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Structural Shifts in Agricultural Markets Caused by Government Mandates: Ethanol and the Renewable Fuels Standard

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STRUCTURAL SHIFTS IN AGRICULTURAL MARKETS CAUSED BY GOVERNMENT MANDATES: ETHANOL AND THE RENEWABLE FUELS STANDARD

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Signed,

John Christian Olson
Dated April 27, 2009

Abstract

For many decades, demand for agricultural commodities has remained stagnant and its growth has been limited. In contrast, agricultural production continues to become ever more efficient by increasing output for stable or decreased inputs. Long-run profits have historically been near zero due to an ongoing relative equilibrium. But recent U.S. energy policy has changed to include a Renewable Fuels Standard (RFS), the goal of which is to boost domestic energy independence in an environmentally sound way. Most of the RFS in the near-term relies on the production of 15 billion gallons of ethanol made from corn. This has the effect of creating a new sector of demand for grain corn and subsequently supports rural economies.

The RFS creates a new demand for 5.5 billion bushels of corn by 2015. At the corn-ethanol conversion ratio of 2.7 gallons per bushel, this will sustain the production of 15 billion gallons of ethanol. The RFS is a blending floor imposed on gasoline refiners. Ethanol producers, on the other hand, are not forced to supply ethanol. While the Environmental Protection Agency (EPA) has the authority to implement the RFS, it does not have the ability to expand ethanol supplies. The U.S. government has therefore supported the use of ethanol through a current 45 cent tax credit for each gallon of ethanol blended into gasoline. Other financial support programs such as grants and loan guarantees are in place for ethanol refiners.

Ethanol in the U.S.is primarily made from the starchy molecules in corn. One bushel of corn in a dry mill ethanol plant will produce approximately 2.7 gallons of ethanol and 17 pounds of dried distillers grains with solubles (DDGS) which can be used

in livestock rations. A wet mill plant will produce other by-products. Ethanol can be used directly in the nation's fuel supply at limited levels of blending. Most cars in the United States can withstand the corrosive nature of ethanol in blends of up to 10% or more. But flex-fuel vehicles, which are able to operate on 85% ethanol are increasingly becoming available for sale and their use continues to grow.

Corn ethanol is a very complex issue when implemented on such a large scale as the RFS dictates. The amount of transportation fuel actually displaced by its use is a hotly debated topic. In any case, the large scale production of corn ethanol has created a firm link between agricultural markets and the energy sector. Ethanol is also an environmental issue. One of the primary goals of the RFS is to combat global warming and whether or not this is achieved it currently in debate. Aside from the climate change issue, there are other environmental ramifications tied directly to ethanol such as contamination, water use and land-use change.

Since the inception of the RFS, price volatility and uncertainty has never been greater. In the first half of 2008, prices for all commodities reached historically high levels. This raises the concern of the impacts with the RFS has on markets other than corn. The livestock industry and other grain markets have been affected to some degree by the RFS. This is in part due to the changing profile of the major trading participants in the commodity trading centers.

All of this is related to a structural change which has taken place in the agricultural markets as a result of the RFS. Historical relationships between price, supply and demand have adjusted and currently continue to adjust. The reasons for the adjustments are founded in economic theory regarding system-wide demand shocks. In this case, the demand shock is roughly a net 50% increase in the demand for corn by 2015 compared to the most recent decade. The adjustments which take place can be summarized by three periods. In period 1, the demand curve shifts outward, equilibrium is lost and higher corn prices are observed. In period 2, the market struggles to find a new equilibrium by increasing output. This period is marked by increased volatility and market participants over and under react to price signals until the new equilibrium is discovered. Period three is represented by the discovery of a relative market equilibrium at price higher than previously, but not as high as the initial demand shock.

Results from, a fundamental analysis of the grain markets show that the expected market behavior has begun to take place and agriculture finds itself in period 2 of the changes described above. While most of the price changes and acreage shifts can be explained, the degree to which prices have increased are not fully explained. A change in trading center activities (Boards of Trade, etc.) may help to further account for the new prices. A survey of brokers shows that the behavior of commercial traders has significantly changed since RFS implementation. Volatility and uncertainty have ensued.

The consequences of the RFS to the farmer have also been significant. Farm income has increased significantly sufficiently to overcome the riding costs of fuel and fertilizer. The risk exposure of farmers has also changed; the data indicates that exposure to risk has increased greatly. However, the farm gate prices have been more than enough to compensate for the changes in risk.

