55.65- 63.50 per barrel), which is significantly below barrel-of-oil equivalent prices between US$67 to US $70 (Smeets 2008; Brandao 2007). The costs of ethanol production in other countries, or the cost of using other feedstock sources, is significantly higher than from using sugarcane in Brazil. The cost of the production of ethanol is determined by three main factors: the cost of sugarcane production, the cost of its processing and the rate of its conversion into ethanol. As long as raw materials account for roughly 60% of the production costs, the comparative advantage of sugarcane is crucial to the commercial feasibility of Brazilian ethanol (De Almeida 2007). The cost of sugarcane production in Brazil is in order of $170-$210 per ton, while the costs for other countries are significantly higher: $250 per ton in South Africa, $308 per ton in Mexico, $525 per ton in the United States, and $770 per ton in Italy (Unica 2007, 4).

The price of ethanol depends on the price of gasoline, which is almost a truism. Petrobras is a key player in this market, as it has a de facto monopoly in petroleum derivatives and has a large market share of distribution and sales of gasoline, diesel and ethanol. Until 2002, the price of gasoline to the producer was set by the government and until 2001 a percentage of the producer sales price was a tax known as PPE (Parcela de Preso Especifica) (Macedo and Noguiera 2005, 30). The revenue was used to subsidize hydrous ethanol: to make it cheaper than gasoline; for the transportation of ethanol; and to harmonize prices throughout the country. As noted, the ethanol market was liberalized in 1999. Subsidies were eliminated, and Petrobras used PPE revenue to postpone or sometimes avoid changes in the domestic price of gasoline and other petroleum derivatives in periods of instability in the international petroleum market (Petrobras 2008).

A substantial amount of the business literature suggests that the main success of the program was the government's domestic subsidization of the FFV market (BNDES and CGEE 2008; De Almeida 2008; Smeets 2008; Rothropf 2007). In 2003, there were only 49,000 FFV's sold. According to Petrobras, the sales of FFV's increased to 1 million in 2004, 2 million in 2006 and by 2007, 4.5 million of the light-vehicle fleet (Petrobras 2008). The expansion of this market for domestic ethanol consumption is supporting the industry's trajectory of growth.

One of the primary costs to this model that the economic literature emphasizes is the subsidies that were required during the program's initial phases of development. In fact, it is estimated that Proalcool cost the private sector and the Brazilian government US $7.1 billion dollars (Hira and De Oliviera 2008, 7). The important aspect for this analysis is that any country seeking to expand its ethanol sector must have the financial capital, both at the government and private levels, to subsidize the various sectors and policies during their phases of growth. In the case of Brazil, the government and various key institutions worked in harmony with the private sector to absorb the financial costs of development.

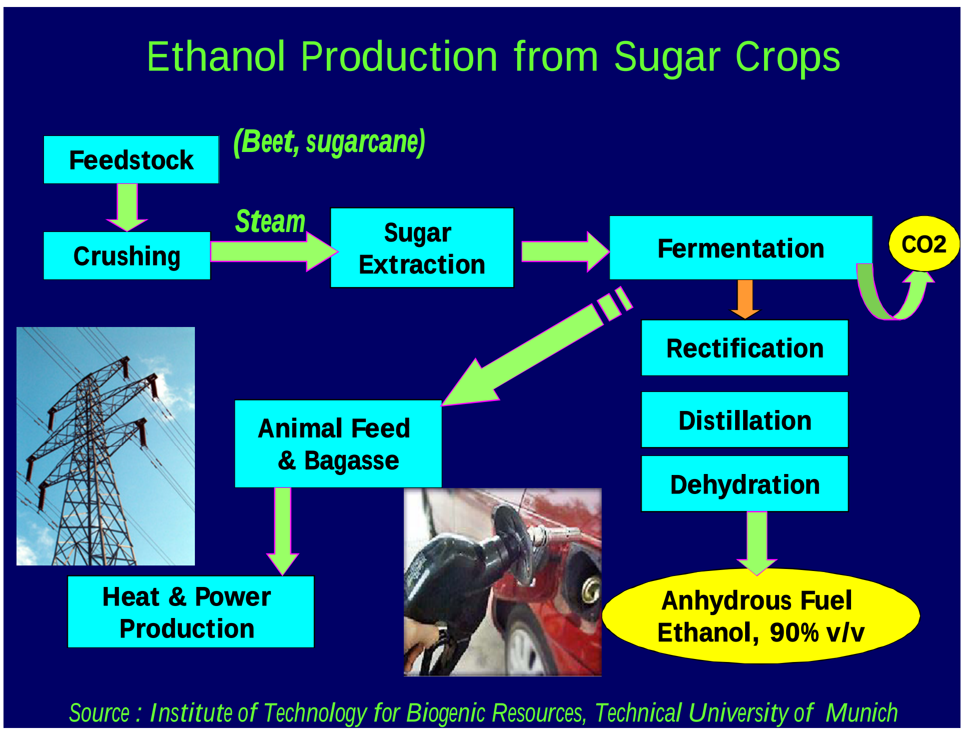
An additional benefit that the literature addresses is job creation, which is the result of agricultural-industrial linkages, as the ethanol industry is intimately linked with the production of sugar. With respect to the quality of the jobs, information from the Brazilian National Household Sampling Survey (PNAD) indicated important improvements in several socioeconomic indicators. These included increases in the degrees of formality versus informality, growth in income and benefits received by employees, marked reduction in child labor and increase in schooling levels (BNDES and CGEE 2008, 203). It must be noted, however, that the literature emphasizes that the labour involved in ethanol production is generally heavy and exploitative and the state must be permanently vigilant in strictly enforcing labor laws (World Resources 2005; WorldWatch Institute 2007; Amnesty International 2009). This is a significant factor to promote the progress of effective labor relations and social responsibility in this sector.

1.4.3 Sustainability Requirements

Ethanol's Definition

Ethanol is an alcohol-based, clean-burning fuel produced from renewable feedstocks. It falls within the category of high-octane fuels, meaning it is highly efficient and preventative of engine knock. It can also be used as an oxygenate component to petroleum to minimize carbon monoxide emissions by augmenting the petroleum's octane properties, thereby improving combustion, and diminishing exhaust emissions (WorldWatch Institute 2007, 14). It is produced from starch, which can be derived from a variety of feedstocks including sugarcane, corn, potatoes, sugar beets, switchgrass, barley, wheat and grains, and through a variety of processes. The refining process of ethanol can be categorized into three stages: growing and cutting of the cane; the refining process of the sugar and then blending with gasoline derivatives; and the distribution to the market place (Hira 2009b) (Figure 1.1).

Figure 1.1 Ethanol Production from sugarcane



1.4.4 Comparing Sugarcane and Corn

The debate over the sustainability of biofuels is ongoing in academic circles. Nonetheless, one aspect on which the sustainability literature does present consensus on is that sugarcane ethanol is the most energy efficient type of feedstock to produce ethanol (Rothkropf 2008; De Almeida 2007; Goldemberg 2009; Kojima and Johnson 2005; Farrell and Delucchi 2007). In order to have a greater understanding of the mechanics behind the sustainability debate, a review of first and second generation biofuels is warranted.

The sustainability literature clearly separates the various biomass feedstocks used for producing biofuels into two basic categories: the currently available first generation sources, are harvested for their sugar, starch and oil content and converted into liquid fuels by conventional technology (Goldemberg 2009; Kojima and Johnson 2005; Sims and Mabee; Rothkropf 2007); and second generation biofuels, which include matter such as wood-based sources, are harvested for their aggregate biomass. They can only be transformed into liquid fuels by advanced technology, which is not yet cost-effective on the global market. One critical difference between these two groups is the amount of carbon abatement they are able to produce. The sustainability literature is optimistic that once the technological conversion process is economically viable, second generation biofuels are argued to be the 'panacea' in terms of reducing carbon output (Sims and Mabee 2008; Farrell and Delucchi 2008; Rothkopf 2007; Goldemberg 2009; Morreira 2005). Notably, one of the central premises behind this debate is that first generation biofuels will establish the policy drivers, infrastructure and political support in the short-term. By integrating a functional and economically viable framework of first generation biofuels, this will enhance the probability of second generation sources succeeding in a state's long-term pursuit of reducing GHG emissions. There are voluminous amounts of literature which share this position (Goldemberg 2008; Morreira 2005; Rothkropf 2007; De Almeida 2007; WorldWatch Institute 2007;BNDES and CGEE; Brazlian Agroenergy Plan 2006).

The focus for this research is first generation sources, which primarily consists of grain, corn, barley and sugarcane. These feedstock sources contain stark differences in terms of their positive energy outputs. For instance, a large body of research has presented findings that producing ethanol from grain starches is more land-intensive than producing it from sugarcane because corn crops have lower fuel ouputs per hectare (WorldWatch Institute 2007; Goldemberg 2009; Goldemberg 2007; De Almeida 2007; Farrell 2005; Larson 2005; Delucchi 2005). As a result, while the US and Brazil produce comparable amounts of ethanol, the US relies on corn, must use almost twice as much land for production. In comparison to sugarcane, corn starch must also undergo additional processing to convert it into sugars before it can be fermented to ethanol fuel (WorldWatch Institute 2007, 162). Additionally, sugarcane stalks contain so much sugar that the plant is currently the lowest cost source of biofuels. Cane plants produce a large amount of fiber in their stalks and leaves as well, making it possible to ‘co harvest’ a significant amount of cellulostic feedstock for bioenergy. Principally, this is referring to the process of co-generation, which produces enough energy from the cellulostic feedstock to power the production facilities (WorldWatch Institute 2007; Goldemberg 2009; Morreira 2005; Macedo and Noguiera 2005).

The majority of the sustainability literature addresses the importance of first generation biofuels in reference to establishing the infrastructure and policy drivers required to support renewable transport fuels (Sims and Mabee 2008; Bergeron and Klein 2004; Forge 2007). However, the environmental benefits of first generation biofuels are quite variable when all the emissions are included using Life Cycle Assessment (LCA) methodology. In particular, the benefits are not always as good as claimed. LCA is defined as the investigation and valuation of the environmental impacts of a given product or service caused or necessitated by its existence (WorldWatch Institute 2007). LCA of biofuels calculates:

> "…inputs of fossil fuels and fertilizers needed for the production of the biomass, the energy use and emissions from the industrial conversion processes, emissions from the final combustion of the liquid fuel and allocation on an equitable basis to any co-products. GHG emissions from land use change, both direct and indirect, should also be included but this is not always possible due to the lack of data"(Sims and Mabee 2008, 18).

A study conducted by De Oliviera (Table 1.1), illustrates the best and worst case scenarios for sugarcane and corn in terms of their energy balance and carbon dioxide emissions, by using LCA analysis. The results convey a much higher reduction of GHG emissions for sugarcane (2006).

Table 1.1 Best and worst case scenarios for ethanol energy balance

Best and worst case scenarios for ethanol energy balance and carbon dioxide emissions in Brazil (where ethanol is produced from sugarcane) and in the US (where ethanol is produced from corn).					
Scenario	**Yield**	**Energy (GJ) per**	**Ethanol conversion**		**CO2 emission**
	(Mg per ha)	**Mg Nitrogen**	**(L per Mg)**	**Energy balance**	**(kg per m3 ethanol)**
Sugarcane (Brazil)					
Best-case	80	57.5	85	3.87	**461**
Worst-case	69	75.6	80	3.14	**572**
Corn (US)					
Best-case	8.16	57.5	402	1.12	**1392**
Worst-case	7.6	75.6	372	1.03	**1459**

Source: De Oliviera 2006

In general, the sustainability literature highlights a lack of consensus regarding the net GHG benefits and penalties associated with grain and corn ethanol. For example, Farrell (2006) concludes that corn ethanol generates 0.8 units of GHG's for each unit it saves, by comparison. Larson (2005) who studied over 30 LCA's of an assortment of biofuels, discusses that ethanol from wheat ranged from a 38% benefit to a 10% penalty. Delucchi (2005) estimates that emissions derived from corn ethanol can range from a 30% increase to a 30% decrease from those of petroleum fuels. In sharp contrast, is a recent study produced from Harvard University; their researchers' findings indicate that corn ethanol produced a 48% to 59% reduction, three times higher a reduction than previous studies had discussed (Liska 2008). The diversity present in these scientific results produces uncertainty and questions the sustainability of grain and corn-based ethanol versus sugarcane.

1.4.5 Sugarcane Ethanol and Carbon Abatement

Although there is a lack of agreement among academics in regards to corn and grain, the literature reaches different conclusions in respect to sugarcane ethanol. Numerous studies have assessed the net emission reductions resulting from sugarcane ethanol in Brazil, and all have concluded that the benefits far exceed those from grain-based ethanol (De Almeida 2007; De Oliviera 2006; Morreira and Noguiera 2007; Goldemberg 2007; Goldemberg 2009). One area of contention though, is regarding land-use changes which are generally not calculated in LCA analysis. Opponents of LCA analysis contend that this negatively skews carbon abatement benefits. This issue is of significant importance to the sustainability debate and will be discussed in great length in the following chapter.

Kaltner (2005) estimates that the total life-cycle of GHG emission reductions are equivalent to 46.6 million tons annually (12.75 million tons of carbon per year), or approximately 20% of Brazil's annual fossil fuel emissions. In short, academia presents an environmentally sustainable paradigm associated with Brazilian sugarcane ethanol and an inconclusive framework with corn/grain- based ethanol. The Brazilian sugar industry is almost energy-self sufficient due to the use of bagasse, a biomass co-product derived from sugarcane harvesting. Based on the LCA methodology, Macedo and Noguiera (2005) report decreases in carbon intensity due to the recycling of bagasse instead of using fossil fuels. This study is further complimented by Fulton (2004), who articulates that the decreases in life-cycle impacts for sugarcane ethanol are based on two components: (1) the lower inputs, as yields have increased due to productive soil and solar aspects; and (2) virtually all “conversion plants” use bagasse for energy, or forms of cogeneration in the distillation plants, allowing the excesses of energy to be fed directly into the grid.

Conversely, De Olivera (2006) illustrates that the use of fossil fuels for Brazilian ethanol production in 1991-92 contributed to the emission of 1.2 million tons of carbon. On the other hand, the ethanol and bagasse produced avoided emissions of 10.6 million tons of carbon by replacing gasoline in transport and fuel in oil power generation. An additional area of contention that the sustainability literature emphasizes is the need for environmental certification of biofuels (WorldWatch Institute 2007; Morreira 2008; Rothkropf 2007). This is particularly significant as the EU has adopted certain environmental and labor regulations concerning the importation of ethanol into their market. Undoubtedly, this legislation will irrevocably influence Brazil and potentially Paraguay to raise their environmental standards in cultivation of sugar, production of ethanol and labor standards.

In summary, what the sustainability literature emphasizes is that ethanol is heterogeneous in its abilities in reducing GHG emissions. This is primarily based on the type of feedstock used and further exemplified by what the LCA analysis calculates concerning environmental penalties and benefits.

1.5 Conceptual Framework & Qualitative Methods

The following section will outline the general hypothesis for this project and questions that were posed to various stakeholders interviewed during the field research component in Paraguay, July 2009.[2] The answers to the questions will be detailed in Chapter 3, which examines the case of Paraguay. Additionally, this section will be accompanied with three sub-hypotheses for each of the categories from my analytical framework which guided this study.

Dr. Andy Hira, Associate Professor of Political Science at Simon Fraser University, applied to the International Development Research Centre for a grant to investigate the feasibility of establishing a biofuel sector in Paraguay. He was fortunate enough to receive a substantial grant to undergo field research in Paraguay for three weeks, in July 2009. I was chosen as the graduate student to accompany Dr. Hira in the field research component. Dr. Hira facilitated communication with Dr. Plinio Torres at Americana University, in Asuncion, Paraguay. Dr. Torres was the main liaison that coordinated the interviews with various stakeholders involved in the value chain of ethanol during our field research visit. The findings of this study are a reflection of my own observations and answers provided by all the Paraguayan interviewees.

[2] All participants were given a consent form which included details of the study, how the data would be used, how it would be secured, and who to contact with any range of concerns or to receive a final copy of the report. For further information, please see the attached consent form. The suggestions and comments made by these individuals are their own and do not necessarily represent their associated organizations.

1.5.1 General Hypothesis

It is feasible for Paraguayto establish a viable sugarcane ethanol sector in the short-term, given its factor endowment conditions to grow sugarcane sustainably and the country's 100% dependence on fossil fuel imports.

Hypothesis A (Institutional Arrangements that Govern the Ethanol Value Chain):

The Brazilian state's support of research and development was instrumental in the growth of the ethanol industry.

Thus, in order to evaluate whether this program can be replicated to some degree, we need a greater understanding of the institutional organization that governs matters of biofuels in Paraguay.

Key Questions for Key Stakeholders (Interviewees) in Paraguay (July, 2009)

A. Political and Institutional Components

1) Is there a political desire (private sector, agriculture, industry, and government) to expand biofuels in Paraguay?
2) What legislation and institutions are currently involved in ethanol production?
3) How are the institutional structures that govern energy policies in Paraguay organized and who are the key decision makers?
4) What institutional reforms must take place to improve the governance of the ethanol value chain?
5) Who are the key actors involved with labor regulations?
6) What are the key improvements which must be addressed to protect labor from exploitation (if the industry expands)?
7) How are the sugarcane, ethanol producers and fuel distributors organized? What are areas which require enhancing transparency?
8) Who are the key stakeholders in oil and what is their current role in the ethanol industry? Which interests in the oil sector will be threatened if biofuel production becomes a state-led industrial policy?
9) Who are the main actors involved in the automobile sector and what is their relationship to the alternative energy markets?
10) Is there good agricultural research and extension, or a high probability of strengthening it?
11) Are there are cadre of managers that can be called upon to manage the industry?

Data sources and completed interviews

Interviews with government individuals involved with the ministries of agriculture; transportation; industry and trade; labor; foreign and domestic companies operating in Paraguay (auto sector and fuel production chain); NGO's. Key documents from the World Bank, IMF, Inter-American Development Bank.

B. Economic Components

Hypothesis B (Economic Costs and Benefits):

The economic feasibility of Paraguay expanding its sugarcane ethanol sector is contingent on how the market operates, in terms of the structure of relationships among sugarcane producers, the private sector and the government.

1) How are the current prices of ethanol and sugar governed in Paraguay?
2) What type of market regulations would be required?
3) What kinds of research and development funding would be required, to maximize gains in efficiency?
4) Where is the location of the sugarcane industry in proximity to urban centers? If it were to expand, where would be the primary locations be? What would be the cost?
5) Given that subsidies were a substantial component in the success of Brazil's ethanol program; would indirect and direct subsidies be a viable economic option for the Paraguayan government?
6) What kind of policies, if any, would be set up for consumers to switch from diesel engines to ethanol based vehicles?
7) Where would the government get the capital for subsidies and to convert the infrastructure to ethanol expansion?
8) What are the import duties on FFV's? Would the government be able to subsidize loans on FFV's to make them attractive to consumers?
9) What are the key costs of expansion (in terms of infrastructure)?

