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Impact Of Expanded United States Sugar Imports From Cafta-Dr Countries On The Domestic Ethanol Market

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Impact of Expanded United States Sugar Imports from CAFTA-DR Countries on the Domestic Ethanol Market

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Dedication

This thesis is dedicated to my grandfather, George W. Langford, who taught me hard work and commitment provides great rewards; fore he is my angel in Heaven protecting me and guiding me through my life one challenge at a time.

Biographical Sketch

Shaniqua Janine Parker was born on March 29, 1982 in the Bronx, New York. She graduated from Westover High School in Fayetteville, NC in 2000. She received her Bachelor's of Science degree in Business Management from North Carolina Agricultural & Technical State University. After a few years in middle management, she returned to her alma mater to pursue her Master's of Science degree in Agriculture Economics with a concentration in International Trade. As part of her Master's program, she served in Peace Corps in the highlands of Guatemala for 2 years as a sustainable agriculture marketing consultant working with coffee farmers in a coffee cooperative.

Acknowledgement

I would first like to thank GOD for being my best friend and providing me with the best home possible, Elim Christian Fellowship. HE gives me strength and love no matter the circumstances.

I would like to thank my grandmother, Elizabeth Langford, for teaching me an education means nothing if you can't apply it to your life.

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I would like to thank my mentor, Dr. Osei-Agyeman Yeboah, for pushing me when I thought I couldn't bend anymore, and for caring for me and my future no matter what. He truly inspires me, and I have the highest level of respect for such a distinguished man.

I would also like to thank the following family & friends: Natasha Pitter; Tonya Johnson; Dr. Anthony Yeboah; Tyrome, Natalie & Trey Holloman; Yolanda Baker; Mr. & Mrs. Vaughn; Jasmine Edwards; Gina Chavez; my family at Elim Christian Fellowship including my spiritual advisor, Pastor Terry E. Warr & Dr. Joye Warr; my family including Tremayne Langford, Bernice Brown, Berkeley Freeman and Antoine Freeman; my Peace Corps family including Felicia Cassanova, Tiffany Hammond, Marlaine Woodford, and Amanda Baker; and my closest friends including Kishaa James.

Table of Contents

List of Figures

List of Tables

Abstract

The U.S. government set an alternative fuels mandate of 35 billion gallons by 2017. In the U.S., corn is the main resource being used to make ethanol. The United States has been looking at other raw inputs for ethanol production like sugarcane. Sugarcane ethanol is the most cost-efficient biofuel. During the transition period from oil to alternative fuels, the United States should increase sugarcane imports to augment the corn that's available for ethanol production.

The purpose of this study is to determine how sugarcane imports will impact domestic ethanol production. The objectives are three-fold; (1) provide a descriptive analysis of the spatial distribution of domestic ethanol plants and their capacities, (2) econometrically determine the effects of sugarcane imports from CAFTA-DR countries in combination with economic variables (gasoline, ethanol & corn prices) on the domestic ethanol market, and (3) provide policy recommendations for the domestic ethanol market.

This study uses econometric modeling to establish the relationships between domestic ethanol production, domestic gasoline prices, and the relative ratio of domestic corn prices to imported sugar cane prices. An OLS regression model was developed with monthly U.S. ethanol production as a function of domestic gasoline and ethanol prices as well as the relative ratio of domestic corn prices to imported sugarcane prices; covering January 2000 to September 2008. All variables were significant at the 1% level, with expected signs. Gasoline and ethanol prices had a positive effect on ethanol production, while the price ratio of domestic corn to imported sugarcane had a negative effect. Policy recommendations include, but are not limited to, using the increased imported sugarcane from CAFTA as they use domestic sugar, and divert domestic sugarcane to ethanol production.

CHAPTER 1

Background

1.1 Introduction

The United States uses around 384 million gallons of gasoline each day and 140 billion gallons per year, while importing 60 percent of that usage from foreign oil. The need to decrease the United States' dependency on oil has pushed ethanol to the forefront of energy sources.

During the 2006 State of the Union Address, former President Bush announced his goal for replacing "more than 75% of our oil imports from the Middle East by 2025". According to the Department of Energy, meeting that goal will require 60 billion gallons of biofuel a year. A year later, the former President accelerated the timetable and called for "20 in 10" (Energy Future Coalition-United Nations Foundation, 2007).

Ethanol accounts for about 14% of corn use and about 3.5% of overall gasoline usage in the 2005/2006 harvest year (Office of Chief Economist–USDA, 2007). Corn-based ethanol production has been very profitable over the past few years, but the near doubling of corn prices in late 2006 and early 2007 has significantly reduced ethanol plant profitability (Outlaw, et. al., 2007). Other sources for ethanol production are becoming more viable, and cost-efficient.

In the United States, corn is used to make ethanol, but it is not the most efficient resource. President Barack Obama proclaimed at an August 17^{th} town hall,

> "The more we see the science, the more we want to find ways to diversify our biofuels so that we're not just reliant on corn-based ethanol. Now, we can do more to make corn-based ethanol more efficient than

it is, and that's where the research comes in."

(President Barack Obama, 2011)

Sugarcane ethanol is the most cost-effective biofuel available anywhere in the world. For every unit of fossil fuel used in its production, nine units of renewable energy are generated with a reduction of about 90% in greenhouse gas emissions when compared with gasoline (Reuters, 2008).

Brazil's ethanol yields as nearly eight times as much energy as corn-based options, according to scientific data (Rohter, 2006). They are the world's second largest producer of ethanol, and the most cost-efficient due to sugar, the resource that's abundant in their region.

The next few years will be vital to the stability of the ethanol market. With these changes in ethanol, there is a natural effect on the sugar industry. For the United States, it means increased competition for production, especially with the free trade agreements in that area.

1.2. United States Sugarcane Output

Sugarcane, a perennial tropical crop, is processed into raw sugar, molasses, and ethanol. It can be harvested 4 to 5 times before reseeding. In the United States, the government has supported sugar prices for more than 200 years. Through the US sugar policy, domestic sugar prices are controlled by the government, and foreign imports are severely limited; all to ensure that prices would be kept high and quotas kept low.

In the U.S., sugar is produced in twelve of the fifty states. By 2005, seven refineries and twenty-two mills process sugarcane in Florida, Hawaii, Louisiana, and Texas; as well as Puerto Rico (American Sugar Alliance, 2005). Louisiana accounts for more than 50% of the total US sugarcane production (USDA, 2003).

Sugarcane production has grown from an average of 27.7 million tons in the first half of the 1980s to about 32 million tons in the 2000s. Figure 1.1 shows the growth pattern for the southern states over the last 25 years. The largest growth has been in Louisiana, where production has more than doubled since the early 1980s. Growth in Florida and Texas has been strong as well. Area and yield growth have been instrumental in increasing sugarcane production. In Hawaii, on the other hand, high costs and better alternative uses for land have meant a reduction in sugarcane production from 8.8 million tons in the early 1980s to 2 million tons in the 2000s (Haley & Ali, 2007).

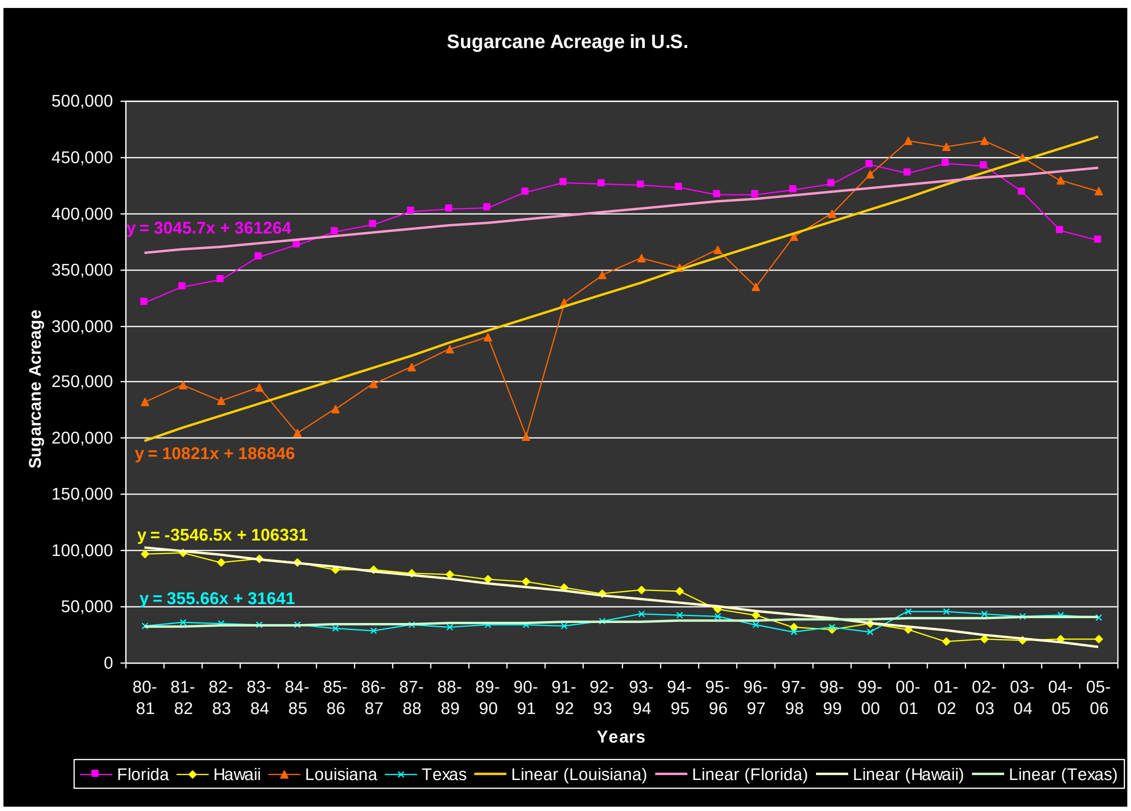

Figure 1.1

In the South, 836,000 acres of sugarcane was harvested during the 2005/2006 year, and Louisiana proved to be the powerhouse of sugarcane production. Since 2000, it has surpassed Florida in production, averaging 31,000 acres of sugar per year from 2000 - 2005.