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Chapter 1 - Introduction

When governments intervene in the market place, there are almost always unforeseen and unintended consequences. The unintended consequences from minor intervention into a specific commodity market may be contained within that commodity market. However, when the intervention fundamentally alters the supply of or demand for a commodity, the unforeseen and unintended consequence may not only be observed within that commodity but may also be present in a number of other closely related commodity markets, and in some cases may even spill over into other somewhat unrelated markets. The overall objective of this thesis is to examine the economic consequences of a major government intervention into a specific commodity market.

During the decade of the 1960's, US farmers received just over $1 per bushel for corn. Corn exports increased substantially in the early 1970's and by the middle of that decade farmers were receiving on average over $2.50 per bushel for corn. However, in the 30 year period from 1976-2005 corn prices remained relatively stable, averaging $2.35 per bushel over that time frame. There were only two years that the annual price of corn for a marketing year was more than $0.50 per bushel higher than the average and there were only two years when the marketing year average price was less than $0.50 per bushel lower than that average.

During those 30 years, corn farmers saw a fairly steady increase in demand for corn: feed seed and industrial use rose from less than a billion bushels annually to nearly three billion bushels; feed usage increased from four billion to six billion bushels; and exports remained level varying around 1.8 billion bushel. Why did prices remain stable over those 30 years when usage increased from seven to eleven billion bushels annually?

The answer is that corn yield increased sufficiently to supply the increasing usage. In 1976 the expected national average corn yield was about 90 bushels per acre and by 2005 it had increased to over 140 bushels per acre. Farmers have been the victims of racing on their own technological treadmill to improve yield and cut cost per bushel. The result, as economic theory would predict for a perfectly competitive market, is that the price of corn has remained close to the break-even cost to produce corn for most producers.

Meanwhile, the world's hunger for fossil based fuels has grown to extraordinary levels. The theory of peak oil has also been a concern for many groups and has spurred the relentless search for a so-called renewable fuel source in order to perpetuate the availability of energy to man and industry.

And finally, increasing concerns about global climate change have pressured special interests and governments to seek a means of minimizing the impacts of human consumption of resources. In many schools of thought, man's consumption of resources and specifically fossil based fuels, emits unsustainable levels of greenhouse gases (GHG) into the atmosphere, which leads to uncontrollable climate change. These scientists argue that in order to maintain a sustainable planet and end environmental injury, GHG emissions must be reduced to natural or even a net negative level.

In the last few years, the US government has responded by creating legislation in response to lobbying pressure from corn growers wanting a higher price for their grain; anti-oil lobbying wanting to reduce our dependence on oil, particularly foreign oil; and environmental lobbying pressure to reduce our emissions of GHG. While this legislation has shown up in a number of different places, two key pieces of legislation have been the Energy Policy Act of 2005 and the Energy Security and Independence Act (EISA) of

December 2007. These two pieces of legislation created federal mandates for the amount of US produced, corn based ethanol that must be blended into our national gasoline. This created a federally mandated increase in demand for corn to be used to meet the ethanol requirements.

Objectives

The overall objective of this thesis is to evaluate the direct economic impacts of the US ethanol industry on the US corn industry and to also document some of the unintended economic consequences in the corn industry and other agricultural industries. The three specific objectives are to:

1. determine if there has been a structural change in the supply, demand and price relationship in the corn industry;
2. determine if commodity brokers believe that the futures market is still effective tool manage price risk for their clients; and
3. determine how farm profitability and risk have changed as a result of ethanol policy with its intended and unintended consequences.

Methods

The core of this thesis is to delve into the economic law of unintended consequences. In one way or another, the extents to which the objectives of ethanol have been met are superficially observed on a day to day basis. The economic effects of corn ethanol at the farm level can be roughly identified, the energy issues can be weighed and the environmental impact can be measured. But a deeper analysis may reveal that ethanol has effects which reach much further than these segments of society. Since the rapid expansion of ethanol, agricultural markets have experienced volatility which had not been previously observed. Farm and futures prices reached unforeseen levels and these markets now seem to be tied to external markets more than ever.

Ethanol demand for corn has been the greatest single economic factor to impact agriculture in many decades. Since the inception of the Renewable Fuel Standard (RFS) risk patterns have changed, volatility has increased and participation in the major trading centers has changed. With all of these changes, higher prices than have ever been observed have come to pass in the commodity markets and may or may not be explained by the traditional fundamental and technical factors. This paper explores the extent to which structural change has occurred and the extent to which these changes are tied to diverting capital and resources to biofuel production. Current primary and secondary data are used to at least partially explain the associations of these changes to biofuel. The primary focus of this study is how these market conditions relate to corn ethanol, as this is the most prominent biofuel currently.