Data sources and completed interviews:

Interviews with sugarcane and ethanol producers, government officials dealing with agriculture, energy, fuel. Interviews with related Ministries in Energy and Transportation; Finance; and Agriculture; Petroprar; automobile importers;

Japanese corporations located in Paraguay. Key reports from WB, IMF and university documents.

C. Environmental Requirements

Hypothesis C

Sugarcane ethanol could be produced in a sustainable way in Paraguay in the short-term, given the country's abundance of available land.

1) Which pieces of legislation and institutions exist in Paraguay which govern matters of environment in reference to both sugarcane and ethanol? What institutions are responsible for the enforcement of mechanized harvesting?
2) What is the role of NGO's in environmental matters? Do they have a working relationship with the current government?
3) Is technological transfer from Brazil possible (to maximize gains in efficiency)?
4) What efforts are being made to improve governance in environmental matters?

Data sources and completed interviews:

Key government environmental documents; university websites and reports on environmental governance; interviews with NGO's and cooperatives; interviews with ministries associated with environmental matters; visits to sugar plantations and refineries.

2: Brazilian Sugarcane Ethanol Paradigm in Focus

2.1 Political and Institutional Components in Brazil's Ethanol Matrix

This section seeks to crystallize central aspects of the Brazilian ethanol industry's institutional framework. By highlighting various key policies during each of the phases of development and emphasizing the various roles played by multiple stakeholders involved in the ethanol value chain, I am then able to identify if symmetries exist in the case of Paraguay. In the previous chapter, I outlined a series of questions I posed to a variety of actors directly, or indirectly involved in the production of ethanol in Paraguay. In order to produce a credible evaluation of these responses, these questions must be answered in reference to the Brazilian case for comparison. I structure this section around Hypothesis A:

The Brazilian state's support of research and development was instrumental in the growth of the ethanol industry. In order to evaluate whether this program can potentially be replicated to some degree in Paraguay, we need a greater understanding of the institutional organization that governs matters of biofuels in Brazil.

2.1.1 Phase 1: (1975-78) Birth of ProAlcool

The alcohol industry received its initial momentum during the mid 1970's. Brazil was heavily dependent on oil imports and the volatility of oil prices put considerable strain on the country's foreign trade balance. The international prices for sugar were also decreasing steadily, and the sugarcane sector desperately needed alternative avenues to generate capital. In 1975, the federal government adopted Decree 76.593 signed by President Geisel, calling for nation-wide production of alcohol to replace gasoline. The plan was known as ProAlcool (Brazilian Agroenergy Plan 2006, 67). The blending rate was set at 10% anhydrous ethanol to 90% gasoline. One important aspect of this phase was that the government had full control over fuel distribution and pricing, and mandated that at every gas station a minimum of one pump was to be dedicated to ethanol. WorldWatch Institute (2007) states that 4 key policies were set up:

1. Low-interest loans were provided by the Bank of Brazil, to aid in the purchasing of capital required for the distillation plants;
2. Petrobras guaranteed the purchase of ethanol;
3. The government regulated pricing and production quotas in order to make ethanol cost-competitive with petroleum; and
4. There were export controls and quotas set for the production of sugar.

It was during this expansionary period that the government decided which ministries would oversee regulation of the program. CINAL (Conselho Internal National) was chosen as the body that would initially guarantee the purchase of fuel against a certain price, set slightly higher than the production costs (Blake 2005, 18). The Ministry of Industry and Trade, and the Secretary of Industrial Technology were also connected with CINAL, thus creating the initial intra-institutional coordination between related ministries in accordance with the ethanol value chain.

2.1.2 Phase 2: (1979-1985) Production in Full Swing

In 1979, the second oil crisis had hit, with prices escalating dramatically. At this time, oil imports accounted for approximately 85% of Brazil's energy needs, and consequently, the price hikes had adverse effects on the national economy (BNDES 2008, 150). This gave the policy makers driving ProAlcool justification to increase production of both sugar and alcohol, in order to reduce foreign dependence on oil and rectify the imbalances in foreign exchange. Between the periods of 1979-85, the production of sugarcane quadrupled as many new distilleries were constructed adjacent to sugar mills. Alcohol became a strategically economic fuel in Brazil's energy matrix (Brazlian Agroenergy Plan 2006, 67). It is important to note that part of the success in this expansion was a derivative of the government guaranteeing prices of ethanol to consumers. Petrobras was the key actor involved and responsible for distributing hydrated ethanol to all stations, while the costs of this policy were primarily absorbed by the government. This expansion was also viable due to US$2 billion in loans from multiple private investors (Hira 2009a, 4). An additional instrument to support the domestic growth of the industry was the introduction of the vehicles which could run on alcohol. In fact, this industry experienced a tremendous amount of growth in its infancy stages. A detailed report produced by BNDES (2008) summarizes the key policies during this phase:

1. The government mandated higher blending ratios of anhydrous ethanol to gasoline (eventually rising to 25%).
2. Ethanol was to be sold at every gas station across the country.
3. Guaranteeing absolute prices to producers of ethanol (even if the international market for sugar was more attractive).

4. Consumers were also guaranteed attractive prices for ethanol versus petroleum.
5. Credit lines were established for mills to increase production.
6. Subsidies were given to consumers who purchased new alcohol vehicles.
7. The government ensured that there were sufficient reserves to support domestic demand, during times that were non-seasonal.

During this period, public opinion strongly supported the actions taken by the government to subsidize the industry. This provided policy makers with the political support they required to substantially inject investment into key areas of research and development (R&D), during this crucial stage of growth (Van der Bake 2005, 20; WorldWatch Institute 2005, 25).

2.1.3 Phase 3: (1985-2006) Troubled Times Met with Liberalization

The situation began to change quite dramatically in 1985. Oil prices substantially decreased which was simultaneously met with world market increases for sugar. Low oil prices meant that the cost of ethanol was no longer cost-effective for the Brazilian government to subsidize. Further, increased world prices for sugar created a dilemma: should policy makers continue to subsidize ethanol to fuel the growing domestic demand, or should they divert a significant portion of the production of sugar for export (Goldemberg 2004, 1143)? These obstacles led the state-led program to re-evaluate the isolated production of sugar for domestic alcohol production. The exportation of sugar was a rising priority on the agenda of the government, which diverted attention away from the expansion and growth of the ethanol sector (Soetavert 2009, 57). Moreover, in response to sugar exports having been given priority from the government, subsidies to mills and price ceilings on the cost of ethanol were substantially decreased.

The literature articulates that the absence of the government's political backing resulted in many periods where the supply of ethanol was not able to meet demand (BNDES 2008; Soetavert 2009; Hira 2009a; Brazilian AgroPlan 2006; World Resources Institute 2005). In response to the increased cost of ethanol (as price ceilings were lifted gradually) and to periods when the commodity was not available in supply, consumers began to lose confidence in the reliability of the ethanol market. The loss of consumer confidence is particularly evident as the industry experienced a substantial drop in purchases of alcohol-based cars, which accounted for 85% of sales in 1985 and only 11.4% by the end of 1990 (BNDES 2008,150).

During the early 1990's, oil prices continued to decrease accompanied by a looming financial crisis across Latin America. Further, Brazil was transitioning into a procedurally democratic state, which ignited many political qualms and fragmentation over the government's political commitment towards the industrial growth of the sugarcane ethanol sector. The government continued to progressively remove regulations and subsidies, which resulted in the end of Proalcool in 1991. In response to the end of Proalcool, the Brazilian institutional framework began to unravel, as economic and political support for the program decreased. With the economy in virtual shambles during the first half of the 1990's, liberalization and privatization seemed to be the only viable option for the government to pursue. After 1996, decreases in oil prices coupled with the decline in government support; resulted in ethanol sales dropping even further. By 1998, ethanol subsidies were eliminated (Xavier 2007; Van Der Bake 2005;

BNDES 2008). At this time, gasoline prices were kept higher than other fossil fuels because of the additional tax.

As liberalization of the sugarcane ethanol market ensued, hydrous (gasoline and ethanol) was sold at up to 90% the cost of gasoline, while during the early parts of the 1980's, ethanol was sold at 57% of the price of petroleum (Xavier 2007, 5). The sharp increases in the price of ethanol are real indicators of how it was no longer cost-effective for the government to support the industry. The progressive removal of key price advantages coupled with the market's inability to satisfy domestic demand nearly decimated the entire industry. From an institutional point of view, policy modifications commenced early in the 1990's, first with the liberalization of fuel prices and secondly, with the deregulation of the sugarcane industry (Van der Bake 2006, 20).

Within the context of instituting neo-liberalism into the various facets of the Brazilian economy, an institutional review of central bodies regulating the ethanol industry ensued. During this period, the production of sugar increased significantly, marking Brazil's hegemonic status as the world's leader in sugar production (World Resources Institute 2005, 28). In an effort to keep the industry's modes of production in swing in 1997, three institutions were created which have a tremendous amount of influence in the current context: (1) the ANP (National Petroleum Agency), (2) CNPE (National Energy Policy Council) and (3) Unica (Union of the Sugar Cane Industry of the State of Sao Paolo). The CNPE was responsible for establishing appropriate mandates for biofuel programs while the ANP's role was that it had to be informed, by distributors, of the volumes of transactions with ethanol. This body's main purpose was to monitor producers' subsidies.

In 2000, institutional reform continued with the formation of CIMA (Inter-ministerial Sugar and Alcohol Council). The primary function of this body was to deliberate on the key aspects of the sugarcane ethanol industry including: a) Brazil's energy matrix; b) economic policies required to maintain domestic supply; and c) matters related to science and technology (BNDES 2008 ,152). This entity is also responsible for regulating the content of gasoline and ethanol; while ethanol is typically blended between 20% -25%, this can further be decreased as a result of lower world gasoline prices. An additional strength of this body is that it is highly coordinated with the Ministry of Agriculture, and Ministries of Finance, Development, Industry, Foreign Trade, and Mines and Energy. This, in effect, produces accountability and the legal framework along side the value chain.

Finally, as noted by Moraes (2000), this period gave birth to a landmark non-governmental organization (NGO) whose purpose was to protect the interests of producers. Unica is comprised of more than 100 industrial producers in Sao Paolo (SP) that are responsible for approximately 58% of Brazilian sugarcane, 58% of sugar and 60% of ethanol. It is one of the most influential institutions in the current context because it "…strengthens producers representation and unifies actions in face of the new reality" (Moraes 2000, 97). The new reality to which Moraes is referring is that the Brazilian government is no longer intimately involved in the market of ethanol, and thus unifying producers and workers is fundamental to protecting their interests in an ever expanding competitive market.

The complete deregulation of the sector is distinguished by Petrobras no longer being responsible for quotas and price regulations. The decreased role of Petrobras further reinforced the perceived limitations in the government's commitment to the industry's survival. From 1999 to 2002, the government's only policy instrument was the blending legislation of 10% ethanol to 90% gasoline, which was used to influence the market of anhydrous ethanol (World Resource Institute 2005, 29). Moreover, instead of focusing on quotas and price regulations, the government's efforts were directed towards research and development, thereby supporting studies aimed at optimizing differences in cane varieties (Van Der Bake 2006, 21). The policies between 1985-2002 can be summarized by the following:

1. During the late 1980's, levels of political support for the ethanol market decreased in response to low oil prices and international sugar prices which increased substantially. The exportation of sugar became a priority on the agenda of policy makers in Brazil, and this resulted in periods of ethanol shortages.

2. Loss of consumer confidence in the market resulted in the dramatic decrease in sales of alcohol-based cars.

3. There were progressive removals of regulations and subsidies.

4. Liberalization of the fuel market ensued.

5. This was coupled with the deregulation of the sugarcane industry.

6. There was an institutional review of public bodies that previously regulated the industry.

7. Finally, Petrobras was no longer responsible for quotas and price regulations.

Summary of Brazilian institutional framework

The following section will briefly highlight some of the central pillars of the Brazilian government's institutional framework during the periods of 1975 to 1999 (Table 2.1 and Table 2.2). CINAL (an inter-ministerial commission) held an instrumental role until the institution was phased out in response to deregulation in 1999. It was the government's main vehicle responsible for regulating and coordinating the industry with Ministries of Industry, Commerce and Tourism; Mines and Energy; Finance; Agriculture; Division of Supply and Agrarian Reform; Science and Technology; Environment; Water and Legal Amazon; Planning and Budget (Hira 2008; Rothropf 2007:). CINAL initially guaranteed the purchase of fuel against a certain price, set slightly higher than production costs. CNAL and CENAL (the National Executive Commissions) were also created in the late 1970's, in response to the exponential growth the industry experienced. Further, these bodies aided in providing assistance with subsidies and investment through CINAL. The IAA (Azucar do Alcool) and Planasucar were also created during the primary stages of development. They were particularly unique institutions in that they provided solutions to problems that the market was experiencing such as fixing prices. They also offered advice to key policy concerning future market outcomes.

During the first phase of development (1975-1979), the sugar producers enjoyed low interest rates and R &D subsidies to increase capacity and invest in technologically advanced ethanol mechanics. These policies led to significant increases in ethanol and sugarcane production. Further, sugar quotas were introduced during this period, which resulted in cooperation amongst sugarcane industries, leading to the creation of Copersucar (The Cooperative of Sugarcane, Sugar and Ethanol Producers of the State of Sao Paolo). The government also invested substantially in agricultural R & D, through bodies such as Planalsucar and key Universities, producing research which resulted in high yields of sugarcane during the later parts of the 1980's.

As for policies which influenced the domestic ability to control demand during the 1980's, the government's main instruments were blending ratios and consumer prices after the introduction of the alcohol-based vehicle. It is important to emphasize that for the purpose of this analysis Table 2.1 illustrates the significance of the government intervention in the market and support of R & D during crucial phases of development and then the gradual reduction of its influence once the market had stabilized (Table 2.2).

In this context, the leadership role of the Brazilian government (at both the federal and state levels) in providing incentives and a clear institutional framework was absolutely essential. This role included the setting of technical standards, support for the technologies involved in ethanol production and use, financial advantages and market conditions.

Table 2.1 Institutional Framework from 1975 to 1979

Institutional Framework	1975 Start of ProAlcool	1979 Start Hydrated Ethanol Production
Government	CINAL	CINAL
Institutions	IAA Planasucar	IAA Planasucar
		CNAL- CENAL
Policy Instruments	Low interest rates , R & D, subsidies	Low interest rates, R& D, subsidies
	Guaranteed purchase of cane & ethanol	Guaranteed purchase of cane & ethanol
	Sugarcane export quotas	Sugar export quotas
	Fixed gasohol blend ratio's	Fixed gasohol blend ratio's
		Low hydrated ethanol prices
Market Reactions	Production of ethanol engines	Production of ethanol engines
	Increasing cane ethanol production	Increasing cane ethanol production
		Copersucar- CTC

Source: Van Der Blake 2005; Rothkropf 2007; BNDES 2008

Table 2.2 Institutional Framework from 1990 to 1999

Framework	1990 Start of Deregulation	1999 Complete Deregulation
Government	CINAL	CINAL
Institutions		
Policy Instruments	R & D	R & D
	Guaranteed purchase of cane & ethanol	Guaranteed purchase of cane & ethanol
	Fixed gasohol blend ratio's	Fixed gasohol blend ratio's
	Higher hydrated ethanol prices	
Market Reactions	Increasing cane ethanol production	Increasing cane ethanol production
		FFV's
		Increasing ethanol production
	Copersucar-CTC	Copersucar- CTC

Source: Van Der Blake 2005; Rothkropf 2007; BNDES 2008

Once the market had stabilized post-1999, the ANP's responsibilities changed, they included: "inspecting and applying administrative and pecuniary sanctions pursuant to laws or contracts; enforcing good conservation practices, the ration use of biofuels, and environmental preservation; organizing and maintaining the archive of information and data relative to the regulated activities of the biofuels industry; and specifying standards for biofuels" (BNDES 2008, 151-52). In other words, it is currently the main regulatory institution, which monitors the activities of the petroleum and biofuel industry. However, it is no longer responsible for keeping track of ethanol transactions.

In the BNDES (2008) report, the last function of the ANP should be emphasized as having a tremendous amount of significance: "…it relies on adequate technical support as well as the establishment of communication channels between biofuel producers, engine manufacturers and environmental agencies" (BNDES 2008,152). The latter is a key attribute that facilitates intra-institutional cooperation amongst key institutions in the value chain. This level of cooperation is fundamental to support a transparent and legal framework, by means of efficient administration. This is undoubtedly a significant area of concern in the case of Paraguay committing to the industrial expansion of ethanol production, and will be discussed in the following chapter.

The institutions which govern the prices of ethanol include: 1) CNP (National Petroleum Council); 2) CENAL, which guarantees the purchase of fuel against a certain price, set slightly higher than production costs; and 3) ANP, which oversees the regulation, contracting and inspection of biofuels related economic activities. For this analysis, the important observation here is that these are centrally appointed bodies with clear mandates directed from related ministries which work interdependently to ensure the stability of prices and viability of the ethanol market.

In 2003, the industry gained new momentum with the introduction of FFV's. De Souza (2008) emphasizes that the industry was revitalized due to three main factors: rising international prices for oil, increasing international demand for alternative energy sources and substantial increases in domestic demand due to the introduction of FFV's .The government gave the industry a new level of support, as they classified FFV's for the same tax breaks that were previously given to the alcohol-based vehicles (Hira and De Oliviera 2009, 5). The main advantage of FFV's is that they can run on any mix of fuel content. In other words, they can operate on pure ethanol, a blend of ethanol and gasoline or simply gasoline. Introducing these vehicles to the market provided options to consumers at the pump, albeit depending upon which fuel blend was more cost-competitive at any given time.

According to Brazil's National Association of Automotive Vehicle Producers (ANFAVEA), by December 2007, there were 4.5 million FFV's on Brazilian roads, some 20% of all light vehicles sold (ANFAVEA 2007). During this period, the cost of oil was also rising, which meant that ethanol was becoming cost-competitive vis-a-vis oil derivatives. Consumers had the choice to choose which fuel was cheaper, ultimately by owning a vehicle for which the government provided financial incentives. By 2006, the sales of FFV's reached approximately 80% of all light-vehicles sold (Petrobras 2008). The emergence of the FFV market reinvigorated hydrated ethanol production, as long as oil prices did not collapse under US$35. Since the emergence of FFV's, the industry has grown exponentially.