In 2005/2006, Louisiana harvested 420,000 acres of sugarcane from 445,000 acres under cultivation. This acreage accounted for 49% of total U.S. harvested acreage (Shapouri, Salassi, & Fairbanks, 2006).

1.2.1. U.S. Sugar Protection Program. In 1789, the federal government imposed an import tariff to raise revenue, and for the next 100 years, the sugar tariff yielded almost 20% of all import duties. The following Acts have paved the way for a stable sugar market in the U.S.

The Sugar Act of 1934 regulated domestic sugar production, imports, and prices; and in the Agriculture and Food Act of 1981, the government agreed to purchase raw cane sugar and refined beet sugar for a specific price per pound if commercial prices were not high enough. Subsequent agricultural acts continued to provide price supports for sugar, keeping quotas low and prices high in the domestic market (Encyclopedia of American Industries, 2007).

In the 2002 Farm Bill, the Secretary of Agriculture was directed to operate the sugar program at no net cost to the US Treasury by avoiding sugar loan forfeitures in the non-recourse loan program (ASA, 2005). The non-recourse loan program allowed producers to pledge their sugar as collateral against a loan from the government at the price-support loan rate. Loans can be taken for up to 9 months, so processors can then pay growers for their sugar, typically about 60% of the loan. The program permits processors to store the sugar rather than sell it for lower-than-desired prices. When the sugar is sold, the loan is repaid (Haley, 1998).

In recent decades, the United States has imposed strict quotas on sugar imports, cutting imports by 80% since 1975. The tariff rate on sugar imports, in excess of the quota, was also high enough to discourage imports. This quota has created great controversy regarding U.S. trade with developing nations. More than 110 countries grow sugar cane or beets, and many of the developing nations have become more dependent on sugar as a source of employment and income. In the early 1990s, the U.S. imported less than 1.5 million tons of sugar to make up the difference between the sugar cane produced domestically and the approximately 9 million tons used (EAI, 2007).

A unique aspect of the program is that it is meant to operate at no-cost to the U.S. government. The USDA has the authority to limit imports in order for the price to be high enough to prevent forfeiture, thereby incurring program costs. Import control is an active part of the program because the world price of sugar is typically below the unit loan repayment amount. Total imports vary yearly to meet the price targets. Originally a quota system was used that allocated import shares to source countries on the basis of their averaged exports to the United States from 1975 – 1981, excluding high and low years. The quota system was replaced by the tariff-rate quota (TRQ) system that still allocates the shares today (Haley, 1998).

Under a TRQ, a certain amount of import access is provided at a lower, preferential tariff rate (in-quota tariff). For imports outside the TRQ, the (over-quota) tariff rate is much higher. In the case of sugar, the United States as part of the World Trade Organization's (WTO) Uruguay Round Agreement on Agriculture (URAA), committed itself to provide minimum access for 1.256 million short tons, raw value (STRV) by way of TRQs. The U.S. Trade Representative (USTR) has the responsibility to make any determination and announcement of country-specific sugar TRQ allocations. Current allocations of U.S. sugar imports under the WTO TRQs are made based on historic trade shares during the 1975-81 period when the United States had more or less unrestricted sugar import access (Haley & Ali, 2007). It specifies 16¢ a pound tariff on all over-quota shipments. This amount is sufficiently high to cap exports at the USDA-assigned levels (Haley, 1998).

The most recent Farm Bill, the *Food, Conservation, and Energy Act of 2008* has made some very serious additions to the former bills in regards to sugar. For the first time in over 20 years, the bill has raised the loan rate for sugar by a ¼ of a cent per year for three years. This takes the rate to 18.75 cents for cane sugar. The sugar industry is guaranteed a minimum of 85% of domestic market share.

1.2.2. Industrial Uses of U.S. Sugar. After 1985, domestic demand for sugar decreased because high fructose corn syrup (HFCS) replaced sugar in beverages (Haley & Ali, 2007). HFCS, which is made from corn, is a perfect substitute, a 1:1 ratio for liquid sugar, in the production of some edible products like beverages, soft drinks, and bakery goods. Industries that used sugar as a primary input were forced to find a sugar substitute because the U.S. Sugar Program increased domestic sugar prices (Marzoughi, Kennedy & Hilburn, 2008).

This trend may be heading in reverse due to the recent increase in HFCS prices. One of the main causes of the increase in HFCS prices is the demand change for corn. There has been a significant increase in corn demand due to an increase in ethanol production, which is also made from corn. HFCS production costs have increased making HFCS a less competitive alternative sweetener for sugar. This is especially evident if we note that sugar is a perfect substitute for HFCS, not vice versa. This means we can expect a higher demand for sugar in the U.S. (Marzoughi, et. al., 2008).

The increase in demand for ethanol has generated interest in using U.S. sugar crops as feedstock for producing the fuel. However, the costs of producing ethanol from various sugar crops, byproducts, and products vary widely (Haley & Ali, 2007). Of the various sugar crops and products, molasses is the most cost-competitive with corn, the USDA estimates. In 2007, the cost of producing 1 gallon of ethanol from molasses is estimated $1.27, which compares with

$1.03 for corn wet milling and $1.05 for corn dry milling. Single-gallon ethanol costs from the primary sugar crops are more than double the corn cost: $2.35 for sugar beets and $2.40 for sugarcane. The costs of using U.S. sugar products are even higher: $3.48 for raw cane sugar and $3.97 for refined sugar. Although high ethanol prices seen in 2006 imply that ethanol production from U.S. sugarcane and sugar beets could be profitable, these prices are expected eventually to drop when increased corn-based production from newly built factories begins (Haley & Ali, 2007).

1.2.3 U.S. Sugar Trade under Liberalization. Based on the neoclassical trade theory, free trade increases the social welfare of countries that are involved in trade. Removing trade barriers in the sugar market will have significant effects on the world sugar market. It reduces the consumer sugar price in countries that have been highly protected from imports, especially the United States as well as the European Union and Japan. It also increases the world sugar price up to 40% in favor of developing countries that have a comparative advantage in producing sugar. By removing the trade barriers, sugar production shifts from developed countries, typically not having a comparative advantage, to developing countries. This increases employment and income in the developing countries. It has been estimated that implementation of free trade in the sugar market creates a gain of as much as $4.7 billion per year for sugar exporting countries (Mitchell, 2004).

The United States and five Central American countries, Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua, began negotiations for a trade agreement, CAFTA, on January 27, 2003. Negotiations to fully integrate the Dominican Republic into CAFTA, forming CAFTA-DR, were concluded on March 15, 2004. All seven countries, as depicted in Figure 1.2, signed the trade agreement August, 2004. The role of CAFTA-DR is to reduce high tariff rates to levels that will allow a freer flow of goods and services with the U.S., and to lock-in the lower applied rates for many products to ensure permanent U.S. access to the market (Paggi, Kennedy, Yamazaki & Josling, 2005).

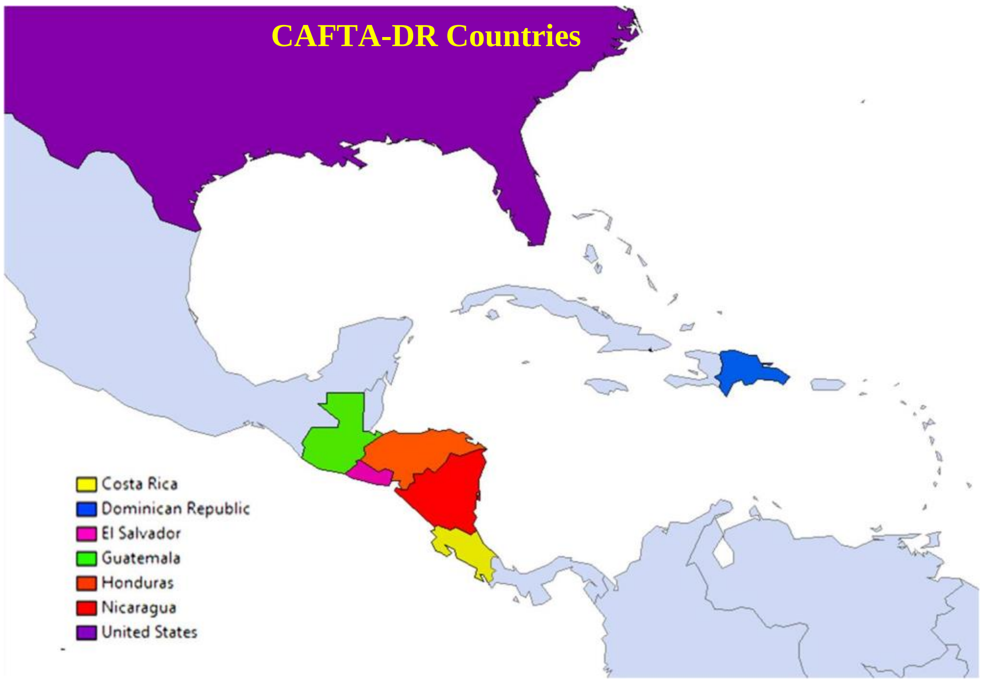

Figure 1.2

The United States is using this free trade agreement (FTA) to enhance economic development in these countries because they wish to pursue a more export-oriented economic development strategy.