Thesis Organization

Following this introductory chapter, the next chapter will be a brief introduction and background on the foundations of the ethanol industry. The first parts will review the preceding legislative initiatives which led to the current policies as well as an overview of the current U.S. biofuel policy. Following is an overview of the industry as it stands at the time of this writing. Some simple statistics are given in order to visualize the makeup of market participants and ethanol consumers. In order to understand many of the terms related to corn ethanol issues, it is helpful to have reviewed this chapter before continuing.

In Chapter 3, a thorough review of current academic, government and industry publications is given. A plethora of research has been done on issues related to corn ethanol and its various impacts on economics, culture and the environment. Research on some of these areas is limited, but an attempt is made to present all the topics which are tied to ethanol production including the arguments made by both supporters and opponents of corn ethanol.

Chapter 4 consists of a theoretical discussion about structural change. The ramifications that the economy might expect to go through from such an imposing artificial demand as the corn ethanol mandates are analyzed. It is followed by the methods of analysis used to achieve the objectives and a brief description of the data used.

Chapter 5 is a compilation of the results from testing the economic theories related to ethanol production. The results will follow an outline similar to the objectives laid out above. Namely, there will be a fundamental analysis of acreage shifts, pricing changes and ethanol production from the corn supply of each year. Secondly, a survey of country futures brokers is presented to qualitatively measure how the trading markets have changed since the ethanol mandates have been put into place. Finally, the effects on the costs and returns of farmers after the shocks of ethanol are analyzed. Chapter 6 consists of my conclusions and implications for various market participants. I will reflect on what has been presented throughout the entirety of this thesis.

U.S. biofuel policy and its impacts on economic markets are complex and significant. The reason why so much literature has been issued relating to ethanol is that the topics of impact are seemingly endless. It is certainly difficult to objectively measure any of these changes but it is expedient to start with a basic, fundamental analysis before drawing any conclusions regarding any one ethanol issue. The whole story must be told and this is intent of this thesis.

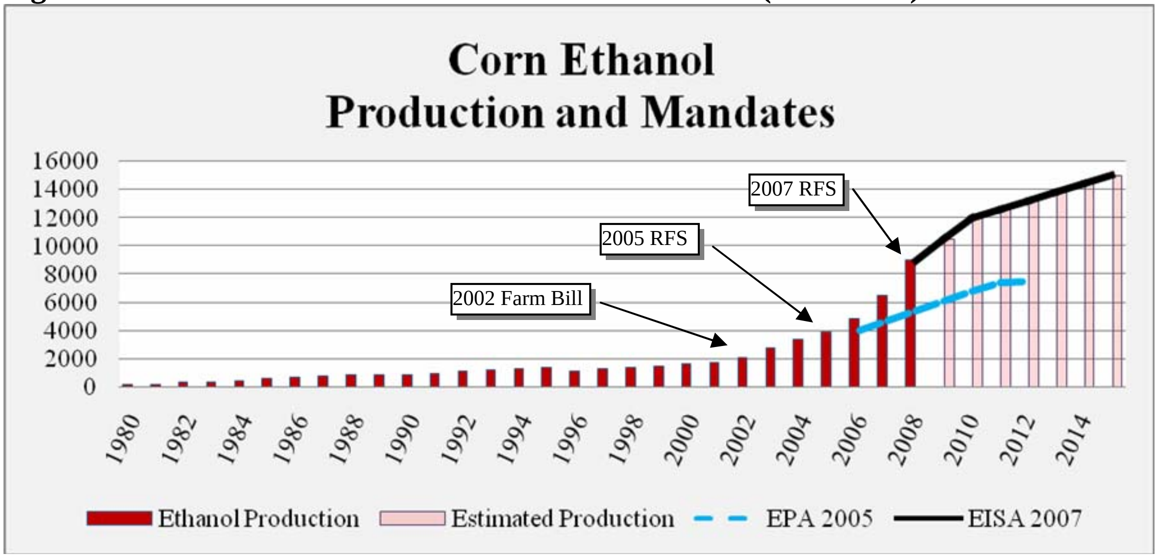
Chapter 2 – Biofuels Background and Ethanol Policy

At times the energy, political and rural economic sectors have been at odds with each other but are cooperating for the common goal of replacing fossil fuels with *biofuels*. Biofuels are defined by Merriam-Webster's Online Dictionary as "a fuel (as wood or ethanol) composed of or produced from raw materials." Biofuels are different from fossil fuels in that they are produced from *recently dead* organic materials as opposed to *fossilized* hydrocarbons like oil or gas.