2.1.4 Conclusions

The set of incentives has changed significantly over the course of the ethanol program in Brazil. During the initial stages of growth, the government controlled the fuel market through Petrobras, which had a monopoly on ethanol distribution. The government gradually reduced its influence with the monopoly ending in the latter parts of the 1990's. Currently, the government's role is not only much smaller, but also considerably different in nature as well. The majority of the government's mandate is focused on ensuring that the transformation to a market-driven sector proceeds smoothly, regulating the level of ethanol to be blended with gasoline, and aiding in the improvement of the industry's environmental performance. Activities which are regulated include: sugarcane field burning; bagasse management; soil quality; storage for herbicides and insecticides; the preservation of forests; water quality; the storage of ethanol; and sugarcane transport.

As previously discussed, the program commenced with subsidies, but they were gradually phased out. Finally, when the market turned around in response to increases in the world market price for oil (making ethanol more cost-competitive), they supported the consumer purchases of FFV's through tax breaks. This was an instrumental move by the government which in the long-run has resulted in sustaining the market. Moreover, during the initial phases of development a coherent regulatory and legal framework was produced, which ultimately created the necessary intra-institutional coordination between key ministries, marking efficiency, coordination and vertical integration of the value chain.

2.2 The Economic Performance of Sugarcane Ethanol

The following section will investigate what the literature identifies as the central economic benefits and costs to the Brazilian ethanol program. This is evidently a key pillar in reference to the feasibility of Paraguay expanding its ethanol sector in the future. This section will begin with primary data on sugarcane and ethanol production, thus illustrating Brazil's competitive advantage in the industry. Subsequently, I will map out ways in which the ethanol market operates through the industry's value chain with reference to key economic actors and stakeholders. Once the cost-benefit analysis has been presented, I can then proceed with observations concerning the applicability of Hypothesis B in the following chapter which examines Paraguay.

Hypothesis B:

The economic feasibility of Paraguay expanding its sugarcane ethanol sector is contingent on how the market operates, in terms of the structure of relationships amongst sugarcane producers, the private sector and the government.

2.2 Key Economic Indicators

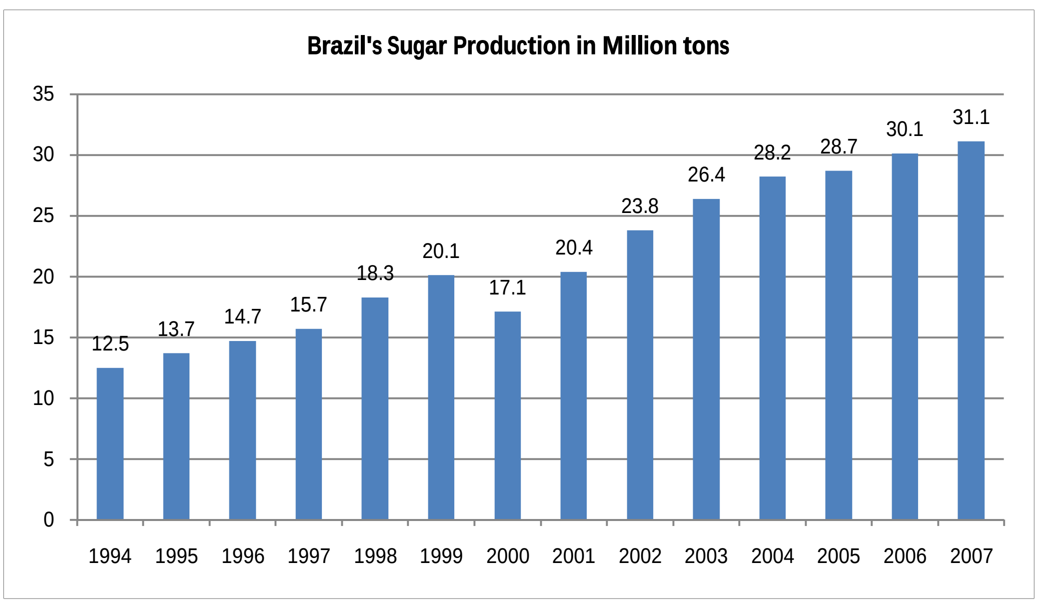
Brazil is the world's leading sugar producer and exporter, accounting for approximately 20% of global production and 40% of the world's exports (De Almeida 2008 156). One important aspect of the Brazilian sugarcane industry is that has been able to take advantage of the flexibility between ethanol and sugar production based on what the market conditions are. Sugarcane covers 7.8 million hectares in Brazil, or 2.3% of the country's total arable land (Goldemberg 2009). It is grown primarily in the South-Central Brazil with the harvests running from April to December and in the Northeast from September to March. The South-Central region produces over 85% of Brazil's sugarcane. SP accounts for 60% of the country's sugarcane production (Unica 2007). Sugar represents a particularly significant sector of Brazil's economy, with the sugar/ethanol industry contributing to 3.5% GDP and 3.6 million jobs, thus representing 2.9% of Brazil's labor force (World Watch Institute 2005, 27). These indicators are real measures of the industry's success (Table 2.3).The value of production in 2006 reached $10 billion, which represents 17% of the country's total agricultural output. The sugar sector generated 25% of the world's sugarcane (310 million tons) and currently ethanol uses 50% of the total amount of sugarcane produced (Goldemberg 2008). Table 2.4 reflects the trajectory of growth in sugarcane production.

Table 2.3 The Sugar/Ethanol Sector in Brazil

The Sugar/Ethanol Sector in Brazil, 2006-2009	
	US$12 billion annual market
Gross Turnover	$12 billion (R$36 billion)
Share of National Income	3.5% of GNP
Employment	3.6 million jobs (direct, indirect, and some induced)
Sugarcane growers	70 thousand
Sugarcane harvest	340 million tons of sugarcane
Output-sugar	24 million tons of sugar
Output-ethanol	14 billion liters of alcohol
Exports-Sugar	13.5 million tons of sugar
Exports-Ethanol	690 million liters of alcohol
Taxes	$1.5 billion (R$4.5 billion)
Investments	$1.2 billion/year (R$3.5 billion/year
Producers	302 mills

Source: Goldemberg 2006, 2007, 2009

Table 2.4 Brazil's Sugar Production



Source: Unica 2007[3]

[3] Quantity of sugar is reflected in million tons.

Brazil is the world's most efficient producer of sugarcane due to a variety of key factors: natural conditions which make the cultivation less energy intensive than in other non-tropical regions, irrigation, tropical geographic location and a centrally coordinated effort by the central government (Hira and De Oliviera 2009; BNDES & CGEE 2008,9). Table 2.5 highlights Brazil's competitive advantage in the sector, where the cost of production is in the order of $10.45 per ton. Additionally, there are no longer any centrally coordinated efforts by the government in the sugar market and domestic prices depend on international costs and on the foreign exchange rate.

Table 2.5 Sugarcane production and costs

Sugarcane Production and Costs Internationally, 2006-2007

Country	Sugar Production (1000 tons)	$/ton
Brazil	31450	10.45
Caribbean	n/a	15
China	12855	23
India	30140	15
Mexico	5633	29
USA	3438	29

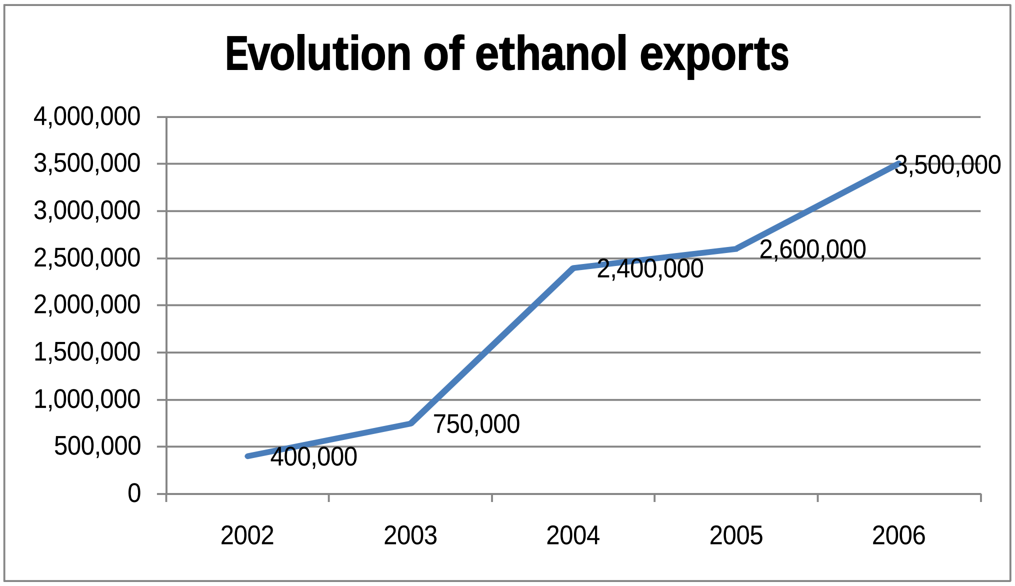
Source: Production from Goldemberg (2009)
and costs are from Bain (2007)

2.2.1 Why is Brazilian ethanol cost-effective?

There are many factors which contribute to Brazilian ethanol's cost-effectiveness. Geographically, sugar and ethanol plants are located close to sugarcane producing regions in Sao Paolo (SP). In that area, there are excellent soil and climatic conditions, sufficient transportation, moderate infrastructure, which is fairly adjacent to consumer locations. Further, there is a sophisticated science and technology foundation which has been a fundamental component in increasing productivity and enhancing economies of scale for mills and distillation plants (BNDES 2008, 157). It is crucial to comprehend that the expansion of ethanol and sugarcane in the last decade has materialized not only due to the increases in cultivated areas, but also because of the significant gains in productivity and agro-industrial actions. SP has a sheer competitive advantage in the production of sugar. As a result, Brazil has one of the lowest costs for producing ethanol in the world.

In 2006, ethanol production in Brazil was estimated at 17.7 billion liters (Brazilian Ministry of Agriculture 2007). In fact, approximately 80% of this production was absorbed by the domestic market. Exports have also increased rapidly since 2003 (Figure 2.1), marking the maturity of the industry and increased demand for the product abroad.

Figure 2.1 Evolution of ethanol exports (million liters)



Source: Unica 2007

The country is also gearing up for significant expansion in production to meet a surge in demand on global markets. Goldemberg (2009) estimates that Brazilian ethanol production will double by 2012/2013, thus replacing 50% of petroleum that otherwise would have been consumed by the country. However, for Brazil to maintain its leadership position, it will have to develop a cohesive strategy of capacity expansion supported by the necessary infrastructure and innovation. The challenge is to do so in an environmentally sustainable way that does not infringe on national reserves, while finding the capital to finance new projects.

In terms of exports, one significant point must be addressed. The key entry point into the European market is through the Netherlands, which imported approximately 10% of total ethanol exports from Brazil in 2008 (De Almeida 2007, 152). The EU has recently implemented initiatives to create targets for renewable energy in all transport sectors by next year (IEA Bioenergy 2009a). These targets, coupled with sustainability requirements that the protocol mandates, have the potential of putting Brazilian ethanol at risk, unless they comply with the EU's environmental certification criteria. If Brazil fails to comply with regulations of certification, the EU market could be a great opportunity for Paraguayan sugarcane ethanol to enter, given that they could meet the sustainability requirements.

2.2.2 Present Status and Projections of the Industry

Currently, there are 325 plants in operation in Brazil, producing 425 million tons of sugarcane annually. It is estimated that this translates into one-half being used for sugar and the other for ethanol. In 2006, roughly 17.8 billion liters of ethanol were produced, using 2.9 million hectares of land (Goldemberg 2008). A normal plant will crush 2 million tons of sugarcane per year and yield 200 million liters of ethanol per year (1 million liters per day over 6 months, April to November). This amounts to something in the region of US$150 million in sales per year (WorldWatch Institute 2007). The agricultural area required to produce these amounts is approximately 30,000 hectares. Most of the larger distilleries are found in SP, where 75% of the ethanol is being produced. It is important to highlight that this is an area which is a great distance from the Amazon rainforest. This counters allegations that current ethanol production is currently directly causing deforestation.

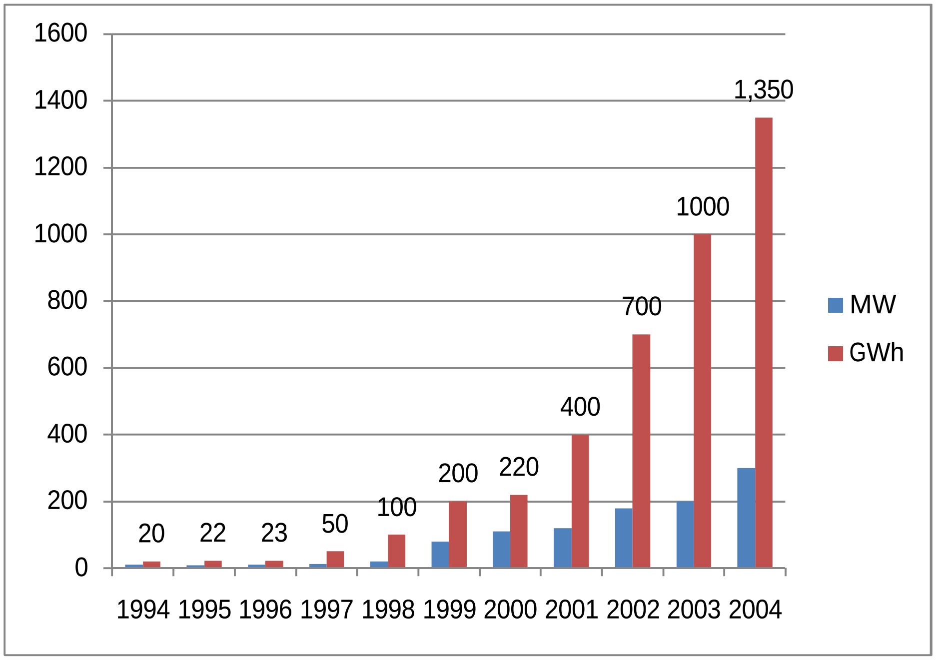
2.2.3 How are prices governed?

Another area that contributes to Brazilian ethanol's cost-effectiveness is price. De Almeida (2008) conveys that it is a challenge to calculate the exact price of ethanol. The cost is determined as follows: the cost of sugarcane production, the cost of its processing and the rate of its conversion into ethanol. Macedo and Noguiera (2005) estimate the cost of ethanol in Centre-South Brazil at US $0.21 per litre, which is equivalent to approximately US$33.39 per barrel and cost-competitive with oil below USD $35 per barrel. As discussed, Petrobras is a key player in this market and has a de facto monopoly in petroleum, and a large market share of distribution and sales of gasoline, diesel and ethanol.

2.2.4 Energy Matrix

An additional factor which makes Brazilian sugarcane ethanol sustainably competitive is that most mills produce all the energy they need through bagasse-based co-generation power plants. Cogeneration is the process of transforming a given energy form into more useful energy. Sugarcane growers can salvage leaves and tips, which contain as much energy as bagasse, but these are traditionally burned off before harvest. As noted by De Almeida (2007), each ton of sugarcane has the capacity of producing 280kg of bagasse and 90% of this bagasse is then utilized as a source of heat and power generation. The use of this efficient technology has enabled mills to sell a surplus of power to the market. Unlike other industries, ethanol not only has the potential to be self-sufficient by using co-generation, but it can also contribute to the electricity sector by selling power or feeding it back to the grid (Table 2.6).

Table 2.6 Electricity Sales from Co-generation at Sugar Mills- Electricity Sold to the Grid- SP

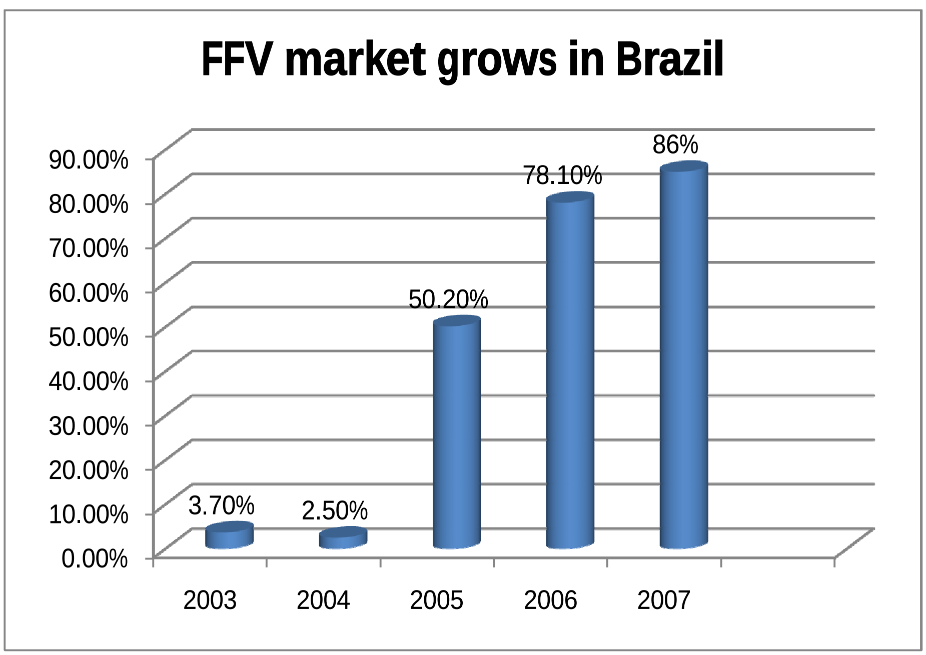
P 

Source: World Resource Institute 2005

2.2.5 Fuel-Flex Vehicles

One of the main driving forces which revitalized the industry was the introduction of FFV's in 2003. Currently, there are 33,000 service stations which have at a minimum of one pump dedicated to pure hydrous ethanol (E-100). However, in the early days of ProAlcool, cars were manufactured to run exclusively on petroleum or ethanol, but not the two simultaneously. This meant that consumers had to choose which fuel content was more competitive. This changed as FFV's hit the market in 2003, since these vehicles can run exclusively on ethanol, gasoline or a mixture of the two. As discussed, the current successes in Brazil's ethanol program are driven by three main factors: 1) mandatory blending procurement, 2) the expansion of the FFV market, and 3) tax breaks given to consumers who purchase FFV's (Rothkopf 2007; De Almeida 2007; Goldemberg 2009; WorldWatch Institute 2007; BNDES and CGEE 2008). According to Petrobras (2007), FFV's hit the one million mark in 2004, 2 million in 2006 and by 2007, represented 4.5 million of the light-vehicle flight. FFV's represent approximately 86% of all new light-vehicles sold in 2008, an impressive jump from 2003 when they made up 3.7% of the light-vehicles sold (Petrobras 2007) (Table 2.7). Notably, although the introduction of FFV's on the domestic market has resulted in the majority of new sales, they only represent approximately 20% of the existing automotive fleet (21.4 million) in Brazil (Unica 2007).