CAFTA-DR defines detailed rules that would govern market access of goods, service trade, government procurement, intellectual property, investment, labor and environment. Agricultural trade barriers in the Central American countries are higher than those for manufactured goods. The average bound tariff rates on US agricultural products entering CAFTA-DR vary by country from 35% in Honduras to 60% in Nicaragua. Although the applied rates are lower, in the range of 11-13%, they are not permanent and can be increased to the bound level without consultation with trading partners (Paggi, et al. 2005). The key to the agricultural agreement is market access, with relatively few provisions in the areas of export subsidies and sanitary and phyto-sanitary regulations (Paggi, et al. 2005).

The Congressional Budget Office estimates that by providing additional import access guarantees in compliance with CAFTA-DR, the sugar program will likely cost an additional $500 million over the years 2006-2015. As with programs for most agriculture commodities, conditions in domestic and world markets are highly variable, making estimates of program costs for sugar somewhat uncertain. Actual costs could be either higher or lower in any given year, and these estimated costs represent the best estimate of expected costs over the estimated time period.

1.3. Ethanol

Ethanol is a clear, colorless ethyl alcohol fuel. It is made up of oxygen, hydrogen and carbon (CH_3CH_2OH). Ethanol is made from the sugars found in grains like corn, sorghum, and sugarcane to name a few. Corn is the most commonly used grain for production in the U.S. because a kernel of corn is approximately two-thirds starch, which manufactures depend on.

Ethanol has two production processes – wet milling and dry milling. Figure 1.3 and Figure 1.4 show these production processes. In the United States, most ethanol plants prefer the dry milling process instead of the wet milling process for a number of reasons. Ethanol is commonly mixed with gasoline in ranging percentages creating a transitional fuel to boost octane levels. E10 is 10% ethanol and 90% unleaded gasoline. Today, more than 75% of American’s gasoline contains some ethanol, most at an E10 blend (American Coalition for Ethanol, 2011). E85 is the most common mixture of ethanol to sell as a fuel by itself with 85% ethanol and 15%

gasoline. It is an alternative fuel for flexible fuel vehicles (FFVs). There are currently more than 8.5 million FFVs on America's roads today (ACE, 2011). For the United States, though, mostly E10 is used for the boosting of octane levels. Most of the gas stations across the nation use an E10 blend of gasoline, but there are many other low quantity mixtures in use. As the bio-energy industry continues to grow, the amount of a high level ethanol mix will continue to grow.

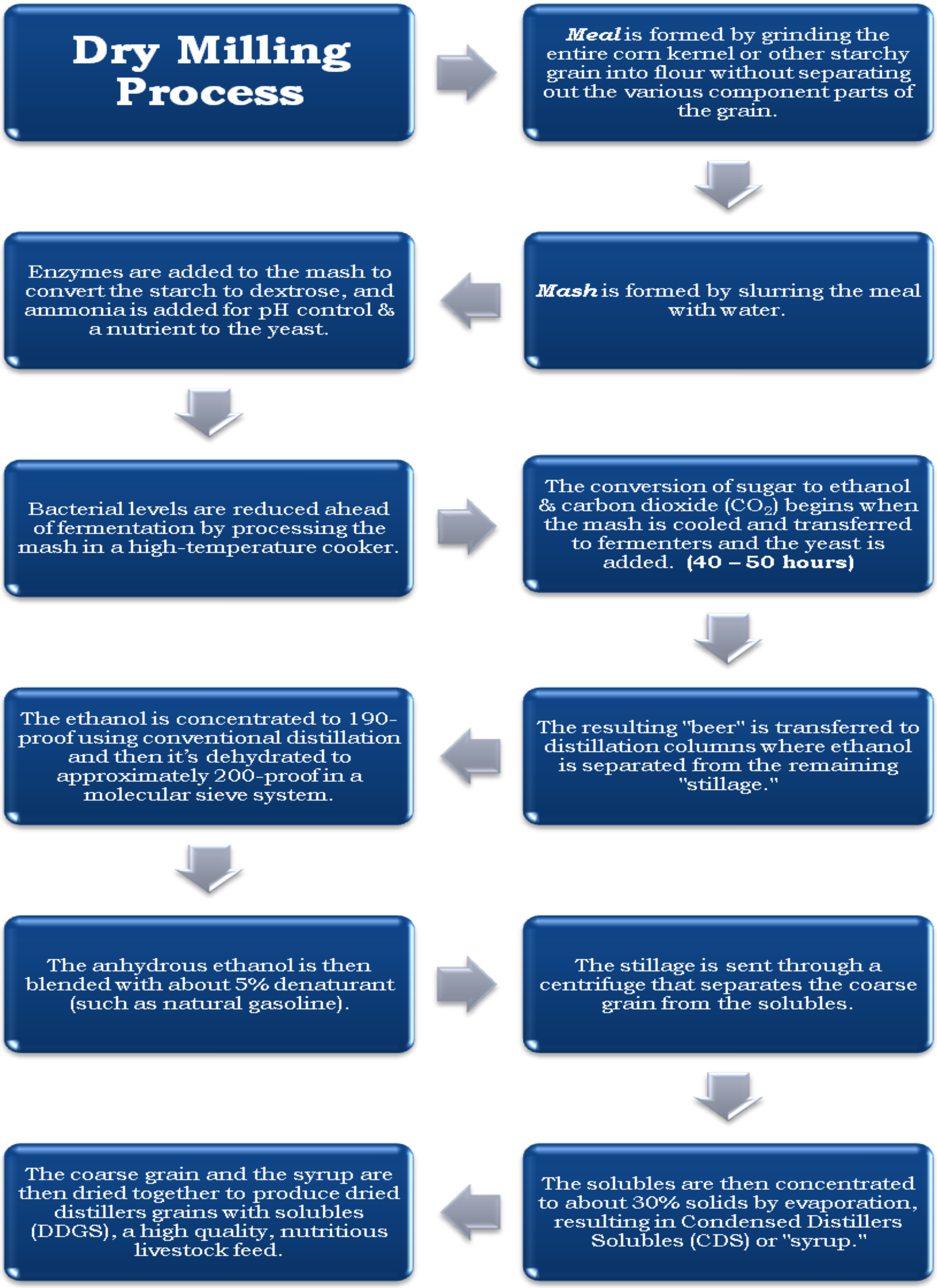
Dry Milling Process
Meal is formed by grinding the entire corn kernel or other starchy grain into flour without separating out the various component parts of the grain.
Mash is formed by slurring the meal with water.
Enzymes are added to the mash to convert the starch to dextrose, and ammonia is added for pH control & a nutrient to the yeast.
Bacterial levels are reduced ahead of fermentation by processing the mash in a high-temperature cooker.
The conversion of sugar to ethanol & carbon dioxide (CO_2) begins when the mash is cooled and transferred to fermenters and the yeast is added. (40 – 50 hours)
The resulting "beer" is transferred to distillation columns where ethanol is separated from the remaining "stillage."
The ethanol is concentrated to 190-proof using conventional distillation and then it's dehydrated to approximately 200-proof in a molecular sieve system.
The anhydrous ethanol is then blended with about 5% denaturant (such as natural gasoline).
The stillage is sent through a centrifuge that separates the coarse grain from the solubles.
The solubles are then concentrated to about 30% solids by evaporation, resulting in Condensed Distillers Solubles (CDS) or "syrup."
The coarse grain and the syrup are then dried together to produce dried distillers grains with solubles (DDGS), a high quality, nutritious livestock feed.