Biofuels are generally converted from organic material into either ethanol or bio-diesel. Biodiesel is derived from vegetable oils like palm oil or soybean oil and refined to a combustible form for automobiles. Ethanol is either derived from fermentation of starchy goods like potatoes or grain, or from the cellulose in the other portions of plants like wood, leaves and stems. The viability of each of these as an energy source ranges according to each product and the technology used to produce them.. For example, outside of economic conditions, the net energy balance (NEB) of cellulosic ethanol is negative due to currently inefficient technologies. But altogether, biofuels continue to gain prominence on the world stage as an answer to the challenges in the introduction.

The most prevalent of biofuels in the United States today is ethanol produced from grain corn. The refining capacity for corn ethanol is expected to reach 13.5 billion gallons in 2009. This is an increase from only 2.1 billion gallons in 2002.

Figure 1. Corn Ethanol Production and RFS Mandates (1980-2015)



Source: Renewable Fuels Association, Environmental Protection Agency

Figure 1 is an illustration of this growth. The trend has largely been supported through legislation and subsidies from the government which initiated the first pro-ethanol mandates in 2002. The U.S. congress and supporting industry groups have cited the challenges outlined at the opening of this paper as imperatives for moving toward corn-based ethanol. The legislation has since grown to include other biofuels such as biodiesel and especially cellulosic ethanol, but current applies most directly to corn based ethanol.

By debatable measure, the expanded production and use of corn ethanol has achieved its goals of stimulating agricultural markets, reducing dependence on foreign and fossil fuels and putting downward pressure GHG emissions. Extensive literature has been published regarding these issues. The current available store of academic research is vast in its approach to biofuels from the perspective of agricultural, energy and environmental economics. In some cases a general scientific consensus has been met regarding the merits of corn ethanol. In other cases, the table is open for debate.

Policy and Legislation

It is vital to have a general understanding of the evolution of biofuel policies and current legislation supporting ethanol use. Ethanol has been produced from corn since the early 1980s but only entered the public arena in 1992. The policy regarding ethanol has changed from exploration as a fuel additive to that of fuel replacer. While industry groups have lobbied congress for years to expand ethanol production, government agencies have been reluctant until recently to authorize active government support for the ethanol industry. Today, the United States government supports ethanol use through subsidies, blending mandates and capital expenditure guarantees.

Energy is the newest portion of farm legislation first appearing in agricultural policy in the 1990 farm bill. This is also the first time energy was directly linked to agriculture. The Food, Agriculture, Conservation and Trade Act of 1990 was also one of the first pieces of legislation to address global climate change. In fact, this was an important enough item that it gained a section title in the 1990 bill. Contained within this section was a program created to fund "biomass energy demonstration projects." These demonstration projects were established to support research in developing energy from renewable and domestic sources. The demonstration projects were organized to stimulate interest in biofuels as a viable replacement for conventional energy.

The next major support for ag-based energy development was organized in the 2002 farm bill. This time, energy was important enough to have its own title and section dedicated to it. This legislation further funded research in biofuels and expanded its reach to include hydrogen and fuel cell technologies. The provisions of the 2002 farm bill energy policy were limited to funding research but would give rise to a focus on developing a sustainable bioenergy sector.

By 2005 enough interest in biofuels and specifically ethanol had been generated that congress chose to actively integrate them into the nation's energy supplies. The first major step in the process of creating a viable bioenergy sector was the Energy Policy Act of 2005. Most of this act was focused on developing other-than-bio sources of energy such as nuclear and solar power. But as part of this legislation the RFS was first established which set mandates for the amount of biofuels to be used as energy linked to timetables. The RFS put biofuels at the forefront of alternative energy development. It also authorized the first subsidy for fuel refiners who blend ethanol with conventional gasoline. There has been a form of subsidy to refiners since 1978, when they started to receive a waiver for a portion of the gas taxes for ethanol blended gasoline.