Table 2.7 FFV market in Brazil



Source: ANFAVEA 2007

Market projections indicate that sales will likely stabilize around approximately 90% of vehicles. Unica (2007) predicts that if this trend continues by 2010, there will be some 10 million FFV's in circulation. Conceivably, increases in FFV's sales will likely correspond to increases in world market prices for oil, thus making ethanol more attractive at the pump.

2.2.6 Job Creation

The growth of the industry has had a significant impact in terms of job creation. Yet, the literature does argue that working conditions of cane cutters are not optimal and need to be substantially improved (World Watch Institute 2007). The work is seasonal, back breaking and often exploitative. Local legislation seems, in principle sufficiently strict to ensure proper working conditions and also allows free organization into networks of protection such as unions, land agencies and so forth. However, the information present in the literature indicates that compliance with legislation is often lacking and law enforcement is weak (World Watch Institute 2007; Amnesty International 2009).

Data remain scarce in terms of actual numbers of cane cutters, with studies placing them roughly at 1 million (Brazilian Agroenergy Plan 2006; WorldWatch Institute 2005). The Brazilian Agroenergy Plan (2006) claims there are 982,000 thousand direct formal workers involved in the sugar and ethanol value chain, and 4.1 million workers which are dependent, in some form, on the sugarcane ethanol sector. WorldWatch Institute (2007) reports that Brazilian jobs in the ethanol industry cost 25 times less than one in the petroleum sector, as a great deal of the employment tends to be tailored towards low-skilled labor. Further, since the vast majority of employment in ethanol production is in farming, transportation and processing, the majority of these jobs are in rural communities which need the sources of employment.

In terms of sugarcane cutters, Brazil has formally introduced legislation which seeks to progressively gear the industry to mechanized harvesting, thus eliminating some of the dire conditions that workers face. However, the move into mechanized harvesting could likely produce major negative effects for those workers that are dependent on manual harvesting, as it is a significant source of rural employment.

2.2.7 Finance

Prior to the liberalization of the sugar and ethanol industry, the Brazilian government and BNDES absorbed the majority of the costs of production. BNDES and CGEE (2008) estimate that subsidies amounted to approximately US$7.1 between the years of 1979-1989, with the government contributing US$4 billion and the remaining amounts being injected by private institutions. Moreover, during the years of 1980-85, the government provided economic incentives in the form of low-interest loans to agro-industrial enterprises who wanted to produce ethanol. This amounted to nearly US$ 2 billion in loans, which is representative of 29% of the total investment required to get the industry into a strategic position (Rothkropf 2007). Goldemberg (2007) estimates the amount of subsidies to be around US$30 billion over the duration of 20 years, yet conveys that over US$50 billion in oil imports were saved. According to these sources, "…US$195.5 billion in foreign exchange; US$69.1 billion avoided imports, and US$126.4 billion in foreign debt interest were saved through the program "(Hira and De Oliviera 2009, 7).

Rothkopf (2007) explains that current financing of the industry remains constrained by high interest rates and a lack of dedicated financing lines from BNDES and other financing institutions. Moreover, sugar and ethanol producers convey that the structure of the returns requires credit lines tailored specifically to the needs of the industry.

Presently, there is $10 billion worth of investment planned by 2014 for the creation of 89 new production facilities. Although interest rates are falling, they remain high and act as a disincentive towards increased FDI (Rothkopf 2007, 520). In order to support the projected expansion, guaranteed financing lines will be required for the Brazilian government and the private sector. Some in the private sector such as Unica (2007) report that there is an abundance of financing available for newly emerging projects. Financing typically is derived from several sources such as national development enterprises and ministries, state and local governments, multilateral organizations, and private institutions. Additionally, financial markets such as the Brazilian Mercantile and Futures Exchange (BM &F) and Bolsa de Valores do Estado de Sao Paulo (BOVESPA) are supplementary sources of resources for the ethanol industry. Further, the increased endorsement of the carbon credit market could also serve as an additional source of sustainable funding for the industry's expansion.

In terms of investment from the public sector, there are various developmental banking institutions which are indirectly or directly involved in financing the Brazilian ethanol industry's expansion. The main players include: the National Development Bank of Brazil (BNDES), Banco de Brasil SA, Banco do Nordeste do Brazil SA, Banco da Amazonia SA, the Regional Development Bank of the Extreme South, the Development Bank of Minas Gerais (BDMG), and the Development Bank of Rio Grande de Sul. It is important to note that BNDES is the main financing wing of the Brazilian government vis-a-vis the Ministry of Development, Industry and Foreign Trade. BNDES's mandate is primarily focused on domestic economic development and infrastructure ventures. This institution "…seeks to strengthen the capital structure of private companies and the development of the capital markets, the trade of machines and equipment and the financing of exports (Rothkropf 2007, 519)." For the purposes of this research, what I am emphasizing is that, although the Brazilian financing structures are not without their incongruities, there seem to be a multiplicity of avenues which do in fact support the growth and future investment of the sector. This is a vital ingredient to support the continued success in this industry.

2.2.8 R & D, Investment

The sustained capacity to improve and diversify its production by investing in R & D is one of the most important factors underlying the success and growth of

Brazil's ethanol enterprise. The growth rates in both sugarcane and ethanol are the results of new variety developments, biological pest control, improved management of crops, and greater soil selection (Rothkropf 2007). These efforts were initiated by SP's government the Instituto Agronomico de Campinas (IAC) and Instituto Biologico. In 1970, Copersucar, a private cooperative of sugar and cane producers, created the Center for Technological Research. This research center was instrumental in the expansion of sugarcane production and the industrial development of the sector (Walter 2007; Rothkropf 2007; Goldemberg 2007). In 1971, the Brazilian government created the Programa Nacional de Melhoramento de Cana de-Acucar (Planalsucar), focusing on the progression of new varieties of sugarcane. Planalsucar was initiated to minimize the technology growth rate difference between industry and the production with the sugarcane cane sector. In other words, with industry developing faster, an agricultural production lag could have impeded the growth of the industry. Although this institution was eventually phased out due to liberation measures of the late 1990's, it did serve as an influential tool in producing competitive varieties (Walter 2007, 41).

The interesting policy that Copersucar (which is now called the Center for Sugarcane Technology (Centro de Tecnologia Canavieria) initiated during the period of 1980-1990 was the investment of approximately 1% of their annual revenue directly into R & D related to sugarcane. SP also financially committed US$8 million to R & D in the areas of sugarcane breeding improvements (Walter 2007, 42). Additionally, the MCT (Ministry of Science & Technology) was at the forefront of providing research funding to a variety of institutions and organizations. This body was by far the largest ministerial investor in R & D, investing $850 million during the periods of 2003-2005.

2.2.9 Infrastructure

In general, the appropriate conditions for transporting and storing ethanol are not significantly different from those used for petroleum-based fuels. Yet, there are three essential differences: the seasonality associated with ethanol production, the geographic distribution of this production, and the compatibility of transport methods (tanks, trucks and pipelines) which will come into contact with ethanol and its various blends. Thus, infrastructure must be designed around these three processes, in order to ensure the full productivity of this liquid fuel. In the case of infrastructure, transport, storage and distribution are arguably the most significant barriers constraining the further expansion of the Brazilian industry.

2.2.10 Expansion

In terms of future expansion, Rothkropf (2007) identities five key barriers:

1. New strategies and methods of design for cane expansion and ethanol production are limited;
2. Financing lines towards production tend to lack focus, as there are no national financing lines specifically dedicated to ethanol;
3. The lack of technological innovation is a severe bottleneck to growth. Genetic engineering, innovative breeding of cane, process technology, and human-capacity building, specifically in the area of cane processing, all require more attention;

4. Infrastructure is lacking in key areas for the export of ethanol and to the ability to service new regions (local markets);

5. Lack of tax policies.

These five areas can provide certain lessons for Paraguay, in terms of what obstacles they could strategically pre-empt during the expansionary phases.

2.2.11 Conclusions

The economic cost-benefit analysis of this section has assessed the way in which the ethanol market operates in Brazil and observed the relationships among sugarcane growers, the private sector and the government. This multiple stakeholders approach has ultimately produced vertical integration, economies of scale and the lowest cost in production of both sugar and ethanol in the world. If the Paraguayan government seeks to be competitive in the production of sugarcane ethanol, it must be done through the partnership of all actors involved in the value chain of biofuels. This coordination is fundamental to absorb the costs and provide the capital required to support growth in the industry. Thus, the economic feasibility of this industry advancing in Paraguay is directly correlated with establishing a multiple stakeholders approach with key stakeholders. Areas of market cooperation include: mandating a blending procurement, providing financial assistance to producers, protecting investment, supporting the FFV market and providing tax breaks to consumers to buy these vehicles. In Brazil, substantial subsidies and hefty investment into R & D, both from the public and private sectors, were also crucial factors which provided the industry with the tools to become competitive.

2.3 The Sustainability of Brazilian Sugarcane Ethanol

In the first chapter, the environmental literature surveyed conveyed the most contested areas concerning ethanol and its various types of feedstocks. My findings indicated that of all the types of feedstock sources to produce ethanol, sugarcane is clearly the most energy efficient in terms of climate benefits. The following section will further investigate additional areas that the sustainability literature discusses in reference to Brazilian sugarcane ethanol including: land-use changes and deforestation; LCA analysis; existing environmental legislation; key actors governing matters related to the environment; the need for any biofuel regime to operate under criteria which incorporates international environmental certification; and the importance of first generation biofuels to establish the policy drivers for the commercial availability of second generation biofuels. I will evaluate these issues in great length in order to make observations concerning Hypothesis C. This section is structured around Hypothesis C:

Sugarcane ethanol could be produced in a sustainable way in Paraguay in the short-term, given the country's abundance of available land.

2.3.1 The Availability of Land

The availability of agricultural land in Brazil to support future growth of the sugarcane sector is heavily discussed and debated in the literature (De Almeida 2007; Rothkropf 2007; Walter 2007; Macedo and Noguiera 2005; De Oliviera 2004; IEA Bionergy 2009; WorldWatch Institute 2007; BNDES & CGEE 2007). According to Goldemberg (2009), in 200 land use for ethanol production in the

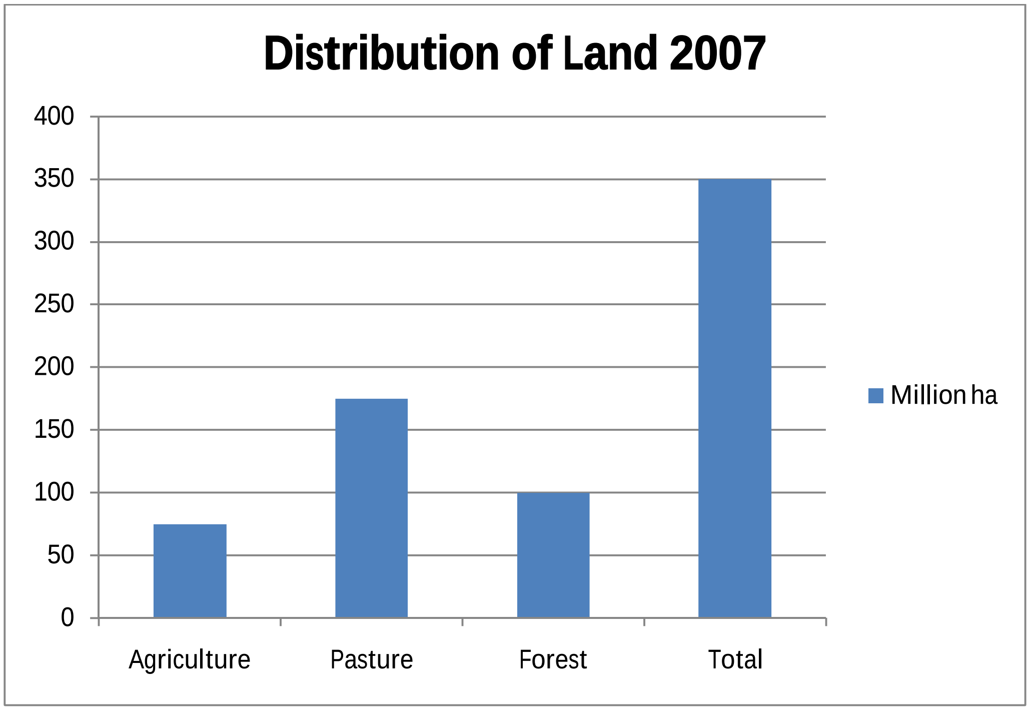
US (from corn) was 51 000 km^2 and in Brazil (from sugarcane) 29 000km_2. Together the production from both countries amounted to 0.55% of the total available agricultural land in the world, of which there is currently 14 million km^2 (Goldemberg et.al 2009; 10) (Table 2.8). It is estimated that by 2020, Brazil will be planting around 14 million hectares of sugarcane, producing more than 1 billion tons of cane, 45 million tons of sugar, and 65 billion liters of ethanol (Jank 2008). Brazil currently has approximately 232 million hectares available for agriculture and pasture. Of this, 74.1% is occupied by pasture while the major crops of soybean and corn occupy 8.8% and 6.0%, respectively (Table 2.8).

Table 2.8 Yields and areas of corn and sugarcane for ethanol production 2006

Yields and areas of corn and sugarcane for ethanol production (2006)		
	Corn (US)	**Sugarcane (Brazil)**
Harvested areas (thousand km2)	286	62
Area used for ethanol production (thousand km2)	18% or 51	47% or 29
Average yield (2003-2006) (metric tons/km2)	936	7400
Total production (2006) (million metric tons)	268	455
Present production of ethanol (million m3/year)	18.6	17.8
Ethanol yield (m3/km2)	365	614
World total agricultural arable land	**14 million km2**	

Source: Goldemberg et al. (2009)

Figure 2.2 Distribution of land in Brazil

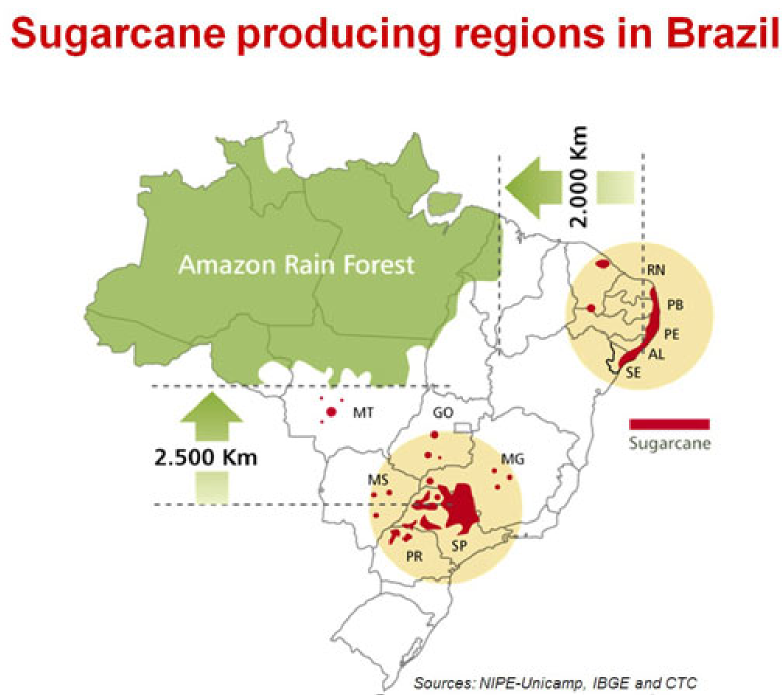


Source: IBGE 2008

2.3.2 Deforestation

There are serious concerns that increased expansion of sugarcane for the production of ethanol will have a direct impact on deforestation of the Amazon rainforest. On one hand, some analysts argue that it is other industries and not the crop of sugarcane directly causing deforestation. For instance, approximately 20% of cattle are located in the northern parts of the country. Between 1990 and 2005, the cattle industry grew from 13 million to 41 million. Taking these figures into account, De Almeida (2007) estimates that mean production of cattle-raising to be 0.9 cattle per hectare of land. This translates into the cattle industry being directly responsible for the 30 million hectares of lost forest in the Amazon region (De Almeida 2007, 165). Morton (2006) discusses the growth of soybean production in the Brazilian Amazon, which increased by 3.6 million hectares between the periods of 2001-2004. The argument that sugarcane expansion is not directly responsible for causing deforestation is further supported by Goldemberg et al., (2009) who document that 75% of the production of ethanol is located far away from the Amazon forest (Figure 2.3). Goldemberg and colleagues (2009), also emphasize that the expansion of sugarcane in Brazil is taking place over pastureland of which more than 2 million km^2 is currently available. This figure also includes 100 000km2 in SP, which currently produces two-thirds of all Brazilian production (Goldemberg et al. 2009, 11).

Figure 2.3 Sugarcane producing regions in Brazil



Brazil accounts for approximately 3% of the world's GHG emissions. Deforestation in the Amazon rainforest accounts for an estimated 75% of Brazil's total GHG emissions, while Neto (2005) reports that fossil fuel consumption is responsible for 23%. What is present in the literature is that increased expansion of sugarcane is not directly responsible, but could cause indirect pressure on the cattle and soy industries, pushing them further into the Amazon. For example, the IEA (2009) discusses how sugarcane plantations are primarily located on pastures, displacing a significant percentage of cattle ranching. This may lead to intensified cattle production on existing pastures or the emergence of new cattle areas closer to the Amazon. If a substantial part of the pasture expansion were to take place in regions adjacent to the Amazon, CO^2 emissions derived from deforestation would severely reduce the climate benefits produced from Brazilian ethanol (IEA Bioenergy 2009a).

If additional land-use for sugarcane production leads (directly or indirectly) to the conversion of pastures, the GHG emissions may be severe and could have a major impact on the overall GHG balance. This point is supported by the IEA Bionergy Report (2009b;43) which emphasizes that:

> Limited data is available to quantify soil losses, and they depend on a large number of assumptions, e.g. the time frame to measure soil carbon loss, various carbon accounting systems, the definition of the reference system. It is very difficult to determine the indirect effects of further land use for sugar cane production (i.e. sugarcane replacing another crop like soy or citrus crops, which in turn causes additional soy plantations replacing pastures, which in turn may cause deforestation), and also not logical to attribute all these soil carbon losses to sugarcane. These effects have no yet been fully included for the GHG emissions reduction comparison by the IEA (2004), or for that matter for any other biofuel.