Figure 1.3

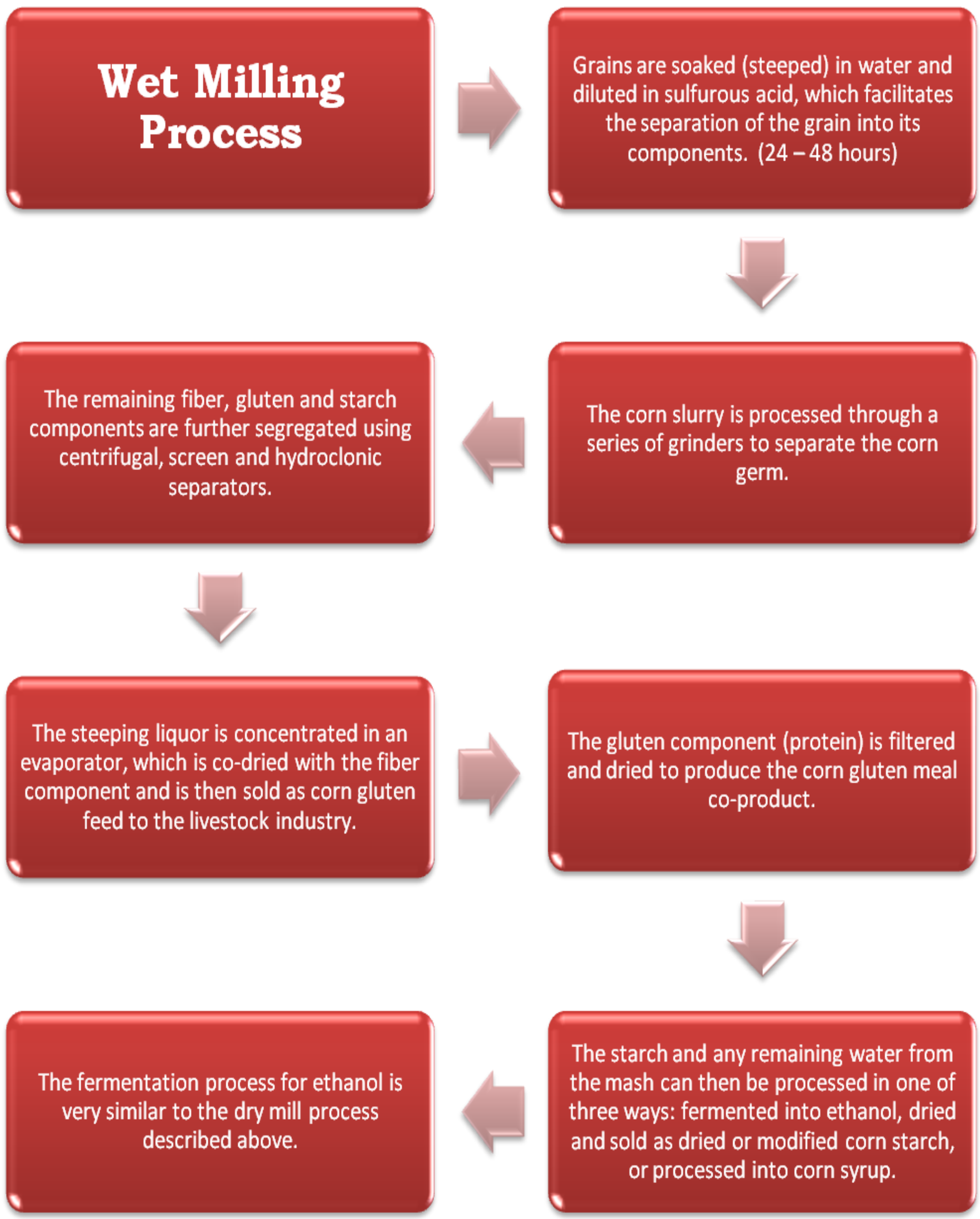
Wet Milling Process
Grains are soaked (steeped) in water and diluted in sulfurous acid, which facilitates the separation of the grain into its components. (24 – 48 hours)
The corn slurry is processed through a series of grinders to separate the corn germ.
The remaining fiber, gluten and starch components are further segregated using centrifugal, screen and hydroclonic separators.
The steeping liquor is concentrated in an evaporator, which is co-dried with the fiber component and is then sold as corn gluten feed to the livestock industry.
The gluten component (protein) is filtered and dried to produce the corn gluten meal co-product.
The starch and any remaining water from the mash can then be processed in one of three ways: fermented into ethanol, dried and sold as dried or modified corn starch, or processed into corn syrup.
The fermentation process for ethanol is very similar to the dry mill process described above.

Figure 1.4

1.3.1. Domestic Ethanol Industry. The demand for ethanol in the United States has been increasing due to high prices of petroleum-based fuels and reduction in the use of methyl tertiary butyl ether (MTBE), an oxygenating gasoline additive (Haley & Ali, 2007). The U.S. Environmental Protection Agency mandates the use of oxygenate blends in some states. With the phase out of MTBE, demand for ethanol is exactly inelastic up to the percentage of oxygenates required (Babcock, 2008). This increase in demand for ethanol has had a big influence on corn prices. Corn futures increased so much so that on December 21, 2007 closing bids for 2008 new crops was $4.63 per bushel (May, 2007).

The United States consumes about 140 billion gallons of gasoline a year. That's equivalent to 200 billion gallons of ethanol because of ethanol's lower energy content (84,400 btu/gal) than gasoline (124,000 btu/gal). According to EIA, one 42-gallon barrel of crude oil produces 18.4 gallons of gasoline, so it takes 1.46 gallons of ethanol to produce the same energy as a gallon of gasoline. In 2008, ethanol displaced 5.9 billion gallons of gasoline, which is roughly equivalent to five percent of the total U.S. crude oil imports. Replacing 25% of current U.S. gasoline use would require about 50 billion gallons of ethanol per year. It is clear that enough cellulosic biomass is available on an annual basis to produce that much fuel and much more in the future (EFC-UNF, 2007).

In 2005, the United States produced almost 4 billion gallons of ethanol, and in 2006, produced almost 5 billion gallons as shown in Figure 1.5. While this was a significant increase, further expansion in the industry is continuing with production expecting to exceed 10 billion gallons by 2009. In 2008, the U.S. produced over 9 billion gallons, so the projected target is in line. Even with less than full capacity utilization in the industry, ethanol production will grow to more than 12 billion gallons by 2015 in USDA's 2007 long-term projections, which are well above the renewable fuels standard mandated by the Energy Policy Act (Westcott, 2007).

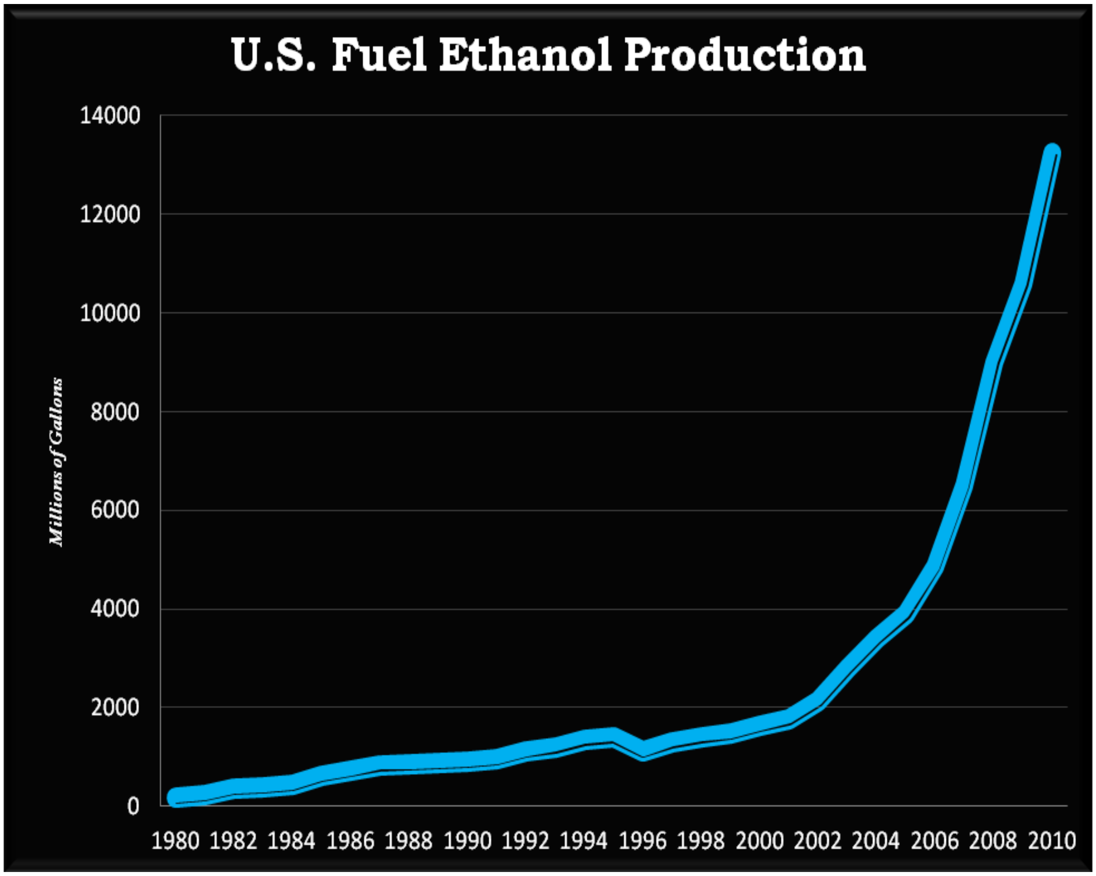

Figure 1.5

These increases in ethanol production are due in part by the government's help. The U.S. federal government has subsidized the production of ethanol at 51¢ per gallon up until 2009 and 45¢ per gallon, primarily, to promote the development of the ethanol industry. The trade policy for ethanol exercises a 54¢ per unit tariff per gallon and a 2.5% ad valorem tariff. According to Elobeid and Tokgoz (2008), U.S. trade barriers have been effective in protecting the ethanol industry and keeping domestic prices strong. There is also new legislation that has been proposed to create a different, higher subsidy for cellulosic ethanol.

Ethanol Producer magazine reported that in early 2007, there were 118 ethanol plants operating in the United States with 60 additional plants under construction (Outlaw, et. al., 2007). Of those 118, only one, Verenium, uses sugarcane, located in Jennings, Louisiana as shown in Figure 1.6.