On December 19, 2007, President Bush signed the Energy Independence and Security Act into Law. This legislation built on the previous bills and directed more public resources toward developing the biofuels industry. The keystone of this law was the expansion of the RFS. Initially, the RFS stipulated that 7.5 billion gallons of corn ethanol be produced and blended by 2012 with an additional 250 million gallons coming from non-corn biomass from 2012 onward (see figure 1). But the 2007 bill grew the RFS to a total of 36 billion gallons of ethanol by 2022, 15 of which would be derived from corn. A more detailed explanation of the RFS can be found below.

Finally in 2008, the aptly named Food, Conservation and *Energy* Act of 2008 (italics added) irreversibly linked the energy sector with agriculture. Funding in the 2008 farm bill has expanded to guarantee loans for ethanol refineries, expand research efforts, support biomass production and many other provisions. Although this law is directly tied to the Energy policy of 2007, it is technically the current and periodic farm bill legislation. What this means is that the biofuel supporting law in the Farm Bill is *in addition to* the energy legislation of 2007.

The cumulative legislation related to biofuels and ethanol has amassed a great deal of public attention and governmental complexity. But most of it can be categorized into three basic areas: Blending mandates through the RFS, subsidies and loan guarantees (financing) and exploration. Below a broad overview of each of these categories is given in order to more fully understand the role of government in the development of the ethanol industry as it stands today.

Renewable Fuels Standard (RFS)

Some confusion exists surrounding the concept of the RFS. Many perceive it to be a production mandate. While it mimics the attributes of a production floor, it is actually a blending mandate meant to obligate transportation fuel refiners to blend a minimum volume of ethanol and biodiesel into the domestic energy supply. Additionally, it is more of a moving target than a fixed standard. There is no mandate that ethanol be produced. There is, however, an EPA mandated *blending wall* which stipulates a blending ceiling of 10% for conventional vehicles. But combined with fuel for flex-fuel vehicles, there is virtually no limit to the cumulative amount of ethanol which can be blended.

The RFS was first introduced in 2005 as a guideline of benchmarks for the nation to reach each year over time, to finally achieve a goal of a certain level of biofuel use. This first version of the RFS was quite timid compared to the 2007 modification of the standard. Table 1 outlines the phase-in of biofuels as legislated by the RFS. It was quite simple and, in fact, was limited to mandating corn ethanol usage levels.

Table 1 – Renewable Fuel Standard 2005

Year	*Renewable Fuels (Corn Ethanol)*
2006	4.0
2007	4.7
2008	5.4
2009	6.1
2010	6.8
2011	7.4
2012	7.5

Source: Environmental Protection Agency

But in 2007, the current version of RFS was expanded to include more varieties of biofuels. Not only was the goal for corn ethanol usage increased, but the new RFS includes the mandatory blending of cellulosic ethanol and biodiesel. Additionally, the new RFS differentiates the types of biofuels and classifies them by assigning a status related to their actual GHG emissions and energy values. The current RFS is summarized in Table 2.

The most notable differences between 2005 and the current version of the standard are obviously the volumes mandated and the timeline of commitment to biofuel use. The newest version has committed the United States to increasing ethanol usage at least through 2022 with the aim of replacing up to 25% of the nations transportation fuels with domestically sourced ethanol. Further discussion regarding the effectiveness of this policy in reaching these goals can be found in later chapters. There is an especially large deficit in current literature regarding the tolerance of current automobile profile and

Table 2 – Renewable Fuel Standard 2007 - 2022

Year	***Corn Ethanol***	***Advanced Biofuel****	***Cellulosic Biofuel***	***Bio-mass Based Diesel***	***Undifferentiated Advanced Biofuel*****	***Total RFS***
2008	9.0					9.0
2009	10.5	.6		.5	.1	11.1
2010	12.0	.95	.1	.65	.2	12.95
2011	12.6	1.35	.25	.8	.3	13.95
2012	13.2	2	.5	1	.5	15.2
2013	13.8	2.75	1		1.75	16.55
2014	14.4	3.75	1.75		2	18.15
2015	15	5.5	3		2.5	20.5
2016	15	7.25	4.25		3	22.25
2017	15	9	5.5		3.5	24
2018	15	11	7		4	26
2019	15	13	8.5		4.5	28
2020	15	15	10.5		4.5	30
2021	15	18	13.5		4.5	33
2022	15	21	16		5	36

Source: Renewable Fuels Association, Environmental Protection Agency
** =Derived from renewable sources other than corn starch which reduce GHG emissions by 50% compared to conventional gasoline*
***=Must reduce GHG emissions by 60%*

infrastructure of various levels of ethanol in fuel. Ethanol is highly corrosive and by some estimates, 15% is the highest level which can be tolerated by current automobiles and fuel handling facilities. The question regarding how the nation’s transportation fleet will change is an urgent one. But today, the USDA is urging the EPA to raise the blending wall to support the industry.