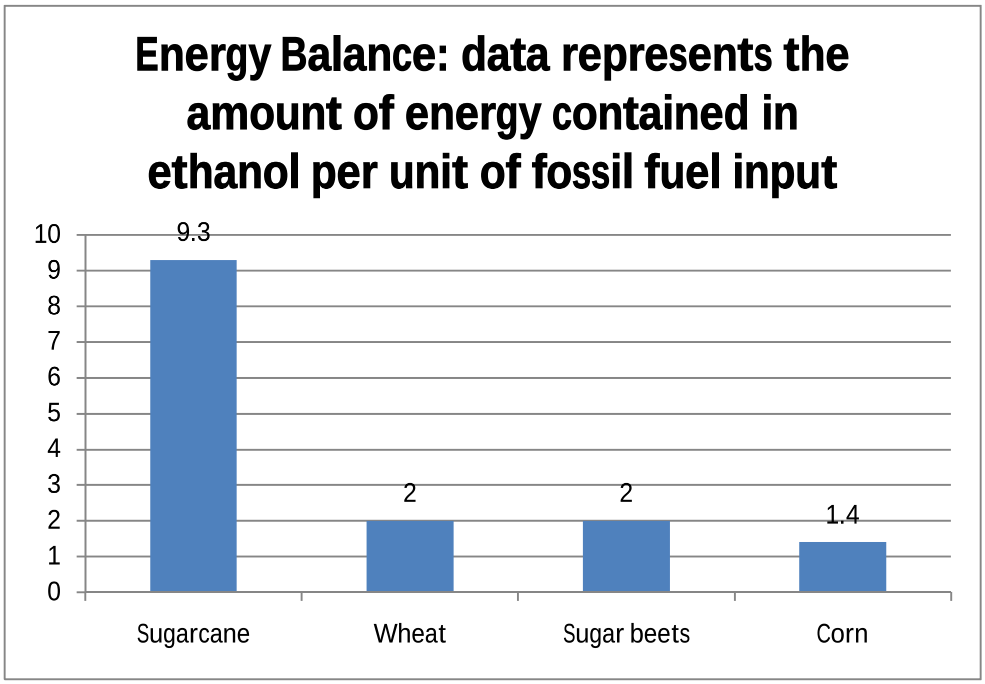
Notably, quantifying these effects and their uncertainty clearly exceeds the scope of this project, but is deemed an important research endeavor for the future.

In terms of addressing deforestation of the Amazon rainforest, President Lula da Silva has recently passed a law which requires the country to reduce its national GHG emissions by 39% by 2020 (Law and the Environment 2010). There are two main clauses to the bill: the promotion of clean energy by reducing dependence on fossil fuels; and substantially decreasing deforestation in the Amazon region. The reduction in deforestation would result in approximately 20.9% emissions reduction by 2020, and has the potential of decreasing deforestation by 80% by 2020 (Law and the Environment 2010). The details concerning how this will translate into specific policies are still to be seen, nevertheless there seems to be a framework in the works which seeks to serve the interests of reducing GHG emissions by addressing the causes of deforestation.

2.3.3 The Net Energy Balance

The net energy balance for ethanol is defined here as "…the ratio of the energy contained in a given volume of ethanol divided by the fossil energy required for its production (in the form of fertilizers, pesticides, diesel fuel spent in mechanized harvesting and the transportation of sugarcane to the processing mill)" (Goldemberg 2008). Sugarcane is comprised of three components: sucrose, bagasse, and tops and leaves. Bagasse contains 1/3 of the energy in the sugarcane, and is the primary source of energy that fuels the demands needed at the mills. The other two-thirds are split between the sucrose and the tops and leaves. This ultimately produces a net energy balance for sugarcane ethanol which is considerably high between the range of 8.3 to 10 (Table 2.9). This is sharp contrast to corn based ethanol, where the net energy balance is significantly lower at 1.3. One of the main reasons for this variance is that ethanol produced from corn, requires much more fossil fuel inputs and greater amounts of land to produce the same amount of ethanol (Goldemberg 2008).

Table 2.9 Energy balance of feedstock sources



Source: WorldWatch Institute 2007

2.3.4 GHG Reductions and Life Cycle Assessment Analysis

In general, studies which address GHG reductions produced from sugarcane ethanol can vary substantially in their findings. The choice of methodological approach to calculate this also strongly influences the outcome of analyses, as has been presented with claims associated with land-use changes. According to the IEA (2009b) all of the values entering into LCA of GHG emissions calculation are viewed as uncertain. The emission factors are typically more hypothetical, as they tend to be representative of temporary scenarios, or can be the product of an earlier LCA calculation. In LCA of GHG emissions, the benefits of biofuels are estimated in terms of the reduction of GHG emissions compared with conventional fossil fuel avenues. It assesses the energy balance involved in the production process of ethanol. As noted, the results tend to vary significantly, as this method calculates the use of fertilizers, pesticides and other inputs in the agricultural phase of production. According to the IEA (2009b), there are only two studies to be taken seriously which address estimates of GHG reductions produced from using ethanol which include: (1) Macedo and colleagues (2004) and (2) Oliviera and co-workers (2005). Table 2.10 illustrates the energy and greenhouse gas balance of ethanol production. There is a substantial difference between the findings of these two studies. A more in-depth analysis of the underlying data is shown in Table 2.10.

Table 2.9   Energy and greenhouse gas balance of sugarcane ethanol production

The energy and greenhouse gas balance of sugarcane ethanol production		
Source	**Energy Output: input**	**GHG emission (kg/m3)**
Oliviera et al., 2005	worst case 3.1 best case 3.9	worst case 572 best case 461
Macedo et al., 2004	Average 8.3 best case 10.2	Average 389 best case 359

Source: IEA Bionergy (2009b)

Table 2.10 Energy inputs used for sugarcane production

Energy inputs used for sugarcane production	Macedo et. al, 2004		Oliviera et al., 2005
	Gj/ha		Gj/ha
Agricultural operations	2.61	Diesel fuel, various operations	23
Transportation	2.51		
Fertilizers	4.36	Fertilizers	4.78
Lime, herbicides, pesticides etc	1.32	Lime, herbicides, insecticides etc	1.99
Seeds	0.38	Seeds	3.35
Equipment	2		
		Labour	2.86
Total	**13.18**	**Total**	**35.98**

Source: IEA Bionergy (2009b)

The key difference between both studies is how they accounted for the consumption of diesel in their calculations of GHG balances. The IEA compared Oliviera's results with an additional key study by Ortega (2003) and concluded that Oliviera's accounting for diesel consumption was "erroneous" by comparison. Based on this, they excluded Oliviera's results from their analysis concerning the energy and green house gas balance of ethanol production (IEA 2009b, 52). According to Macedo et. al, (2004), the energy balance of ethanol is 8.3 (mean) to 10.2 (best available technology). In sum, in terms of reducing GHG emissions, ethanol from sugarcane is viewed as the most energy efficient type of biofuel; reducing GHG emissions per kilometer between 85-90% in comparison to gasoline (IEA 2009b, 53).

The lack of solid empirical data in some circumstances and of a commonly agreed methodology for LCA (e.g. how by-products are taken into account) contributes to uncertainties in the climate impact of biofuel chains. These uncertainties can be summed up into three categories:

1. Uncertainty deriving from the complexity of biofuel chains. These could be resolved with more commonly agreed upon methodology.

2. Uncertainty resulting from un-resolved methodological and scientific factors. These can only be resolved with further research.

3. Uncertainty arising from specific environmental and social concerns, for example, a more thorough conception of the effects derived from land-use changes, and therefore indicators and criteria that will need to be developed, calculated and regulated.

Despite these reservations in the data and methodologies used to calculate reduction in GHG emissions, the literature asserts that some conclusions can safely be drawn in regards to sugarcane ethanol (Rothkropf 2007; IEA Bionergy 2009b; WorldWatch Institute 2007; De Almeida 2007):

- Cogeneration offers the most effective way to mitigate the effects of GHG emissions. The conversion of bagasse into ethanol and/or electricity is crucial for the overall performance, and substantial increases are possible when this second generation feedstock can be also be used for ethanol production.

- Sugarcane is by far the most energy efficient type of feedstock and produces the most climate benefits in comparison to all other sources of first generation biofuels.

- First generation biofuels will establish the policy drivers and infrastructure for the commercial availability of 2nd generation, which are considered to have significantly higher climate benefits than 1st generation.

- Ethanol produces low emissions, giving a drastic reduction in atmospheric CO2.

- Ethanol presents lower toxicity and is biodegradable.

- Ethanol contains oxygen and therefore burns more efficiently, resulting in "lean" combustion and less exhaust emissions, mainly CO.

- Ethanol does not emit sulphur oxides (SOx).

- Ethanol reduces emissions of "photochemical smog" precursors due to its lower photochemical reactivity.

- Ethanol does not emit particulates.

- Ethanol is less volatile than gasoline, causing less evaporative emissions during storage, transportation and handling.

2.3.5 Local Impacts: cane burning

The literature clearly identifies that one of the main local environmental impacts derived from the production of sugarcane ethanol is the practice of burning straw (De Almeida 2007; IEA Bionergy 2009b; Rothkropf 2007; Unicamp 2006). The majority of the mills in Brazil use manual harvesting and to increase productivity, sugarcane straw is burned prior to the harvest. Manual harvesting without cane burning is theoretically possible, but not economically viable. There has been a gradual shift towards mechanized harvesting, which is reflected in Brazilian legislation articulating a gradual ban to be completely implemented by 2030. However, the change from cane burning (manual harvesting) to no cane burning (mechanized harvesting) has both positive and negative consequences.

Generally the advantages associated with the phasing out of manual harvesting include: the reduction of emissions which are damaging to human health; the decreases to damage of infrastructure and soil erosion; and the overall reductions in GHG emissions which are derived from cane burning (Unicamp 2006, 48). In terms of the negative impact, mechanized harvesting significantly reduces the need for cane workers. This is a serious concern for labor unions, which have been advocating for programs of professional requalification for rural workers working in the manual cane sectors. This policy directly affects one of the main reasons behind government support of the industry, facilitating employment. It is not detailed in the literature exactly how the government plans on dealing with this controversial issue; beyond the discussion of professional requalification programs.

Macedo (2005) estimates that if full mechanical harvesting takes place in SP and 50% in the rest of Brazil, 165 000 jobs would be lost. However, this employment reduction has the potential to be compensated by the industry's growth and expansion. For instance, it is estimated that for each 100 million ton expansion of sugarcane production, 125 000 direct and 136 000 indirect jobs will be created (Macedo and Noguiera 2005). The issue of cane burning is highly complex due to manual harvesting producing both positive and negative impacts. Nevertheless, Brazilian legislation articulates the phasing out of manual harvesting, which is in line with international regulations over the environmental certification of ethanol. As noted by Unicamp (2006), if the government were to fully compensate for the loss of employment, this would increase the cost of ethanol production by 40% and is therefore a major barrier towards certification (52). An additional drawback of mechanical harvesting is that diseases and pests can increase, in comparison to cane burning and manual harvesting. Mechanical harvesting has the likelihood of increasing the amount of pesticides and insecticides, which could also result in lower yields of sugarcane.

2.3.6 Local Air Pollution

Ethanol has had an extremely positive impact on local air pollution in Brazil. By blending ethanol with gasoline, it has allowed for the elimination of lead in petroleum, the elimination of 100% sulfur dioxide and a 20% decrease of approximately 20% of carbon monoxide emissions (World Resources Institute 2005, 35). Noguiera and Macedo (2005) calculated that this translates into roughly US$500 million of avoided "social" costs per year. It has been estimated that pollutant emissions in SP and other metropolitan areas have been reduced to ¼ of that prior to the development of Proalcool (Goldemberg 2008).

2.3.7 Environmental Legislation

In theory, Brazil has the most advanced legal framework which seeks to govern the protection of the environment in Latin America. However, lack of enforcement seems to be one of the main challenges. The importance of having appropriate laws in effect that guide producers towards the best practices and prohibit actions which threaten the environment has become integral to the sustainability of ethanol. In Brazil, there are 5 key pieces of legislation which directly affect the sustainability of sugarcane ethanol (IEA 2009b):

1. CONAMA Resolution 237/1997, which states that there are three phases of environmental licensing to be complied with for producers of sugar and ethanol plants.

2. Environmental Impact Studies and the Environmental Impact Report, which are highly complex documents for the licensing process.

3. State Law 11.241. 20002 (Sao Paulo), which established a deadline for unburned sugarcane harvesting, and to implement mechanized harvesting in all areas by 2030.

4. State Law 4.7771 of 1965, and Law 7.803 of 1989, which determines that farms have to preserve a "Reserva Legal." This entails that there is a legal responsibility to preserve areas located within a property or rural possession, which are dedicated to sustainable use of natural resources, conservation and rehabilitation of ecological processes, conservation of biodiversity and shelter, and the protection of native fauna and flora.

5. "Law in progress" which seeks to target deforestation of the Amazon rainforest. The bill addresses two areas: the promotion of clean energy by reducing dependence on fossil fuels and decreasing deforestation in the Amazon region. The reduction in deforestation would result in approximately 20.9% emissions reduction by 2020, and has the potential of decreasing deforestation by 80% by 2020.

The key point for this analysis is that there are laws in place which govern sustainability matters over the production methods of sugarcane ethanol. Although enforcement seems to be lacking, at the very least there are the foundations for an environmental framework which has the potential of being further developed.

2.3.8 Environmental Certification of Sugarcane Ethanol

Defining criteria for sustainability and setting standards are logical strategies to help ensure that biofuels are developed in an environmentally sustainable manner. The term “sustainability” has environmental, social, and economic implications, in all aspects of biofuel chains. Safeguarding sustainability is multi-faceted and highly complicated, specifically with regards to environmental certification. Certification entails the procedure whereby a third party assesses the quality of management in reference to a set of standards. In the following section, I will briefly discuss the most common principles and criteria that have been proposed for safeguarding sustainability; instruments which are available to meet these requirements; and strategies for implementation. I will also examine Brazilian policies which are in place to meet these standards.

The sustainability of biofuels is a highly complex concept. However, in reference to the production of biofuels meeting certification, the literature points to some key principles which are commonly agreed upon (IEA Bionergy 2009b, 70; Walter 2009; Woods 2007):

- Greenhouse gas balance: The value chains of biofuels should significantly reduce GHG emissions in comparison to the consumption of fossil fuels, including the emissions produced from land-use changes.

- Energy balance: Biofuel chains must produce more energy than that required for feedstock production, the conversion process and aspects related to logistics.

- Biodiversity impacts: Biofuel chains should not pejoratively affect biodiversity.
- Impacts on food: Biofuel chains should not directly affect the supply of food.
- Biofuels and social welfare: Biofuels should contribute to social mobility for those who work in the sector.

According to the OECD Joint Transport Research Center, these principles need to be converted into requirements and criteria, by which the environmental benefits of biofuels can be calculated. LCA models, with commonly agreed methodology can provide the appropriate framework to undergo such evaluations (IEA Bioenergy 2009b). Given the complexity of sustainability issues, future policy making with regards to biofuels will require an integrated approach, considering the interactions of land use, agriculture, forestry, and social development. Translating these principles into criteria and indicators is a substantial task. There will be some principles which will not be difficult to convert, yet others will prove more challenging in terms of measuring what their quantities are. The OECD (2009) states,"…generally, there is also a clear trade-off between obtaining perfect information and practical limitations in data gathering: an ideal set of indicators may require data gathering efforts that significantly increase the cost of bioenergy or their feedstocks" (70).

Once the principles have been converted into measurable quantities, there is also the need to produce a framework on how to implement them. Implementing the certification process can cover the whole value chain including: feedstock production, the conversion process, and logistical components; or focus particularly on the how the feedstock is produced. This step will need to be tailored to exactly what specific state requirements stipulate for the importation of biofuels. A third step in the certification process includes producing accounting mechanisms which can track the amount of energy being saved or used. Currently, there are three instruments which are being considered: (1) track and trace sourcing: specific information which travels with the biomass throughout its various stages of production (this is very similar to the method used with fair trade products); (2) book and claim: a certified producer of biofuels will be given a certain amount of certificates, which can be traded freely from the physical flows of biomass (this is similar to the ways in which renewable power certificates operate); and (3) an intermediate system of 'mass balancing': which refers to the biomass being traceable to the source yet can be blended with the value chain (IEA Bionergy 2009b). It is important to note that the last instrument is the one which will be endorsed by the EU's Renewable Energy Directive.

Currently, the EU is one of the main bodies stipulating that they will only import ethanol if these certification measures can be verified. The new Directive on Renewable Energy sets ambitious goals for all member states of the EU, to reach a 20% share of energy from renewable sources by 2020 and a 10% share of renewable energy specifically in the transport sector. It also improves the legal framework for promoting renewable electricity, requires national action plans that establish pathways for the development of renewable energy sources including biofuels, creates cooperation mechanisms to help achieve the targets cost effectively and establishes the sustainability criteria for biofuels. The EU's new Directive on Renewable Energy should be implemented by Member States by December 2010 (Woods 2007).This could pose as a serious bottleneck to the continued cost-competitiveness of sugarcane ethanol in Brazil. If Brazil does not comply with these regulations, the industry will likely not be able to take advantage of one of the largest markets. Yet, conversely this could be a tremendous opportunity for Paraguay to seize upon, if they are able by contrast to develop a certification scheme, in accordance with the EU's principles.

2.3.9 Brazilian Sugarcane Ethanol and Current Environmental Certification Procedures

The literature discusses that the production of sugarcane ethanol in Brazil is heterogeneous in terms of finding good and bad examples which meet "sustainability" requirements. Walter (2009) concludes that the production in the Center-South region, precisely in SP, has better parameters. Given the requirements outlined by EU's Renewable Energy Directives; many Brazilian stakeholders recognize that certification of production would be necessary to differentiate between its product. INMETRO is the National Institute of Metrology, Standardization and Industrial Quality. This institution is responsible for the Brazilian Program of Biofuels Certification, of which they have certain requirements for producer's to adhere to in order to commence the certification process. These include (Walter 2009):

1. Sugarcane production should be in accordance with the Agro-Ecologic Zoning (which is a voluntary program mandated with promoting the most sustainable practices possible);

2. All environmental licenses are required;
3. Evidences of water recycling is required;
4. Electricity should be produced on-site, through co-generation;
5. Mechanical harvesting is required for the large part.

It is beyond the scope of this research to delve into the complexity of initiatives of the Agro-Ecologic Zoning. The important aspect for our analysis is to emphasize is that of 177 mills, 145 have complied with the Protocool, which translates into 89% of the production of sugarcane and 13,000 sugarcane suppliers (Walter 2009). An additional initiative is the monitoring of sugarcane areas through satellite images, in all major producing Center-South states. In terms of sustainability criteria in the social domain, the Ministry of Labor and Job has a Task Force which is responsible for verifying working conditions in the agricultural sector.