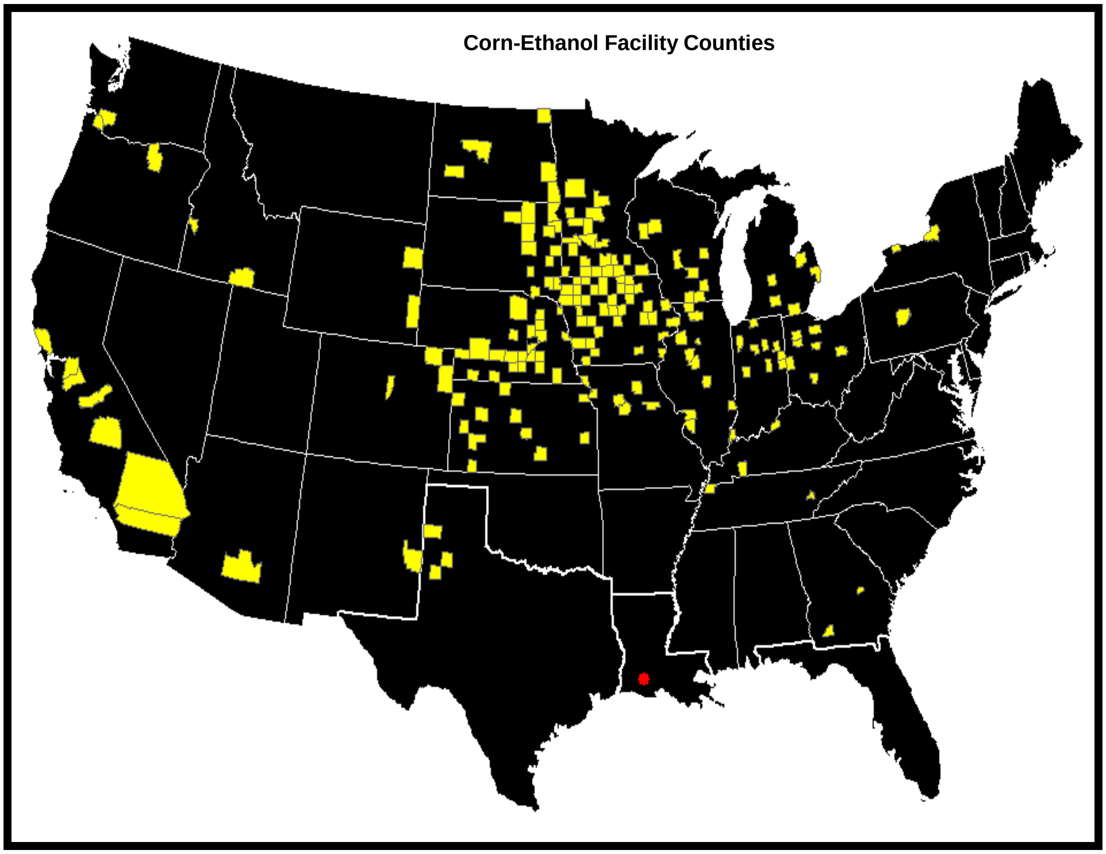

Figure 1.6

Figure 1.7 shows the steady rise in ethanol and gasoline prices in the United States. This increase in ethanol demand has increased corn prices, so much so, that it has generated the interest in using U.S. sugar crops as feedstock for producing the fuel, as well as other cellulosic materials including switch grass, bagassee, wheat, etc.

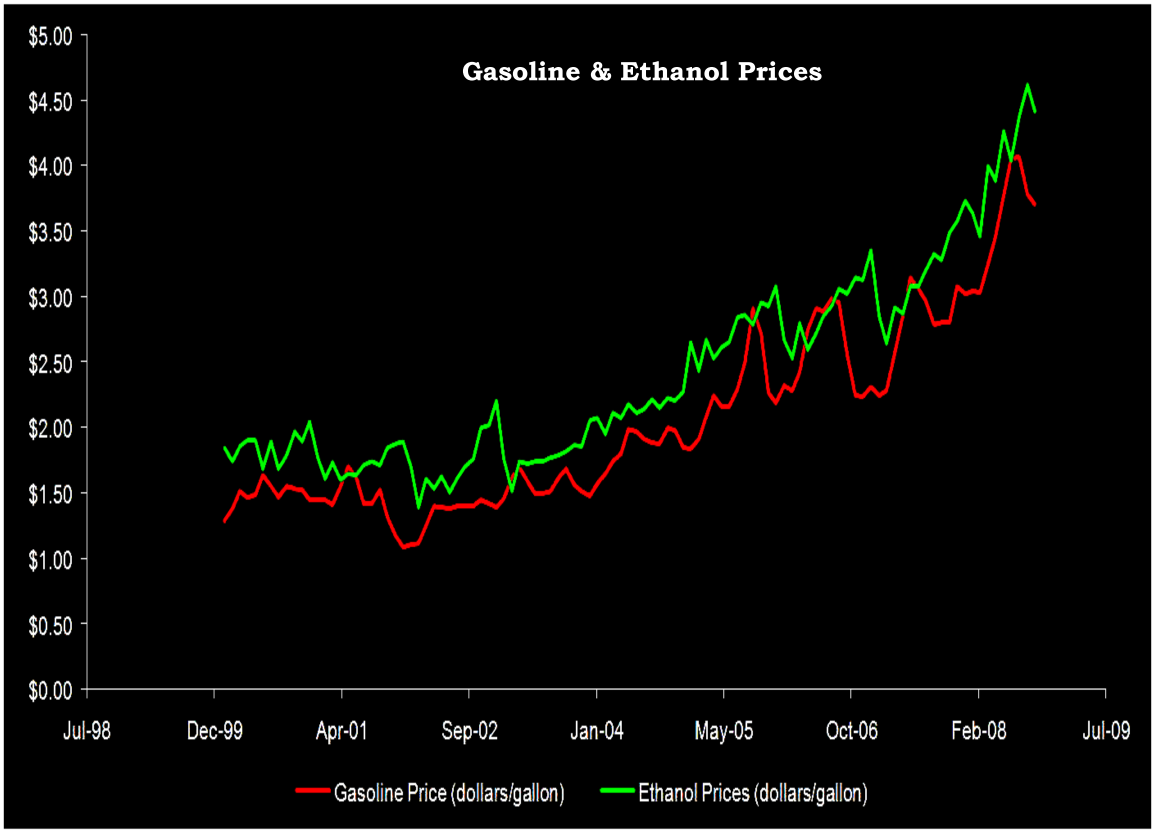

Figure 1.7

1.3.2 Ethanol and the Central American Free Trade Agreement. The United States has an opportunity to boost new industries in the CAFTA nations by emphasizing the importance of involving Central American and Caribbean countries in the ethanol equation. Jamaica, which was the first nation to sign a bilateral agreement with Venezuela under the PetroCaribe Pact, is also Brazil's leading choice as an intermediate destination for the refinement of ethanol destined for the United States (Cohen, 2007).

The ethanol industry in Central America and the Caribbean has extreme growth potential with low production costs and important sources of sugar cane (especially in Guatemala, one of the world's largest sugar producers). The geographical proximity of these countries to the U.S. and the tariff-free access to the U.S. market of up to 7% of U.S. ethanol production under CAFTA are also important factors in the industry's growth (Alexander & Torres, 2006). The Caribbean Basin Economic Recovery Act (CBERA) states that if ethanol is produced from at least 50% agricultural feedstock grown in a CBERA country, it is admitted into the U.S. free of duty (Elobeid & Tokgoz, 2008). The Renewable Fuels Association reported that under the Caribbean Basin Initiative, Jamaica, Costa Rica and El Salvador are the second, third, and fourth largest exporters of ethanol to the U.S., respectively.

CHAPTER 2

Problem Statement

The U.S. government set an alternative fuels mandate of 35 billion gallons by 2017. In the U.S., corn, a feed crop, is the main resource being used to make ethanol. It has done extremely well at inception, but corn cannot reach the alternative fuel mandate itself. In order to meet this challenge, the United States has begun to focus on other raw inputs for ethanol production like sugarcane. The U.S. does not produce enough sugarcane to produce sugarcane-ethanol that is economically feasible; therefore, during the transition period, the United States has to increase sugarcane imports to augment the current corn production. So, can imported sugarcane under CAFTA-DR increase domestic ethanol production?

The six countries of the Central American Free Trade Agreement with the United States have the capacity to help solve this alternative fuels shortage problem. With respect to Agriculture, the general objective of CAFTA-DR is the eventual removal of all barriers to trade (tariff and non-tariff) on all commodities (Yeboah, Shaik, Allen & Ofori-Boadu, 2007).

Implementation of CAFTA-DR has allowed an immediate expansion of the sugar and sugar-containing product imports into the United States from CAFTA-DR partners. Figure 2.1 shows the percentage of sugarcane imported into the United States from CAFTA countries, Latin American countries, and the Rest of the World (ROW).