2.3.10 Second Generation Biofuels

The final topic of this section is a discussion of second generation biofuels, which are produced from agricultural and forest residues and from non-crop feedstocks. Any biofuels framework which seeks to incorporate sustainability requirements into their industry for the long-term, must acknowledge the importance of second generation biofuels for the future. These second generation biofuels are relatively immature so they should have good potential for cost reductions and increased production efficiency levels as more experience is gained.

These types of energy crops will have no effect on deforestation or the availability of food, thus providing tremendous climate and GHG benefits. The economic viability that second generation sources will depend partly on future oil prices increasing, which will give the industry momentum. The literature highlights that second generation biofuels are likely to become an important part of the solution to the challenges of shifting the transport sector towards more sustainable energy sources at some stage in the medium-term. However, there are major economic and technical barriers to be rectified prior to the commercial availability. To address these obstacles, there is a substantial amount of investment internationally in R &D by both private and public sectors. If the technology for second generation biofuels reaches commercial availability, it is estimated that this will allow greater volumes of biofuels to be produced, while simultaneously avoiding various drawbacks such as the high costs of production of 1st generation (Sims 2008).

The IEA (2009b) discusses that in terms of the production of first generation biofuels, particularly sugarcane ethanol, this source will continue to play a significant role in future demand. The transition into an integrated first and second generation biofuels environment is most likely to occur in the next one to two decades. This will depend on infrastructural developments and experiences gained from deploying and using first generation, which should be theoretically transferred to support and guide second generation biofuel development (Sims 2008). What is important for this research is that 1st generation biofuels establish the policy drivers, infrastructure and motivation for the deployment and commercial availability of second generation biofuels (Sims 2008). Thus, in terms of the Paraguayan case with biofuel production, if they can implement a solid industrial policy, they can take advantage of the environmental benefits of second generation biofuels in the long-term. This will likely substantially decrease the cost of production, while simultaneously providing a tremendous amount of climate benefits.

In terms of Brazil, the industrial director of Petrobras Biofuels has recently declared that his company will enter into commercial production of second-generation biofuels by 2015. The company is conducting priority research in cooperation with Petrobras Research (CENPRES) into developing cellulosic ethanol utilizing wastes such as sugarcane bagasse. Richard Castello from CENPRES recently stated that "…this process will permit increasing production 60% using the same planted area. These biofuels demand technological complexity, with the advantage of utilizing wastes as a primary material (Agencia Brasil 2010)." Brazil is well positioned to implement this technology into the modes of ethanol production in the next decade, as the policy drivers from 1st generation are already in place. This should increase the sustainability of its product which is crucial in accessing the EU's renewable energy market.

2.3.11 Conclusions

This section has evaluated a variety of environmental benefits and concerns that the literature addresses in regards to the production of sugarcane ethanol in Brazil. My findings indicate that although there are various environmental uncertainties which are particularly attributed to the methodology of LCA models and land-use changes, the Brazilian sugarcane ethanol industry has produced a magnitude of climate benefits in comparison to using fossil fuels in their energy matrix. The Brazilian ethanol industry has received a significant amount of bad press that increased expansion of sugarcane will increase deforestation of the Amazon, thus countering the environmental benefits proponents claim it produces. However, as my analysis indicates it cannot directly be attributed to the expansion of sugarcane. My investigation revealed that generally the factors which are causing deforestation are the cattle and soy industries, while sugarcane can be associated with putting indirect pressure on the aforementioned agricultural sectors. These claims are significant in regards to deforestation, yet cannot directly be attributed to sugarcane expansion. Further, with the Lula government's new bill that addresses reducing national GHG emissions by 39% by 2020, the appropriate framework is set in place to address these indirect causes. Moreover, my findings also revealed that the integration of the ethanol sector into the Brazilian domestic economy has produced tremendous results in terms of reducing local air pollution, which in the long-term will avoid hundreds of millions in "social" costs per year. In theory, Brazil has one of the most modern environmental legal frameworks in all of Latin America. Yet, the future context concerning the sustainability of its product will be contingent on enforcing environmental certification requirements that the EU Renewable Energy Directive mandates. In terms of this section's applicability to Hypothesis C, which proposes that Paraguay could develop their ethanol sector in a sustainable way in the short-term, the Brazilian example has proved that the environmental benefits far outweigh the alleged environmental penalties and thus it is possible.

3: Paraguay in Focus

3.1 Introduction

This chapter examines the prospects of Paraguay developing a productive sugarcane ethanol sector, by drawing from the Brazilian experience with biofuels. There are two important questions which will guide this chapter. First, at what point on Brazil's historical "learning curve" will Paraguay be able to enter the ethanol market, as the economic conditions are immensely different in comparison with the Brazilian situation of the late 1970's? Secondly, without systematic support from the state during infant stages of growth, is it realistic to expect Paraguay to be successful in advancing this industry? The framework for analysis will mirror that of the chapter on Brazil: (1) political and institutional arrangements that currently govern the value chain of ethanol including areas which require further transparency and development;(2) the costs and benefits of developing this industrial policy in Paraguay; and (3) sustainability requirements which must be incorporated into their framework to maximize their product internationally. Moreover, this chapter will address my hypotheses laid out in Chapter 1, in reference to the questions our research team posed to interviewees during the field research component.

It must be noted that the production of biofuels in Paraguay is a new topic and there are significant gaps and limitations within the literature and data. The field research component of this study consisted of interviewing key stakeholders involved in the value chain of renewable fuels and visiting production sites at which biofuels have already begun to develop. This analysis is thus based on qualitative research, interviews and various documents our research team obtained from these stakeholders.

3.2 Brief Political History

Geographically, Paraguay is land-locked, surrounded by Argentina, Brazil and Bolivia. The country's lack of mineral wealth naturally left it under-developed in comparison to other Latin American countries during Spanish colonization. Like many of its neighbors, Paraguay suffers from many socio-economic problems including: massive institutional corruption; lack of infrastructure for basic delivery of goods; an inefficient central banking sector; high levels of crime and unemployment; large concentrations of wealth in the hands of oligopolies and monopolies; 100% dependence on imported fossil fuels; a massive external debt and so forth (Hira 2009b, 6). All of these have hindered Paraguay's industrial development. However, despite this, there are signs that Paraguay has the potential to recover in some of these areas, as they are a transitioning democratic state which is under a substantial reform process (Library of Congress 2005).

This study's historical analysis of Paraguay commences with the regime of General Alfredo Stroessner, who gained power through a military coup in 1954. Stroessner was viewed as a stern dictator, who ruled with an "iron fist" through the resources of the Colorado Party. According to one official from the

Paraguayan government, his legacy is marked by instituting interests of the oligarchs in key sectors of the political and economic spheres, and these oligarchs remain to some degree institutionally entrenched (Anonymous Government Official). In terms of economic productivity, the Stroessner regime did experience impressive growth during the 1970's, this was led by agricultural production and the construction of the Itaipu Dam (Library of Congress 2005).

General Stroessner was ousted by a military coup in 1989, in response to many allegations of corruption and mismanagement of the economy during various economic crises of the 1980's. Some of the allegations included the Church's opposition to large concentrations of agricultural landholdings in the hands of Stroessner's supporters and widespread institutional corruption (Anonymous Government Official). These concerns coupled with sharp decreases in agricultural export prices led to the demise of the regime. The 35 year old dictatorship of General Stroessner was brought to an end as his military aide, General Rodriguez, deposed him.

General Rodriguez was elected president and initiated a process of liberalization, on the promise of returning to full democratic rule by 1993 (World Bank 2001, 3). Paraguay's transition to democracy has been not been an easy process. One government official characterized the transition to democracy as being an extensive continuity among elites in politics and the bureaucracy (public administration, military and judiciary) (Anonymous Government Official). Stroessner had used the Colorado Party as a tool to safeguard his rule. Party membership was a prerequisite for a career in the administration or the military. Through the party, the country was governed by means of a tight network of control and patronage. Even after the transition to democracy, and many ensuing elections, the Colorado Party remained in power.

In April 2008, after 61 years of Colorado Party dominance, Fernando Lugo and the Patriotic Alliance for Change Party (PACP) won the presidential elections (Encyclopedia of the Nations 2009). However, the new president lacks a parliamentary majority which makes it difficult to implement badly needed reforms, particularly with regards to the socio-economic development of the masses. These reforms will likely pejoratively affect the oligarchs who safeguarded their interests through the Colorado Party's hegemony. Particularly, the Lugo government has vowed to deliver on land-reform in this predominantly agrarian society and to tackle widespread institutional corruption. As one official conveyed, "…in order to understand energy policies in Paraguay, you must understand the legacy of Stroessner and the Colorado Party which remains entrenched today" (Anonymous Government Official).

Despite the fact that the election of Fernando Lugo may point to change, the Paraguayan party system remains dominated by the two traditional parties, the Colorado Party and the Liberal Party. Each is over 100 years old. These parties will likely continue to form the axis of the country's political system at least through the medium-term (Encyclopedia of Nations 2009). Notably, the PACP would have not won the presidential elections without the support of the Liberal

Party, as the two parties formed an alliance to defeat the Colorado Party. Moreover, within the PACP there seems to be fragmentation and a lack of clear direction on certain economic policies. These include whether or not government intervention into the market is warranted; the need to have legislation in place to protect competition; and the re-distribution of land (Interview at Ministry of Industry & Commerce 2009). In general, domestic institutions moderately well perform their functions, but frictions often arise in the interplay between the president and the congress. Thus, in the context of the development of renewable fuel policies, these competing interests are a significant factor in determining whether or not this industrial policy will be successful.

3.11 Social and Economic Indicators

The lack of data on rural incomes and expenditures has made it difficult to discern the real extent of poverty in Paraguay. Nevertheless, the limited data which is available suggests that approximately 10% of the population owns 75% of the productive land (Encyclopedia of Nations 2009). According to the World Bank (2006), the upper 10% of the population accounts for 46.6% of income and consumption, the upper 20% make up 62.4% of all income (World Bank 2006). The poorest 60% of the population make up less than 20% of the nation’s income, indicating high measures of economic polarization. The Human Development Report of 2008, reported that out of a 179 countries surveyed Paraguay ranked 98th (Rothkropf 2007, 95). Further, Paraguay is amongtole the worst-performing of all Latin American countries in regards to reducing poverty in the year's between 1990 and 2007 (World Bank 2010). Rural poverty increased steadily throughout the 1990's and is most notable among smallholders of agricultural land (Toledo 2007). Toledo (2007) conveys that any concerted effort to increase the productivity of smallholders of agriculture in Paraguay through the investment of research and development, could be expected to generate substantial benefits in the reduction of poverty. This point is of significant importance for this analysis, as big business has massively dominated the agriculture sector since the Stroessner regime, with limited signs of overall growth and improved productivity (Toledo 2007). Thus, in terms of developing a strategy which could serve as a vehicle for social mobility, one way this could be achieved is by creating industrial linkages with smallholders of agriculture land through the development of a sugarcane ethanol industry. I will address this point further in the chapter.

An additional pressing problem which corresponds to these extreme levels of poverty is the government's lack of investment in human capital. According to the World Bank (2010), only 36% of the population has an education above primary level. However, the educational system has recently illustrated signs of improvement, as university enrollment had increased substantially (Hira 2009b). Yet, the educational infrastructure has severe qualitative deficiencies, especially with regards to the differences between rural and urban areas (Anonymous Government Official 2009). The lack of investment in human capital is reflected in the government's small contribution of 4.3% of its GDP in 2009 to education and training and 0.1% towards R & D (World Bank 2010).

The economy is predominantly organized around agriculture and agribusiness; these account for approximately 30% of the GDP, 40% of employment and for almost all exports (World Bank 2010). In 2008, the Paraguayan economy grew for a seventh consecutive year, at a rate of 5.0%, which is comparable to many other Latin American countries. However, this growth rate does not seem to be reaching those must vulnerable in society. Urban employment rose to more than 10% at the beginning of the decade, but proceeded to retract to 7.2% in 2007. Yet, underemployment (approximately 26% in 2007), rather than unemployment seems to be the central problem in the Paraguayan economy (European Commission 2010). In 2005, the International Labor Organization reported that approximately 60% of the urban labor force works in the informal sector (World Bank 2010). Further, Paraguay has 26% of the population under the age of 10, which is a significant factor hindering development of the workforce in the long-term (Hira 2009b, 6). These social and economic figures allow one to conclude that the country urgently requires new innovative sources of employment for those in the peripheral categories, particularly in the sector of agriculture. One way this might be achieved is by facilitating industrial linkages with agriculture through the development of a sugarcane ethanol industry.

In terms of investment, the country faces immense challenges in expanding its capital base. Net FDI (US $188.8 million in 2008) remains significantly lower than in other Latin American countries, and is comparable to contributing 1.6% of their GDP in 2008 (World Bank 2010). This is largely attributed to the relatively low level of competitiveness, as market competition operates within a weak institutional framework. Paraguay is the only country in the Americas which does not have legislation which regulates or prevents the formation of monopolies and oligopolies (BTI 2010). As a consequence of this, most of the agricultural sector is dominated by big business, where the benefits of liberalization have not trickled down to those most affected by poverty. A summary of the discussed social and economic indicators are listed in Table 3.1

Table 3.1 Paraguay's Country Profile 2010

Paraguay's Country Profile 2010		
People		
Urban Population		**61.40%**
Life Expectancy at Birth		**71.8 years**
Illiteracy Rate (over 15 years)		**4.70%**
Unemployment Rate (Urban Areas)		**8.90%**
Population in Poverty		**60.50%**
Economy		
Economic Sectors (value added, % of GDP)		
Agriculture		**22%**
Industry		**20%**
Services		**58%**
GDP Growth (2008)		**5.00%**
Trade and Finance		
Currency		**Guarani**
GNI per capita	(Atlas method, 2008)	**US $2,180**
Total external debt		**US$ 3.1 billion**
Total debt service		**6.20%**
Net FDI		**US$ 188.8 million**

Source: European Commission 2010

3.2.1 Agriculture

Approximately 43% of the population live in the countryside, while 99% live in the Eastern region of the country (BTI 2010). The agriculture sector in Paraguay exhibits very little dynamism, with approximately 76% of the total crop output made by three products, soybean, cattle and cotton (World Bank 2010). Overall, this sector of the economy has produced high levels of inequality in land distribution (Carter & Galeano 1995). This particular strategy, of favoritism towards soybeans, cattle and cotton has largely been responsible for the decline of productivity found in small agricultural producers. A combination of crops for cash sale and production for self-consumption is the foundation of rural livelihood in Paraguay. The intense pressures small producers face, including poverty, low productivity, and food insecurity, stem both from lack of access to the means of production, such as land, capital, and lack of support by the government in providing and agricultural inputs (Anonymous Government Official 2009).

In the eastern frontier of the country there are approximately 16 million hectares of land, of which 9 million (or roughly 56%) are allocated for agriculture and livestock. Livestock uses 5.2 million while agriculture is grown over 2.8 million hectares (1.9 for mechanized agriculture and 0.9 for family owned farms) (USDA 2008). There is a clear division of the agricultural sector in Paraguay: 1) family agriculture; 2) beef cattle production; and 3) mechanized agriculture, all of which lack economies of scale and industrial linkages (BTI 2010).

3.2.2 Why Sugarcane Ethanol is a Good Fit for Paraguay

Increasing the productivity of the sugarcane ethanol sector is a good fit due to a variety of reasons. Firstly, Paraguay is 100% dependent on imported fossil fuels (the majority comes from Venezuela).This produces two problematic factors: such as the lack of energy security and imbalances in foreign exchange derived from oil imports. In terms of energy security, most energy international organizations including the IEA (2009b), the WorldWatch Institute (2007), and World Resources Institute (2005) agree that peak oil will be reached sometime around 2030. Thus, in order for economic growth to be sustained by the transport sector in the future, Paraguay desperately needs to develop policies which secure sustainable fuel needs. The time is now for Paraguay to begin establishing and implementing the policy drivers and infrastructure which would be required to support the growth of an alternative fuel sector, for the long-term.

Secondly, Paraguay has the necessary climatic conditions to expand sugarcane production in a sustainable and efficient manner. The country already has a sugarcane and ethanol industry in its infant stages; however, it currently lacks the political commitment from the government. It must be noted that growth in this sector seems likely to be most successful via a multiple stakeholders approach as seen in the Brazilian case, thereby incorporating small agricultural producers into the value chain. One way this could be achieved is through agrarian reform, which is notably one of the promises that elected the Lugo government to office. Further, this is an essential component which could serve as one tool in preventing replication of high concentrations of land and production by elites, as seen in the current agricultural industry.

Thirdly, the main sectors of the economy which generate the majority of the country's revenue, which include soybean, beef and cotton have not produced economies of scale. Moreover, these industries have also not provided social benefits to those most affected by poverty. This is in stark difference with Brazilian ethanol produced from sugarcane that, if developed in a transparent, efficient and equitable way, could produce a magnitude of socio-economic benefits which the current agricultural production in Paraguay has not produced.. Fourthly, Paraguay has the potential to optimize its trading relations with the EU by integrating environmental certification procedures into their production methods. By certifying sugarcane ethanol, and using it in their domestic economy, this would likely reduce the country's GHG emissions. One way for the government to generate additional revenue could be by selling their carbon credits on the international market. All of these points will be discussed further, in subsequent sections of this chapter.

3.3 Political and Institutional Components that Govern the Ethanol Value Chain in Paraguay

The following section will evaluate the current political and institutional environment that governs the value chain of ethanol production in Paraguay. This industry is in its infant stages, with the potential of expanding. Yet, there are severe institutional constraints in a variety of social, economic and political areas that this study will evaluate further. This section is structured around Hypothesis A:

The Brazilian state's support of research and development was instrumental in the growth of the ethanol industry.

In order to evaluate whether this program can be replicated to some degree, we need a greater understanding of the institutional organization that governs matters of biofuels in Paraguay.

3.3.1 Brief History of Biofuels in Paraguay

In sharp contrast with Brazil, Paraguay's history with biofuel production is quite short and rather inconsistent. In 1973, the government of Paraguay initiated a national plan of ethanol in response to the oil crisis of that year. When oil prices dropped by the mid-1980's the government had completely abandoned the program. The government's second attempt at launching this industry was in 1999, when it called for up to a maximum of 20% blending of ethanol to gas (Rothkopf 2007, 96). There seems to be no available data as to what extent this policy was implemented. In theory, the blending policy appeared to consolidate the government's commitment in supporting the growth of this industry; however as will be presented, it was rarely enforced.

In 2006, Mercosur countries created a Special Working Group on Biofuels. The main areas discussed were: measures to increase the production of different feedstock sources; the establishment of groups which could encourage coordination; technological transfer; and analysis of different policies which could be used to encourage investment in the sector (USDA 2008, 6). In 2007, Paraguay and Brazil signed a Memorandum of Understanding on biofuels which called for technological transfer, investment, and assessments of different feedstock sources. According to the USDA (2008), the Paraguayan government has established a relationship with the Brazilian Agriculture Research Corporation (Embrapa), for technological transfer. During our field research, it became clear from various interviewees that deeper Brazilian-Paraguayan cooperation on energy matters is unlikely, given the contestations and millions in back-due payments over the Itaipu Dam contract.

3.3.2 Institutional Organization and Challenges

Overall, Paraguay exhibits severe institutional and political challenges. Policy making is not always transparent, and this lack of transparency is exacerbated by a weak legal and regulatory framework. The absence of coherent procurement policies generally hinders the effectiveness of energy related projects. Paraguay suffers from severe institutional corruption, political fragmentation, a lack of merit-based services, a low tax base, and a lack of government budgeting and accounting. All of these are obstacles to the development of a universal industrial policy (Hira 2009b). In terms of the current biofuels regulatory environment, there seems to be a lack of coordination among applicable ministries involved in the value chain.

For instance, the Ministry of Agriculture is responsible for overseeing and regulating sugarcane production; however, once the product goes through the distillation process, it is solely under the jurisdiction of the Ministry of Industry (Interviewee at Ministry of Commerce and Industry 2009). Lack of coordination between these industries can significantly affect yields and further questions the sustainability of production methods, of both sugarcane and ethanol. The Brazilian experience underlines the need to have a strong agricultural research and extension program. This is important in developing new cane varieties to stay ahead of diseases and pests, distributing information through agricultural services, and ensuring that farmers have the tools to implement findings and recommendations. The only formal coordination that exists between these ministries is under the group known as Rediex, the Roundtable on Biofuels. Rediex, which falls under the jurisdiction of the Ministry of Commerce and Industry, is the main entity which exclusively deals with biofuel production. During our interview with Rediex (2009), one official conveyed their lofty goals for future production of sugarcane ethanol. However, in order to meet these projections in both domestic production and exports, the government will have to develop an explicit state-led framework, not only for key stakeholders, but also concerning rules and regulations over investment. The official at Rediex was quite optimistic that production levels of sugarcane ethanol would increase, yet conveyed how there is currently no industrial state plan to support this (Interviewee at Rediex 2009). One of the chief obstacle's this interviewee discussed was that Paraguay lacks FDI, which he attributed to the inefficiencies of the central banking sector. In Brazil, BNDES guaranteed investment and contracts to ethanol producers which created incentives for the private sector to commit to the industry; no such central banking authority exists in Paraguay.

During my interview with a government official (2009), he conveyed how Paraguay has everything required to cost-effectively produce sugarcane ethanol except the politics. According to this source, most agricultural expansion is not planned by the state or applicable ministries, and tends to be a product of the private interests which remain in power from the Stroessner regime. This produces severe consequences in terms of any environmental assessment on sugarcane and ethanol. He viewed the coordination between related ministries involved in the biofuels value chain as merely having a “theoretical application”, which lack transparency and coordination. This is based on past political behavior, where strategic planning in technology, transportation and agriculture had a complete divorce from the political realm (Anonymous Government Official 2009).

This official also emphasized how Stroessner created new feudal land holdings by giving away strategically productive land to those in the military and members of the Colorado Party. In other words, Stroessner created his own aristocracy whose current interests are best preserved by continuing with the production of cattle and soy. In this view, these agricultural products have more value-added than sugarcane given the magnitude of start-up costs this industry would require. Thus, the agricultural sector would be working at a loss if they expanded the sugarcane ethanol sector (Anonymous Government Official 2009). Further, this representative also conveyed that opposition to this policy stems from allegations of corrupt financial profits derived from Petropar, the state-owned oil company; agrarian reform policies initiated by the Lugo government, which seeks to re-distribute land thus taking it away from the old aristocracy; and transportation costs of sugarcane ethanol which are roughly placed at 10-15% of the cost of production (Anonymous Government Official 2009). In the short-term, this official was not convinced that the government would be producing any coherent framework which explicitly addresses a state-led biofuel program.

Another impediment is that Congress is controlled by the Colorado Party and congruently runs the legislative branch. Thus, any attempt at changing laws, which do not serve the interest of the political oligarchy and elite, will take a lot of time. Any industrial policy which threatens these interests needs to be understood in this context. In summary, although this official was generally quite sceptical about possible change, he did address the fact that the Lugo government is attempting to tackle some of these pressing issues.

Generally, field research revealed major institutional breakdowns related to those ministries discussed. In the case of Brazilian ethanol, the success of the existing framework is based on the intra-institutional coordination between Ministries of Agriculture, Industry, Environment, Transportation and Energy. This ultimately has provided a transparent environment of checks and balances on production. However, Paraguay ultimately lacks a universal body which regulates the sector. In Brazil, the ANP initially kept track of ethanol transactions and currently establishes communication channels between producers, engine manufacturers and environmental agencies. In Paraguay, no such body exists, which questions the legitimacy (e.g. levels of sustainability) of the product.

In terms of the politics behind supporting the growth of the ethanol sector, there seems to be interest by the government that is frequently documented in the media. However, this has yet to translate into real policies and subsidies which would be required to support industrial growth. Further, most of the interviewees had serious doubts as to whether or not the government had the political capacity to enforce such procurement (Anonymous Government Interviewees 2009). This stems back to the alleged high levels of corruption in the bureaucracy; a lack of functioning banking sector; and a general lack of resources at the disposal of the government. Moreover, interviewees continuously discussed the lack of long-term industrial vision of the government, which was crucial in the Brazilian experience with ethanol. Brazilian state-led policies were the reasons why this policy was successful: they created the market and supported it during its primary phases of expansion and various economic obstacles it encountered; it invested substantially into infrastructure, R & D and other areas which produced a productive market; and they decreased state support once the market had stabilized. The current political climate in Paraguay does not illustrate any of these factors. Yet this does not mean it is not possible in the future.

During our interview with the Office of the Vice President, one interviewee described some of the challenges in developing an industrial policy of this nature.

Generally there is a lack of infrastructure, which significantly increases transportation costs and hinders overall efficiency of trade (Interviewee at Office of the Vice President 2009). Currently, the vision of the government rests on expanding infrastructure of ports, roads and railways. There was also discussion of the government trying to sell infrastructure concessions to other Latin American countries. Essentially, Paraguay's geographic isolation is at the center of trade between countries in Mercosur, and in order to make Paraguay competitive, the government could sell these concessions to upgrade the existing infrastructure. If this project is successful, the government is confident that Paraguay could be the transport corridor of the continent (Interviewee at Office of the Vice President 2009). The developments in infrastructure could position Paraguay well in terms of increased future FDI, and in creating the transport and structural conditions which would be required to increase the domestic consumption of ethanol.

3.3.3 The Role of Petropar

An additional obstacle in developing a biofuel industry in Paraguay is the current role that Petropar maintains in the energy market. This state-owned company has a monopoly on the import and wholesale distribution of petroleum products, accounting for approximately 80% of the market (Interview at Petropar 2009). Petropar is also one of the main players in the ethanol game, acting as producer, mixer of ethanol and gas and wholesale distributor of ethanol. In the case of Brazilian ethanol, "…Petrobras was key to stabilizing the ethanol market through its decided policy to create a large market for ethanol, including crosssubsidization during price swings, and its ability to vertically capture the production chain, ensuring retail availability" (Hira 2009b,17). In contrast, the situation with the fuel network in Paraguay is less optimistic. Petropar is heavily in debt to Pedevesa, the Venezuelan state-owned oil giant. This is due to the fact that the state has used Petropar as a vehicle to subsidize diesel, on which more than 75% of cars operate on. According to one interviewee, Petropar has been used as a pawn of the state to make diesel economically viable for the majority of the population (Anonymous Government Interviewee 2009). Currently, diesel is more expensive than gas, yet this was not always the case. In response to increases in prices over the last couple of years and past government policies which supported the consumption of diesel over gasoline; the government has no choice but to subsidize. Notably, these are funds which the government desperately needs to fuel further industrial expansion.

During field research several of the interviewees indicated that Petropar also faces major institutional challenges such as: lack of financial transparency; lack of regulations and standards regarding the quality of biofuels and petroleum; corruption; and the need for substantial upgrades to its technological infrastructure. The lack of technological sophistication in its ethanol production facilities was confirmed when our research team visited one of Petropar's refineries. It was clearly out-dated, in comparison to another Brazilian owned refinery we visited. One interviewee described the current physical status of the refinery as "over-valued and completely run-down" (Anonymous Government Interviewee Interviewee 2009). Petropar is the main wholesaler of mixed ethanol, and despite regulations which call for a maximum of 20% ethanol to gas, not all gas is blended. There are many other players in the ethanol market, which also include smaller private stations. During our interview with a representative from Petropar (2009), he indicated that many retail outlets are not eager to assume the costs of upgrading their facilities to make them ethanol compatible. Currently, the government does not provide any assistance towards these upgrades. In Brazil, the mandatory blending procurement gave consumers confidence in the ethanol market as they could always access it at all stations. In terms of consumer confidence in Paraguay, the alternative fuel network has a long way to go.

There is one potential solution which the literature discusses, in response to the current problems that Petropar faces. Hira (2009b) discusses how Petropar could be privatized, and released of its wholesale position. This would theoretically make it more competitive with other companies in the fuel market. Yet, the likelihood of this occurring is doubtful, given its huge debt and major upgrades which are required. Nevertheless, this seems to be on the table for discussion.

3.3.4 Summary

I have presented the existing political and institutional framework which currently governs the value chain of biofuel production in Paraguay. Although, during field research, it became apparent that there are major obstacles that must be overcome, Paraguay's 100% dependence on oil and robust agricultural society make it a strong candidate to develop an ethanol sector. However, this must be done through the partnership of a multiple stakeholders approach, which calls for including the government and related ministries, farmers, agribusiness, transport companies, and industry involved in the value chain of ethanol. In the Brazilian experience, the program commenced with subsidies, but they were gradually phased out. When the market turned around in response to increases in world market prices for oil, the government supported the consumer purchases of FFV's through tax breaks. This was an instrumental move made by the government and Petrobras, which in the long-run has resulted in the market turning around. The key with Brazil's program was that it was initially state-led.

In the case of Paraguay, the state has not taken an active role in developing the market. The government is "interested" in pursuing the development of biofuel expansion; however it currently lacks a coherent long-term vision. Moreover, the political fragmentation among institutions and within the government itself enables one to seriously question whether this policy has the capacity to be successful. In response to Hypothesis A, we believe that given the government's lack of commitment towards supporting the growth of this industry, it is not feasible in the short-term to expect the ethanol industry to grow beyond that of the private sector.

3.4 The Economic Costs and Benefits of Ethanol Production in Paraguay

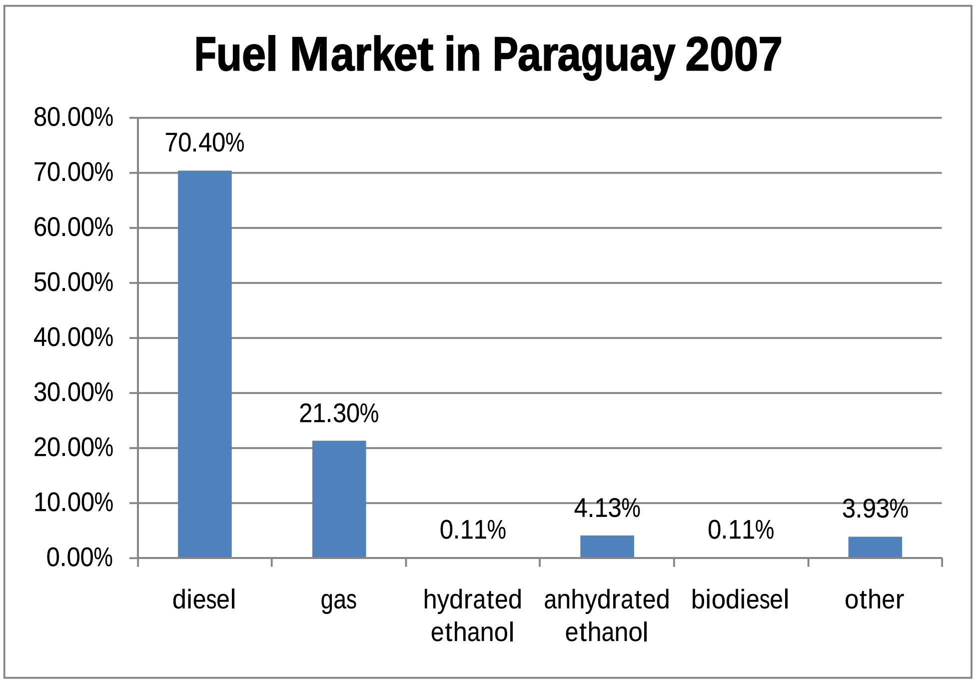
The following section will investigate the various costs and benefits of pursuing an industrial policy based on ethanol. In particular, this analysis will in evaluate the ways in which the ethanol market currently operates in Paraguay and ways in which it can be strengthened by drawing from the Brazilian experience. This section is structured around Hypothesis B:

The economic feasibility of Paraguay expanding its sugarcane ethanol sector is contingent on how the market operates, in terms of the structure of relationships among sugarcane producers, the private sector and the government.

3.4.1 The Energy Market

Paraguay is a significant producer of hydroelectricity and imports 100% of the oil it consumes. The electricity sector is run by the state-owned utility company, the National Electricity Administration (ANDE). ANDE works in conjunction with Brazil, operating the world's second largest dam, the Itaipu. It is estimated that Paraguay uses 16% of electricity from the Itaipu Dam and exports the remaining amount to Brazil (Rothkropf 2007, 97). In recent years, there has been intense conflict between the two countries over revenues owned to Paraguay from Brazilian consumption of the electricity generated by the dam. This has ultimately produced a climate of limited trust in energy matters between the neighboring countries. It is unfortunate that Paraguay has not been able to take advantage of cheap, clean electricity, as transmission lines are sorely lacking throughout the country. Recently, the Lugo and Lula governments have reached an agreement over these back-payments, which could be used as new sources of revenue to finance industrial production and sophistication of Paraguay's infrastructure. When these back payments are transferred to the Paraguayan government, their financial capacity in supporting large-scale industrial expansion could change. According to the USDA (2008), in 2007 Paraguay consumed roughly 1.2 billion liters of diesel and 400 million liters of gasoline. The fuel market consists of 70.4% diesel, 21.3% of gas, and 8.29% of other, which includes biofuels (Figure 3.1)

Figure 3.1 Fuel market in Paraguay



Source: Rediex 2008

3.4.2 Ethanol and Sugarcane Production

The trajectory of ethanol production has been steadily increasing since the government implemented the blending procurement in 1999, articulating a maximum 20% ethanol to gas. Table 3.2 illustrates the growth in production.

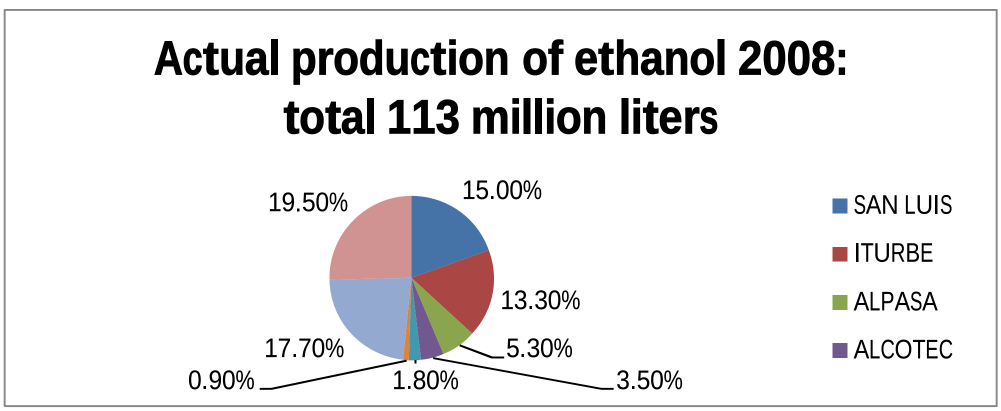
Table 3.2 Ethanol Production in Paraguay

Trajectory of Ethanol Production in Paraguay			
Year	**Areas (HA)**	**Production (Ton)**	**Ton/Ha**
2000/2001	59,580	2,396,180	40
2001/2002	52,399	2,976,290	57
2002/2003	62,255	3,260,475	52
2003/2004	69,942	3,637,000	52
2004/2005	74,000	3,020,000	41
2005/2006	80,000	4,000,000	50
2006/2007	92,000	5,060,000	55

Source: Rediex 2008

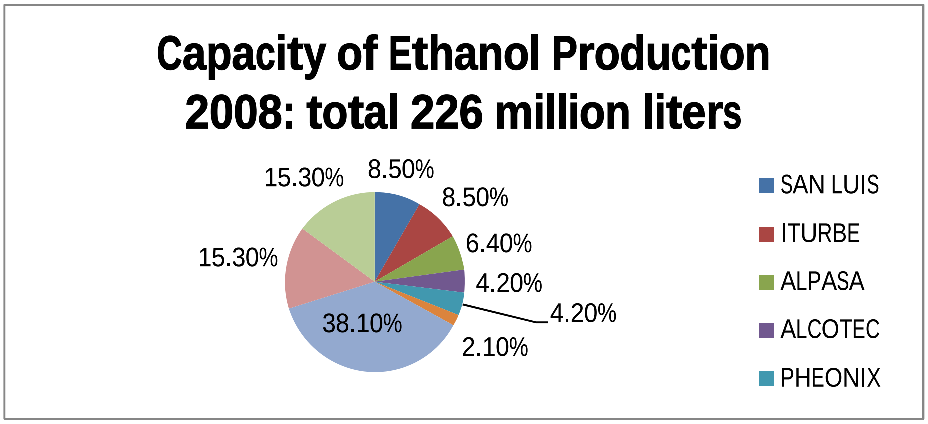
According to Rediex, Paraguay has the capacity to double current production levels (Figures 3.2 and 3.3). These figures also illustrate the main players in the ethanol market, of which Petropar is the only state-entity and the remaining actors are from the private sector.

Figure 3.2 Ethanol production 2008



Source: Rediex 2008

Figure 3.3 Capacity of ethanol production 2008



Source: Rediex 2008

Sugarcane is mostly used in Paraguay as raw material for ethanol production. Tropical to subtropical weather and large availability of fresh water and fertile lands, make the eastern region of Paraguay very appropriate for sugarcane crop. There is a long history of growing sugarcane in Paraguay, and according to the National Sugarcane Program, there are approximately 450,000 hectares of available land to increase production (Inter-American Institute for Cooperation on Agriculture 2007). The production of sugarcane has increased steadily over the last decade, and is illustrated in Table 3.3.