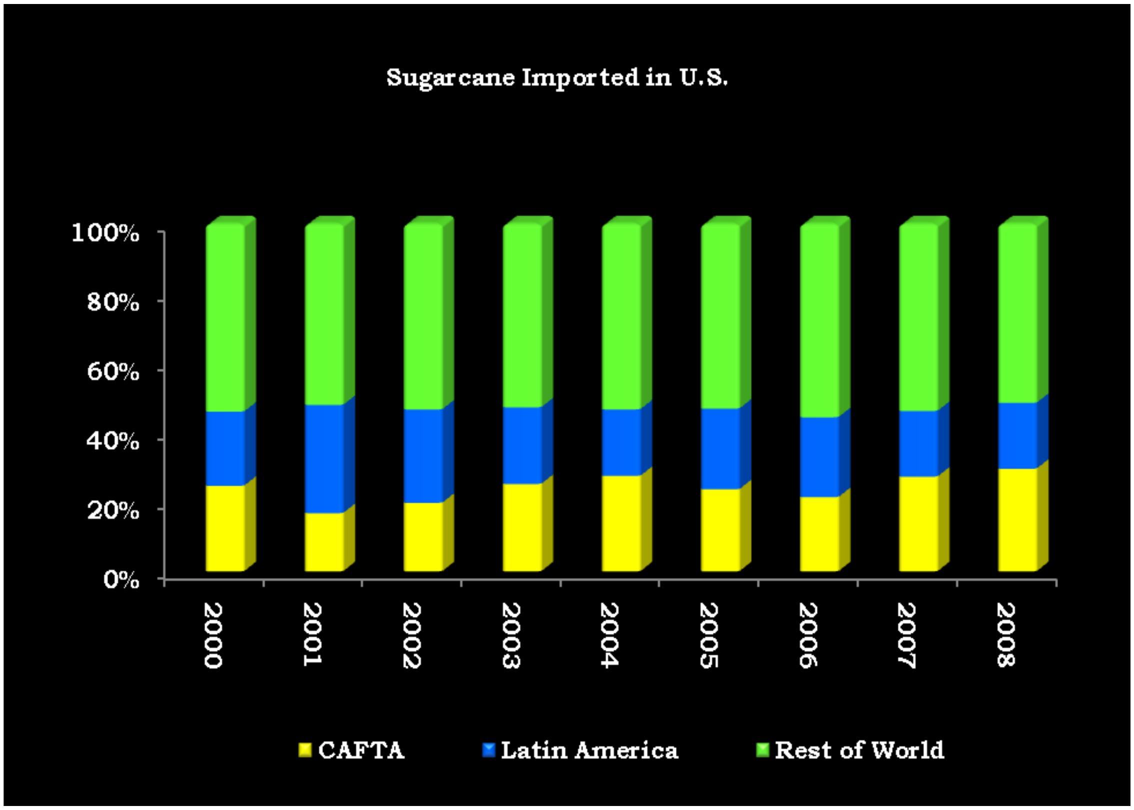

Figure 2.1

The increase in sugarcane imports is in addition to their current access to the US sugar market (United States International Trade Commision, 2004). CAFTA-DR countries already export 311,700 metric tons of sugar each year to the U. S. under tariff rate quotas. In the CAFTA-DR's first year, these countries have exported up to an additional 109,000 metric tons. By the 15th year of the agreement, the countries may export up to an additional 153,140 metric tons. The additional market access is limited to either the specified amount or the net trade surplus for each country; whichever is smaller (USITC, 2004). This additional access is less than 1% of total U.S. sugar supplies. Under the agreement, CAFTA-DR countries will never have unlimited access to the U.S. market because they will always be subject to an import quota (Kennedy & Roule, 2004).

The United States is able to use certain price-based safeguard measures against sugar and sugar-containing product imports from other suppliers, but the CAFTA-DR agreement does not allow the United States to use these measures against its CAFTA-DR partner countries (USITC, 2004). An increase in sugar imports will cause a downward pressure on domestic prices in the absence of government intervention. When the government does intervene, as it currently does through the use of a non-recourse loans, increased imports will increase the cost of maintaining the sugar program. As the US sugar industry faces increased pressure from the world market, the government faces the dilemma of how it can continue to support the sugar industry in light of the increased expense (Paggi, et al. 2005).

Over the past 200 years, the U.S. government has been protecting sugar prices. These domestic prices have been government controlled, and foreign imports have been severely limited through the U.S. sugar policy. The *Food, Conservation, and Energy Act of 2008* established a sugar-to-ethanol program which would provide sugar to biofuel producers at competitive prices. Its only drawback is that it's allowed only during times of excess sugar supply. The program mandates the Secretary of Agriculture to pull enough sugar off the market to keep the price of sugar above the loan rate and the U.S. sugar program, as a whole, balanced (Ebert, 2007). This study explores the effects sugar imports will have on the developing U.S. ethanol market.

2.1. Objectives

The objectives of this study are three-fold; (1) provide a description of the spatial distribution of domestic ethanol plants and their capacities, (2) econometrically determine how the imports of sugarcane from the CAFTA-DR countries in combination with domestic gasoline prices, domestic ethanol prices, and domestic corn prices have on the domestic ethanol market, and (3) provide policy recommendations for the domestic ethanol market.

CHAPTER 3

Descriptive Analysis of Spatial Distribution of

Ethanol Plants in the U.S.

According to the American Coalition for Ethanol and the Renewable Fuels Association, as of July 2009, there were 213 ethanol facilities in the United States either operating or under construction. Currently, there are 220 ethanol facilities. Out of the 220 facilities, 207 are corn to ethanol plants, making up 94.1% of the industry. These plants are located in 30 states with Iowa operating 40 plants and 2 under construction. Nebraska has 24 operating plants, and Minnesota has 21. Figure 3.1 shows the states with ethanol plants currently operating in yellow and the states with facilities under construction with black triangles. Almost all of the ethanol facilities are located near corn mills, or their respective resource.

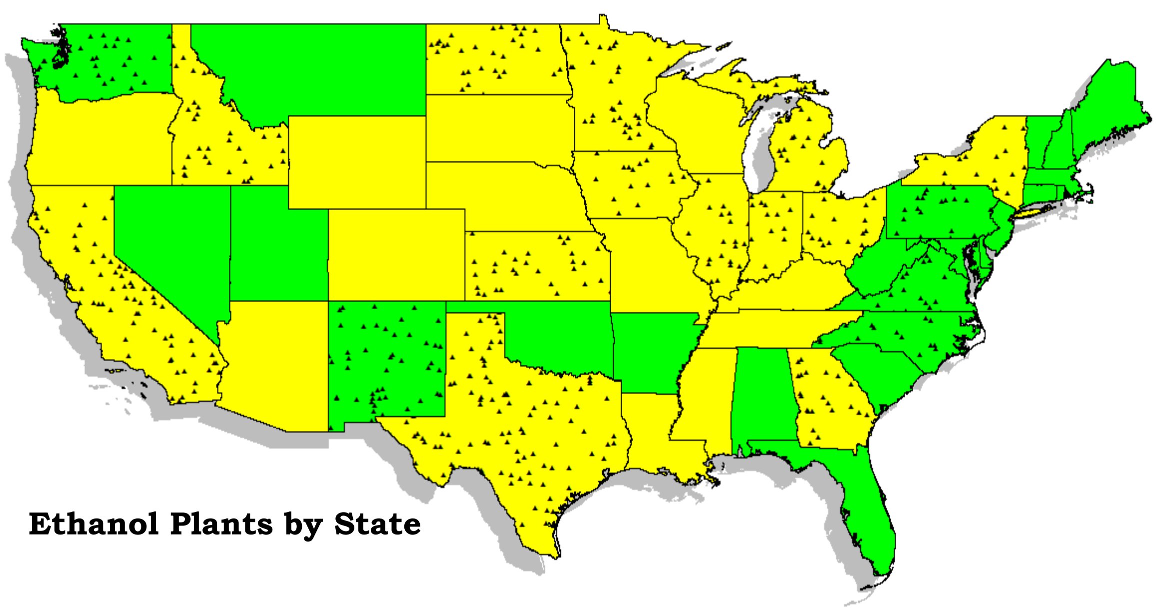

Figure 3.1

Figure 3.2 shows the number of ethanol plants operating per state. The top three corn-ethanol plants are Renew Energy with 130mgy operating capacity in Wisconsin, and tied for second place, Hawkeye Renewables, LLC in Iowa and Valero Renewable Fuels in South Dakota both at 120mgy operating capacity. Although these plants have large outputs, Archer Daniels Midland operates at 1,070mgy total, averaging 133.75mgy among eight ethanol plants in six states.

Number of Ethanol Plants by State

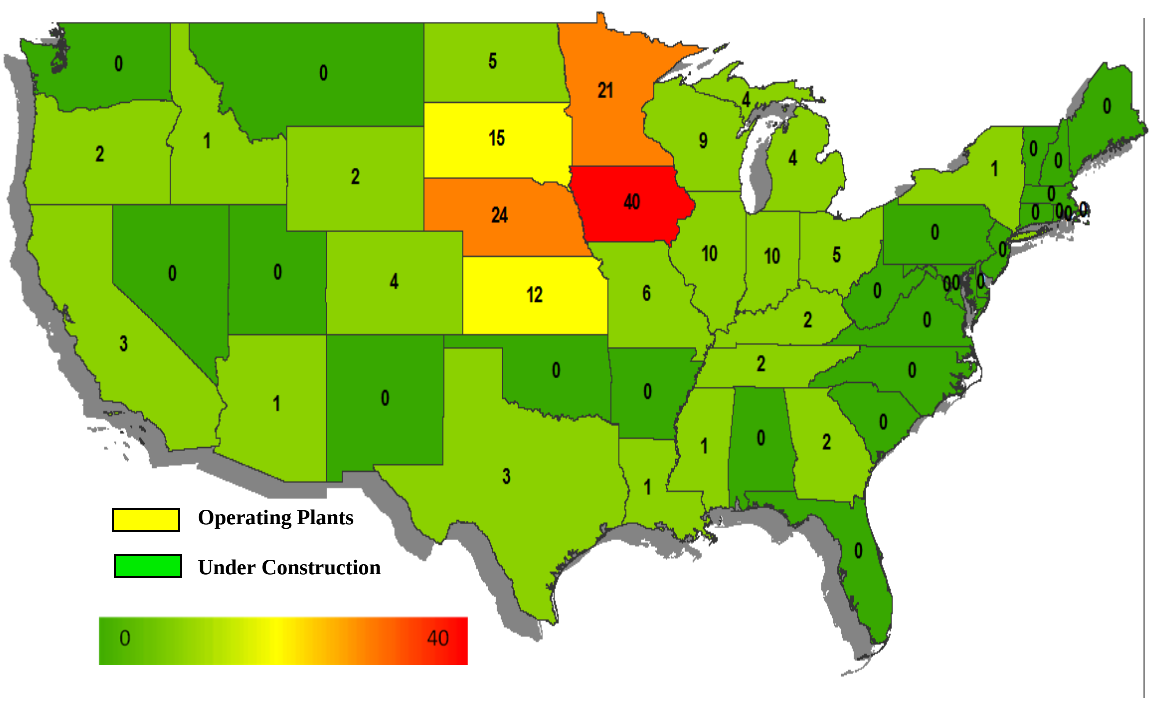

Figure 3.2

CHAPTER 4

Literature Review

There have been some studies that have shown the economic effects of ethanol production on corn and sugar prices in the United States. Most of them were undertaken within the last several years due to ethanol's increased popularity. North Dakota State University's "Ethanol's Impact on the U.S. Corn Industry" (2006) used a simulation model to develop their estimates on changes in ethanol production and those impacts on prices of corn.

Marzoughi, Kennedy, and Hilbun (2008) just recently looked at the "Impact of Corn Based Ethanol Production on the U.S. High Fructose Corn Syrup (HFCS) and Sugar Markets". They found that ethanol production increased corn prices and demand, as well as increased the demand for sugar.

Du (2008) quantified the impact of monthly ethanol production on monthly retail gasoline prices by using pooled regional time-series data and panel data estimation. The analysis proved that there was a negative impact of ethanol on gasoline prices, but how much of an impact varied from one region of the U.S. to the next.

Both Shapouri et. al. (2006) and Bryan and Bryan International (2003) used average prices and production to determine break-even costs of sugarcane to ethanol production. These two studies are among the few that have been completed looking directly at sugarcane to ethanol production in the U.S.

Tatsuji Koizumi (2003) used a world sugar and ethanol production model to analyze how an ethanol, energy or environmental policy in major producing countries will affect the world sugar markets. By using a partial equilibrium model, the paper concluded that world ethanol and sugar prices would increase, but world sugar exports would remain relatively stable due to the increase in raw sugar trade prices benefitting sugar exporting countries.

In Don Hofstrand's publication in the AgMRC Renewable Energy Newsletter (2008), states several reasons why sugarcane is better than corn including: (1) sugar can be converted directly to ethanol unlike corn that has to be converted to a starch first; (2) sugarcane is planted every six years with five cuttings before reseeding, while corn is planted every year; (3) sugarcane yields about 35 tons per acre (entire plant) per harvest acre compared to a mere 8.4 tons with corn; (4) an acre of sugarcane produces about 560 gallons of ethanol compared to 420 with corn; (5) sugarcane's byproduct, bagasse, is used as an energy source for ethanol production, where corn's byproduct is distillers grains with soluble as feedstock, and it uses natural gas, coal and diesel for ethanol production; and (6) about 9 million acres are used for sugarcane-ethanol production in Brazil, while the U.S. uses about 28 million acres for corn.

The paper, "*Refining sweet sorghum to ethanol and sugar: economic trade-offs in the context of North China"* (2005), examines making ethanol from the sugar extracted from the juice of sweet sorghum. It concludes that a flexible plant capable of making both sugar and fuel-ethanol from the juice is recommended. This conclusion coincides with) Jacobs's (2006) conclusion that if ethanol is to be produced from sugar in the United States, the facilities must be located at existing sugarcane plants because of transit cost limitations.

Outlaw et. al.' (2007) determined whether or not it was feasible to integrate ethanol production into an existing sugar mill that uses sugarcane juice as a feedstock for ethanol production. They used a stochastic spreadsheet model to determine that existing U.S. sugar mills could add the necessary equipment they needed to produce ethanol with a successful outcome.

Babcock (2008) estimated the magnitude of welfare changes by using corn to supply a significant portion of fuel supply. He created a new model of the U.S. ethanol industry by combining a detailed, reality-based supply and demand curves of Tokgoz et al. (2007) approach that uses a multi-country system of integrated crop and livestock models to analyze the impacts of different policy scenarios and supply and demand conditions in the U.S. ethanol industry; and the transparency of Gardner's (2007) approach.

This study takes a different approach to the ethanol industry by using a multiple regression model to look at a possible substitute for the production input and how that substitute will affect the domestic ethanol market.

CHAPTER 5

Econometric Modeling

5.1 The Model

In this study, we estimate the domestic ethanol supply equation using the Armington (1969) model. Ethanol supply was modeled as a function of domestic gasoline prices, domestic ethanol prices, and the relative ratio of domestic corn prices to imported sugarcane prices, where all variables are real. For easy derivation of elasticities and interpretation of the estimated parameters, we log-transform all data

Q_E	→	Ethanol Production Volume
G_P	→	Gasoline Prices
E_P	→	Ethanol Prices
C/S_P	→	Corn Prices / Sugarcane Prices

The Armington assumption is the most popular specification used in applied global models of trade, which differentiates products by country of origin (Jomini, et.al, 2009). To avoid unrealistic specialization in trade liberalization scenarios and to facilitate the use of international trade statistics, the Armington model was developed.

Paul Armington (1969) stated the assumption that final goods internationally traded are differentiated on the basis of the country of origin. He assumed that each industry produces only one product, in any one country. That product is distinct from the product of the same industry in another country. The assumption of one consumer for each country was used out of simplicity, and that consumer views the products of one industry that originates in different countries as a group of close substitutes. The standard neoclassical assumptions of perfect competition in all industries and constant returns to scale address the supply side (Lloyd & Zhang, 2006).

Armington's model was built into single- and multi-country computable general equilibrium (CGE) models to study trade policy after CGE models was introduced in the early 1970s (Lloyd & Zhang, 2006).

The Armington model is consistent with the appearance in trade statistics that a country imports and exports the same goods, which cannot be explained by traditional trade models with homogeneous goods. A country appears to be importing and exporting the same aggregate products because trade statistics consist of aggregations of detailed product flows (Jomini, Zhang, & Osborne, 2009). The Armington assumption of product differentiation and imperfect substitution makes existing trade statistics immediately usable for global trade models (Lloyd & Zhang, 2006).

The degree of substitutability between domestic and imported sources of supply or the degree to which they are differentiated is captured by the Armington elasticity. The more the value of this parameter increases, the closer the degree of substitution (Kapuscinski & Warr, 1996). According to Huchet-Bourdon & Pishbahar (2008), the constant elasticity of substitution to maximize utility subject to the budget constraint is formed by the following equation by Armington (1969) as:

$$\textbf{Max} \quad U = \left[\sum_{i=1}^{m} b_i q_i^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \qquad (i = 1, \ldots, m) \tag{1}$$

$$\text{S.t.:} \; E = \sum_{i=1}^{m} p_i q_i \qquad (\sigma \neq 1, \quad \textstyle\sum_i b_i = 1, \quad b_i \in [0,1] \forall i) \tag{2}$$

where, *U* is the utility, *b* is the weighted parameter for the commodity, q_i is the quantity of imports from source $_i$, □ is the elasticity of substitution between import sources, *E* is the total expenditure on imports, and p_i is the price of commodity imported from source $_i$. The demand function for q_i is formed from the maximization of equation (1) subject to equation (2) as:

$$q_i = \left(\frac{1}{p_i} \right) b_i^{\sigma} \left(\frac{p_i}{P} \right)^{1-\sigma} E \tag{3}$$

$$\text{With } P = \sum_i \left(b_i^{\sigma} \; p_i^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{4}$$

Therefore, we can calculate the elasticity of substitution between the sources by writing equation (3) in logarithmic form:

$$\ln(p_i . q_i) = \sigma \ln(b_i) + (1-\sigma) \ln\left(\frac{p_i}{P} \right) \tag{5}$$

where the Armington model was used to derive the demand of the import variable resulting in the final equation:

$$Q_E = f(G_P, E_P, C/S_P) \tag{6}$$

5.2. Data & Estimation Procedures

The multiple regression model is applied to U.S. monthly data of prices from January 2000 to September 2008. The dependent variable, the quantity of ethanol produced, was regressed on domestic gasoline prices in gallons, G_P, domestic ethanol prices in gallons, E_P, and the relative ratio of domestic corn prices to imported sugarcane prices from CAFTA-DR countries in USD per bushel per kilogram, C/S_P, using the Statistical Package of the Social Sciences (SPSS) version 16 software.