Table 3.3 Sugarcane production in Paraguay

TRAJECTORY OF SUGARCANE PRODUCTION			
Year	Area	Production (Ha)	Efficiency (Ton/Ha)
2000/2001	59,580	2,396,180	40
2001/2002	52,399	2,976,290	57
2002/2003	62,255	3,260,475	52
2003/2004	69,942	3,637,000	52
2004/2005	74,000	3,020,000	41
2005/2006	80,000	4,000,000	50
2006/2007	92,000	5,060,000	55

Source: Rediex 2008

The cost of production of sugarcane is quite competitive with that of Brazil, where the cost of is approximately $10.45 per ton, and in Paraguay roughly US$13.70 per ton (Rediex 2008b). Table 3.4 illustrates production costs in the ethanol industry.

Table 3.4 Production costs in the ethanol industry

Production costs in the ethanol industry	
Description	**Quantity**
Cost of land	US$200-1,000/HA
Industrial yield	72-80 liter/ton milled
Average price of sugarcane	US$13.70/ton
Local price of ethanol	US$0.70/liter
Production cost (estimated)	US$0.30/liter
Margin (estimated)	US$0.40/liter

Source: Rediex 2008

It is estimated that approximately 35% of the aggregate area planted with sugarcane is mechanized (Rothkropf 2007,97). Sugarcane mechanization includes the appropriate machinery for preparing the soil and for the harvest itself. The sugar mills are for the most part those that own such machinery, as it extremely expensive. The feasibility of extending mechanization to increases in sugar production is likely. However, if the government does not provide financing avenues to small farmers to obtain the technology, large landholders and agribusiness giants will be the main beneficiaries of expansion.

Paraguay is also an important producer of organic sugar. In 2008, the crop output totaled roughly 100,000 hectares of land, with estimates indicating that this could increase to approximately 450,000 hectares (USDA 2008, 4). According to one official from the Ministry of the Environment, the organic sugarcane industry could be used as a template for “regular” varieties, thereby following sustainability requirements that the EU’s renewable directive articulates (Interviewee at Ministry of the Environment). Unfortunately, there are no further details or reports regarding modeling the sugarcane sector after the organic industry. Nevertheless, the organic sugar industry should have an appropriate framework, which includes rules and regulations in order to sell their product internationally. This could be useful in the future for sugar destined for ethanol production.

3.4.3 FFV’s

One of the key challenges with integrating ethanol in the Paraguayan domestic economy relates to their current fleet of vehicles. 70.4% of all cars run exclusively on diesel, while only 21.3% run on gas (Rediex 2008b). In 2003, the Brazilian industry gained new momentum with the introduction of FFV’s which supported the increased domestic demand for ethanol. The government had classified FFV's for a significant tax break, which encouraged domestic purchases. The emergence of FFV's reinvigorated the production of Brazilian ethanol, as long as oil prices did not collapse under US$35 per barrel. According to Rediex (2008b), there are subsidies in place which make FFV's cheaper than other vehicles, yet the details concerning these tax breaks were not elaborated upon during our interview. In theory, although there might be subsidies in place, the portion of the country that is in an economic position to afford new vehicles is quite small. Given this and the lack of financing available to the lower classes to afford FFV's, it is very unlikely that the FFV market will grow exponentially. One potential solution could be for the government to take an active role in promoting the purchases of FFV's, by providing loans to the lower classes. This would decrease the amount of diesel-based cars, increase domestic demand for ethanol, and ultimately make their domestic environment a much cleaner place.

3.4.4 Job Creation and Skilled Labor

One of the primary motivations to support an industrial policy of this nature is job creation. In the Brazilian case, the sugarcane ethanol sector has created more than 3.6 million indirect and direct jobs throughout the value chain. In the case of Paraguay, one official from Rediex (2009) indicated that unlike Brazil, Paraguay does not have a surplus of available labor, which would be required to manually harvest an expanding sugarcane sector. One report by Rediex (2008a), indicated that there are approximately 25,000 sugarcane workers working across the country. My research team was unable to confirm this data with any another reports, illustrating the inefficiencies in generating statistics which should be available from the Ministries of Labor and Agriculture.

During our field research, we investigated if there were labor unions active in Paraguayan agriculture. It was revealed that labor is not an organized, tightly knit, autonomous force. The firms have traditionally been small and workers were generally not politically active, in comparison to many other South American states (Anonymous Government Interviewee 2009). According to this source, the Stroessner regime anticipated demands of a growing labor force, granted some benefits, and impeded the formation of strong labor unions. Since the demise of Stroessner, there has been limited mobility in terms of strengthening labor union ties (Anonymous Government Interviewee 2009). This is of importance for the comparison with Brazil, because in that country, Unica represents 60% of sugarcane workers and producers and is a landmark organization. It is responsible for producing credible data, overseeing that labor standards are enforced and is one of the main institutions disseminating information for both the public and private sectors.

In relation to skilled labor that would be required to successfully manage the industry across the sugarcane ethanol value chain, Kojima and Johnson (2006) discuss two questions which are applicable to this case study: are farmer's provided with adequate primary education, so that they "be able to respond to new technical, marketing, organizational, and financial opportunities"? And, is there a cadre of managers who could be used across all aspects of the value chain? In response to the first point, the WB (2010) indicated that only 36% of the population has an education above primary levels. This is problematic, but if the government was serious about including farmers in this industrialization process, it could implement training programs geared towards generating the skills which would enable farmers to respond to market and industry conditions. Secondly, with the construction of the Itaipu Dam during the 1970's, Paraguay produced an abundance of engineers. During field research, it became apparent that the majority of universities in Asuncion were engineer and technology based. Thus, the country does possess a pool of high-skilled labor which could be used to manage various sectors across the ethanol value chain.

3.4.5 Government Financing

The lack of government financing is a serious obstacle to the growth of the ethanol industry in Paraguay. Field research allowed us to conclude that the lack of finance is a systemic and endemic problem for producers, both small and large. During our interview with an anonymous government official (2009), he discussed how the financial system is so inefficient that it is difficult for producers to develop economies of scale in ethanol production. During our interview with the Office of the Vice President, one of the interviewees conveyed that ethanol production is not a good fit for Paraguay. He noted that Brazil has sophisticated technology, sufficient capital to finance R & D, and substantial FDI; all of which Paraguay lacks to be competitive (Interviewee at Office of the Vice President 2009). Further, when asked if the government has any plans to encourage FDI, thereby strengthening the investment climate, the official conveyed that there currently are no tools at the disposal of the government. In summary, the lack of a central banking authority, which would guarantee investment and provide loans to smaller producers to increase their economies of scale, is a serious dilemma which ultimately questions the economic feasibility of this policy.

3.4.6 R & D, Infrastructure

R & D is crucial in making sugarcane ethanol cost-competitive. In 2008, the Paraguayan government contributed only 0.1% of its GDP towards R & D, which is worrisome. In the Brazilian case, the growing science and technology foundations have been fundamental in increasing productivity and enhancing their economies of scale for mills and distillation plants. Brazil has created a substantial extension of R & D which is crucial in lowering production costs, increasing varieties, improving innovation and regulating the entire program. It is vital to comprehend that the success of the expansion of ethanol and sugarcane in Brazil materialized not only due to the increases in cultivated areas, but is also attributed to the significant gains made in R & D. The Brazilian experience underlines the benefits of developing new cane varieties, disseminating information through agricultural extension services, and ensuring that farmers implement the findings and recommendations. During field research, it was evident that state of the art technology was available throughout the country, as there were many Brazilian and American agri-business giants. However, our research team could not confirm whether or not there was technological sharing of any kind in the areas of sugarcane cultivation.

In terms of infrastructure, in the first section of this chapter I discussed the government's long-term vision for expansion. During field research, it became apparent that the transport infrastructure throughout the country was grossly underdeveloped. During our interview with one government official (2009), he indicated that transport costs are 40-50% higher than in any other country in South America due to the inefficiencies and limitations with the infrastructure. This situation does show signs of improvement, as the government has plans to increase the capacity of their infrastructure.

In summary, the current status of the transport infrastructure requires substantial upgrades to lower transport costs and support industry in an efficient manner. The government does seem to have a long-term vision to address this issue, which illustrates positive signs for not only future growth in exports, but any industrial policy in general.

3.4.7 Conclusion

This section has investigated the economic benefits and costs of developing an industrial policy based on sugarcane ethanol. Primarily, this analysis was interested in how the current energy market operates in Paraguay, the types of relationships that exist amongst producers, government and the private sector. Given the limitations in data, it is somewhat difficult to discern the true extent of how the ethanol market operates. Nevertheless, what was revealed from our field research is that with the exception of Petropar, ethanol economic initiatives seem to be solely instigated by the private sector. Overall, there is a lack of state-led subsidies for small and large producers, which invariably affects developing their economies of scale. Although, Rediex (2008a) claims that production can increase two-fold, I have serious doubts concerning the methodology that was used to produce these projections. Furthermore, there are severe obstacles that must be overcome such as: addressing the inefficiencies in the banking sector; lack of FDI; increased subsidization for the purchases of FFV's; and the lack of financing in the areas of R & D.

Optimistically speaking, the government is expanding infrastructure and does have a functioning organic sugarcane sector which has the potential to be used as a template for regular cane varieties. Given the aforementioned discrepancies in the ways in which the ethanol market operates and the lack of coordination that exists among sugarcane producers, the private sector and the government, this research has concluded that it is not economically feasible in the short-term. Thus, this study cannot support Hypothesis B which states: "The economic feasibility of Paraguay expanding its sugarcane ethanol sector is contingent on how the market operates, in terms of the structure of relationships amongst sugarcane producers, the private sector and the government".

3.5 Sustainability Requirements

The following section will discuss various sustainability requirements which must be incorporated into Paraguay's framework for biofuel production. Two of the primary motivations for adopting an industrial policy of this nature are the environmental and climate benefits that it will likely produce. In the case of Brazil, our analysis indicated that overall sugarcane is the most energy efficient type of feedstock to produce ethanol. The Brazilian domestic consumption of ethanol, which was supported by the growth of FFV's, has substantially reduced the country's dependence on oil. This, coupled with the energy benefits derived from using co-generation at production plants, has significantly reduced their GHG emissions. There is a tremendous amount of potential for Paraguay to absorb the lessons learned from the Brazilian experience and implement an ethanol regime that is based on environmental certification, as per outlined in the EU's Renewable Energy Directives. As in the other sections of this chapter, data is sorely lacking in terms of environmental assessments on methods of production, in both sugarcane and ethanol. Thus, this analysis is based on field research and secondary sources. We structure this section around Hypothesis C:

Sugarcane ethanol could be produced in a sustainable way in Paraguay in the short-term, given the country's abundance of available land.

3.5.1 The Availability of Land and Deforestation

The vast majority of land in Paraguay is underdeveloped. Although agriculture is a crucial part of the economy, only 7.6% of the country is under cultivation (Library of Congress 2005; 10). According to the USDA (2008), there are approximately 16 million hectares of land, of which 56% is dedicated to agriculture and the cattle industry. At first glance, one would think that Paraguay's natural competitive advantage in adopting a nation-wide ethanol policy would be that it could increase sugarcane production substantially without threatening the environment. However, during field research it became apparent that the country has legislation that prohibits land-use changes. The government currently has endorsed a Zero Deforestation Law, which will come into effect December 2013 (Mongbay 2008). Therefore Paraguay would need to convert existing agricultural land (much of which is underutilized) to sugarcane cultivation. This process could be extremely challenging and ultimately questions the feasibility of this policy.

During our interview with one official from the government, he was not optimistic that owners of large agricultural landholdings would be interested in converting existing crops to be suitable for sugarcane cultivation (Anonymous Government Interviewee 2009). As discussed in the previous section, the agricultural industry would be working at loss if they pursued implementing the soil and technological conversions, that this crop would require. The only way that increased sugarcane cultivation would be possible, is through initiatives which were state-led. This would entail a coherent agrarian reform process, which would undoubtedly encounter massive opposition and threaten the current Lugo government's status in government.

3.5.2 Environmental Certification

One of our initial observations was that Paraguay could differentiate its product from that of Brazil's by supporting the development of a framework which was exclusively tailored to follow the guidelines of EU's Renewable Energy Directive. As detailed in the Chapter 2, this would have to be highly sophisticated and would require a substantial amount of investment. Further, intra-institutional coordination from all related ministries and stakeholders in the value chain of ethanol would have to work together with a common set of rules, principles and mandates. Field research which documented the substantial institutional breakdowns severely questions the viability of this theory. As noted in Section 1 of Chapter 3, the government's position on sustainability is merely "conceptual", as the Ministry of the Environment does not currently have any working groups with applicable bodies such as the Ministries of Industry, Agriculture or Labor. This formal coordination would be required in order to credibly provide environmental assessments on sugarcane and ethanol production.

3.5.3 Conclusion

The primary motivations in developing an ethanol industry are the climate and environmental benefits that it would likely produce. I commenced this research with the assumption that ethanol would create industrial linkages with agriculture. As the industry grew, social benefits would be distributed to those most affected by poverty. Thus, growth in the ethanol sector would not only produce social but impressive environmental benefits. I theorized that Paraguay was well positioned to accomplish this, and find a market niche, by differentiating their product with that of Brazil's. At first glance, Paraguay has an abundance of land, which could be used to grow sugarcane sustainably. However, field research revealed major obstacles in achieving this. One such obstacle is legislation would have to be introduced to facilitate land use changes. Another is the substantial investment needed throughout the agricultural sector to upgrade existing low productivity among smallholders. Further, the lack formal coordination that exists between related ministries of the value chain, negates these primary observations. Thus this study cannot support Hypothesis C “that sugarcane ethanol could be produced in a sustainable way in Paraguay in the short-term, given it’s availability of land”.

4: Concluding Remarks

This research has investigated the feasibility of Paraguay establishing a viable sugarcane ethanol sector, by drawing from the Brazilian experience. In Chapter 1, I presented my analytical framework which was based on three categories. These included: political and institutional components that govern the value chain of sugarcane and ethanol; the costs and benefits of developing an industrial policy of this nature; and sustainability requirements that must be incorporated into any long-term biofuels policy. This section also presented a series of hypotheses which would answer our central question of the research; can Paraguay learn from the Brazilian ethanol program? [4] In Chapter 2, this study investigated the Brazilian program and highlighted key aspects and obstacles that the industry encountered. As a leader in sugarcane ethanol production, the Brazilian experience is clearly the key case for studying the possibilities, costs and benefits, for other countries seeking to develop a sustainable industrial policy based on the production of sugarcane ethanol.

Chapter 3 evaluated Paraguay in great detail. My methodology consisted of interviews our research team held with key stakeholders of the ethanol value

[4] Hypotheses for this project are the following: (a) the Brazilian state's support of research and development was instrumental in the growth of the ethanol industry. In order to evaluate whether this program can be replicated to some degree, we need a greater understanding of the institutional organization that governs matters of biofuels in Paraguay; (b) the economic feasibility of Paraguay expanding its sugarcane ethanol sector is contingent on how the market operates, in terms of the structure of relationships amongst sugarcane producers, the private sector and the government; (3) sugarcane ethanol could be produced in a sustainable way in Paraguay in the short-term, given the country's abundance of available land.

chain. Prior to field research, my research team hypothesized that Paraguay was well positioned to take advantage of developing an industrial policy of this nature. The country's 100% dependence on fossil fuel imports and robust agricultural economy make it a strong candidate for developing sugarcane ethanol in a sustainable way. However, field research revealed systemic and endemic obstacles that must be overcome. In terms of institutional and political matters related to renewable fuels, Paraguay exhibits major systematic challenges. This is reflected in the lack of intra-institutional coordination between key stakeholders across the value chain. Further, within the government itself, there is a lack of coherent and transparent long-term vision, which is crucial in developing an industrial chain based on ethanol.

As discussed, the Brazilian government was at the forefront of nurturing this industry through mandatory blending procurements, price ceilings, subsidies, substantial investment in R & D, and bringing together the private sector to work in coordination through a multiple stakeholder's approach. The government initially used Petrobras as a means of controlling and distributing sugarcane ethanol throughout the country. This established confidence in the market. By contrast, Petropar is financially handicapped and thus unlikely to be able to adopt an active role for the foreseeable future. Moreover, the Brazilian government provided tax breaks to consumers who purchased FFV's, which revitalized their domestic consumption and ultimately the industry. Overall, the current status of the Paraguayan ethanol industry is led by private interests, with little government intervention into the market. If the government does not endorse an active role in the ethanol market, it is likely that production will be concentrated in the hands of agribusiness and elites, who have traditionally been associated with Paraguayan agriculture. This counteracts one of the primary benefits that this policy would seek to achieve, namely the re-distribution of social capital for those most affected by poverty.

After field research it became evident that given Paraguay's political history of entrenched interests from the Stroessner regime, it is highly unlikely that the state in the short-term will have the capacity in changing this structure. This is further exacerbated by legislation which articulates no land-use changes. One of my initial observations was that Paraguay has an abundance of land that could be used to sustain increased production, however given the Zero Deforestation law this is not the case. Any attempt at implementing a framework based on increased sugarcane production would entail re-converting existing agricultural plots to be compatible with sugar cultivation. Further, unless the government provides economic initiatives to those who own land, it is unlikely that this conversion would be in their interests.

Additionally, the conflict over the back dues owed over the Itaipu Dam has propelled a climate of reduced trust related to matters of energy between Paraguay and Brazil. This situation could change, as the two countries have reached a deal concerning back due payments which could be used as a source of revenue to finance an industrial policy of this nature. It is my position that in order for Paraguay to be competitive domestically and internationally, there would have be formal coordination with Brazilian interests for technological transfer and FDI. This would be essential for Paraguay to develop their economies of scale, which is crucial in developing a successful industry based on renewable fuel. The future feasibility of Paraguay's biofuels industry hinges on whether or not the government commits to a long-term vision that is based on sugarcane ethanol.

Bibliography

Interviews

.All interviews were conducted in July 2009, by Dr. Andy Hira, Dr. Plinio Torres Garcete and Alicia Bradsen, in Asuncion, Paraguay. By prior agreement, I have anonymized the specific identities in order to protect the interviewees . I gratefully acknowledge the willingness of participants to meet with us and I thank them allotting time and in setting up site visits. Our research team conducted three site visits; to two alcohol distilleries and to Friesland cooperative.

Interviewees were employed in the following:

-Cardenas Nunes, Justo Pastor, Diputado (Deputy), Congreso de Paraguay (Congress)

-Petropar, Office of the President

-Ministry of Industry and Commerce, Office of the Vice Minister, UTEPI (Unidad Technica de Estudios para la Industria (macroeconomic and industrial policy analysis office), REDIEX (public-private network for export promotion)

-Office of the Vice President

-Ministry of the Environment

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