To examine the validity of the multiple regression model with respects to ethanol production in the United States from January 2000 to September 2008, monthly, equation (1) is estimated using SPSS 16. Table 6.2 presents the results of the estimated coefficients and other significant statistics for the estimated equation (7):

$$Q_E = 1.394 + 0.0241G_P + 0.0372E_P – 0.0199C/SC_P \quad (7)$$

Data was collected from the following sources:

- *Domestic ethanol production*
  - United States' Department of Energy's (DOE) Energy Information Association (EIA) at (http://www.eia.doe.gov)
- *Domestic gasoline prices*
  - United States' Department of Energy's (DOE) Energy Information Association (EIA) at (http://www.eia.doe.gov).
- *Domestic ethanol prices*
  - United States Department of Energy's Energy Efficiency and Renewable Energy at (http://www.eia.gov)
- *Domestic corn prices*
  - United States Department of Agriculture's (USDA) National Agricultural Statistical Service (NASS) at (http://www.nass.usda.gov)
- *Imported sugarcane prices*
  - Weighted average prices
  - United States International Trade Commission's Interactive Tariff and Trade Data Web at (http//dataweb.usitc.gov)

CHAPTER 6

Results and Discussions

The descriptive statistics of the variables are provided in Table 6.1. The average domestic ethanol production per month is 1,181,988 gallons, but production can be as low as 1,132,771 gallons or as high as 1,231,351 gallons of ethanol. The gasoline and ethanol prices can be as low $1.09 per gallon and $1.39 per gallon, respectively, and as high as $4.06 per gallon and $4.62 per gallon, respectively. The average monthly domestic gasoline price is $2.05, and the average monthly domestic ethanol price is $2.41. The relative ratio prices of domestic corn prices to imported sugarcane prices can be as low as $3.78 per kilogram/bushel and as high as $20.59 per kilogram/bushel.

Table 6.1

Descriptive Statistics of Variables

(N = 105)					
Variable	***Units***	***Mean***	***Standard Error***	***Min***	***Max***
Ethanol Production	***Gallons***	***1,181,988***	***2,818***	***1,132,771***	***1,231,351***
Gasoline Prices	***Dollars/ Gallon***	***$2.05***	***0.071***	***$1.09***	***$4.06***
Ethanol Prices	***Dollars/ Gallon***	***$2.41***	***0.075***	***$1.39***	***$4.62***
Corn / Sugarcane Prices	***Dollars per Kilogram/ Bushel***	***$0.36***	***0.352***	***$3.78***	***$20.59***

The F statistic is significant at ($p < 7.2323E-266$) with R^2 of 0.88. All variables are also significant at the 1% level. The coefficients of gasoline and ethanol prices are positive as expected and statistically significant at ($p < 0.0014$) and ($p < 0$), respectively. The elasticity of 0.0241 for gasoline implies a 1 percent increase in domestic gasoline price will increase ethanol production by about 0.024 percent. This may indicate an inelastic response of ethanol to gasoline prices but the fact the U.S. consumes 140 billion gallons per year implies a lot of savings from imported gasoline. The own price is however, more elastic. This means it will be very difficult to move all the corn for feed and other usages, and divert them to ethanol production. The own price elasticity of 0.0372 for ethanol implies a 1 percent increase in domestic ethanol prices will increase domestic ethanol production by about 0.037 percent.

Table 6.2

Results of Multiple Regression

Unit	**Elasticity**	**Standard Error**	**P-value**
Gasoline Price (dollars/gallon)	0.0241	0.0073	0.0014
Ethanol Prices (dollars/gallon)	0.0372	0.0078	0.0000
Corn/Sugarcane (Dollars per kilogram/bushel)	-0.0199	0.0040	0.0000
Intercept	1.3935	0.0034	0.0000
$R^2 = 0.88$			

The coefficient of the ratio of domestic corn prices to imported sugarcane prices from the CAFTA-DR countries is positive and statistically significant at ($p < 0$). The elasticity of this price ratio of 0.0199 implies a 1 percent increase in domestic ethanol production will increase the relative price of corn to sugarcane or the domestic input to the imported input by about 0.0199 percent. This result is consistent with literature. Ethanol prices move in the same direction.

CHAPTER 7

Conclusions & Policy Recommendations

The theory of supply teaches that when the price of a good increases, the quantity of that good offered will increase as long as all other factors remain unchanged. Ethanol producers have increased ethanol production over the past few years in response to the renewable fuels mandates. This increase in ethanol production can be said to be based off of the prices of gasoline, ethanol, sugarcane and corn.

7.1 Current Industry Highlights

There have been some recent closings of ethanol facilities because of high prices, and the collapse of the financial market which made access to operating credit and capital for expansion and new construction virtually unobtainable. Despite these closings, the U.S. ethanol industry is still operating at about 85% of capacity (RFA, 2009). At the end of 2008, the ethanol industry had 172 operating plants including several inputs other than corn, as well as operating 25 states holding a production capacity of 10.6 billion gallons of ethanol (RFA, 2009). In 2009, 14 more ethanol facilities went operational making it 186 operating plants in the United States. With President Obama's push for further advancement in the biofuels industry, it will be no surprise that these numbers will continue to rise as the 27 ethanol facilities currently under construction have yet to make their way on line.

7.2 Policy Recommendations

The results of the study indicate that all of the independent variables (domestic gasoline prices, domestic ethanol prices, and the relative ratio of imported sugarcane prices to domestic corn prices) have a positive effect on ethanol production.

With this information, the U.S. ethanol industry should pursue researching into alternative inputs and resources used in ethanol production. Having diverse and alternative sources inputs will help decrease peaking corn prices, and it will also increase competition in the ethanol industry, which helps to keep ethanol prices stable. A complete saturation of the market by different means or production will keep costs down for processors, and in turn, the end consumer.

Sugarcane farmers in the South take advantage of their industry being protected by the government and incorporate ethanol-producing equipment at their sugar production facilities. As noted in the literature review, Gnansounou et. al., Jacobs, and Outlaw et. al. stated that ethanol production equipment could be successfully integrated into existing sugar mills making them flexible in production and capable of producing both sugar and ethanol. Figure 7.1 shows how many sugar mills are in each state. Out of the 26 sugar mills, Louisiana has 12 mills and 4 cooperatives, Florida has 6 mills and 1 cooperative, Hawaii has 2 mills, and Texas has 1 cooperative.

Leading the Agricultural Research Service (ARS) Sugarcane Research, Edward Richard estimates that an acre of sugarcane could yield nearly 1,240 gallons of ethanol using both the sugar and fiber from their new sugarcane varieties. These new "energy sugarcane" varieties with high stalk contents of sugar and fiber were released in April 2007. If the continued research holds to be true, then the sugarcane industry could make up at least 6% of the total U.S. production of ethanol by diverting only half the acreage used for sugar production. Six percent may not be a lot; but with other resources being used in the ethanol production process, it will dilute the costs of production for all producers and reduce prices for the end consumer.

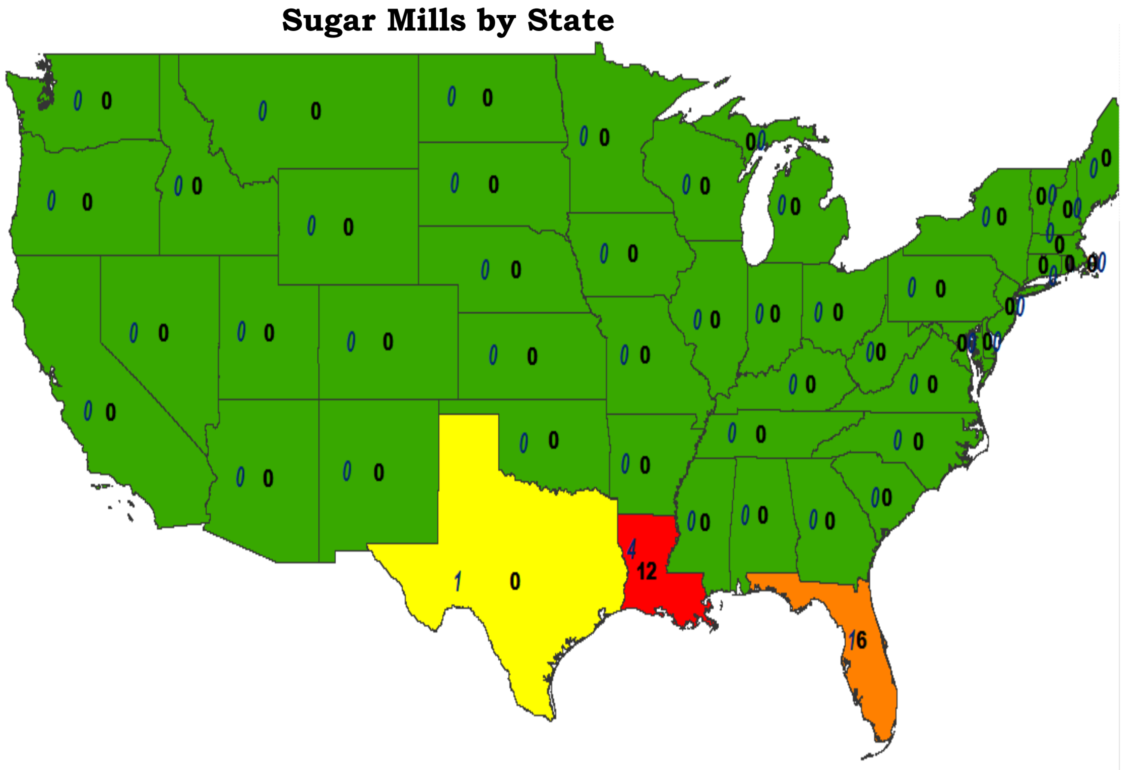

Figure 7.1

For the sugar industry as a whole, they should take the possible opportunity that awaits them with the CAFTA agreement. The increase in the amount of sugar imported can supplement the diversion of sugarcane to ethanol. This way, the ethanol industry gets the boost it needs, and the sugar industry can remain relatively stable.

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