It is crucial to understand the mechanism by which the RFS is implemented and enforced. I will reiterate here that the RFS is not a production mandate but rather a blending floor. It is set forth by congress and implemented as law. But the authority to oversee and implement the RFS is delegated to the Environmental Protection Agency (EPA), which has some limited freedom in the way it carries out the process.

Each year, national gasoline demand is projected by the U.S. Department of Energy. From this projection, a percentage is calculated of the total gasoline demand which would be required to meet the RFS. Then, according to the volume capacity of fuel refiners, they are assigned a Renewable Volume Obligation (RVO). Fuel refiners are required to demonstrate that they are in compliance with the RFS from year to year by tracking the volume which has been blended through identification numbers which were previously assigned to each "batch" of ethanol produced or imported. These Renewable Identification Numbers (RINs) are specific to an individual lot of ethanol which tracks its origin, volume and end destination. At the end of the refining year, the RINs are tallied and used to sum up the total volume of ethanol which was blended for that given year.

Interestingly, these RINs carry more intrinsic value than a simple tracking device. They can also be traded at the market and substituted for meeting individual refiners' RVO. For example, if refiner A has difficulty in meeting its assigned RVO for the year, it can purchase a surplus RIN from competing refiner B which may have surpassed its own RVO for the year. Finally, the RINs can actually be saved or traded for the next years RVO and subsequently count toward the national RFS. By decree the EPA allows up to 20% of the following years RVO can be met by the current years RINs given the RVO at individual refiners has been surpassed.

Therefore it is very apparent that the RFS is not a cut and dry mandate for a sudden consumption of ethanol at a defined level from year to year. This insight provides a deeper conceptualization of the background in how the RFS affects the farm and agricultural economies.

Financing

Government has also extended its hand into the financing side of ethanol economics. On the supply side, investors are given the opportunity to share risk with the public through loan guarantees, grants and a guaranteed demand through the RFS. On the blending side, fuel refiners are given federal tax incentives and subsidies to use ethanol in their fuels. There are also many tax incentives at the state level, but these vary from state to state and are too numerous to expound upon here. It is sufficient to note here that individual states reduce the tax burden on refiners for blending ethanol at some level or another in addition to the federal support. Many states also offer different programs in the form of loan guarantees or tax credits for capital expenditures on ethanol processing plants. But the most significant subsidy is at the federal level and is universal across all states.

The subsidy is the most straight-forward of the financing support. The formal name of this subsidy is the Volumetric Ethanol Excise Tax Credit (VEETC). The VEETC provides the funding to support ethanol production through creating a demand-side market for ethanol producers. The roots of the VEETC extend back to 1978 when ethanol was given an exemption from the fuel excise tax. The new version (VEETC) removes some of the prior restrictions for qualifying for the exemption such as blending limits. When the VEETC was first authorized, it refunded 51 cents per gallon of each gallon of ethanol blended into gasoline. It was put into the American Jobs Creation Act of 2004 and is intended to last through 2010. In the 2008 Farm Bill, the VEETC was reduced to 45 cents per gallon. The VEETC is larger ($1.01/gallon) for ethanol from advanced biofuels, such as cellulosic ethanol, but our main subject here is corn-based ethanol.

It is estimated that $22 billion dollars will have been paid to refiners through the VEETC by the end of 2010. No analysis will be provided here regarding the net returns to the public by way of this tax credit, but considerable discussion could be generated if interests were directed to calculate those levels. Another intriguing aspect of the VEETC is the fact that it is set at a flat level and in no way tied to the profitability of ethanol production or blending. Common sense would dictate that if the VEETC were necessary to stimulate ethanol consumption, then the VEETC should fluctuate as the profitability of ethanol rises and falls. The necessary size of the VEETC to make ethanol consumption profitable would also provide an interesting topic for future research.

The final support for the domestic ethanol industry is a protective import tariff on foreign-sourced ethanol. While this product is still subject to the same policies regarding RINs and is treated as an equivalent substance, imported ethanol faces a 54 cent per gallon tax until December 31, 2010. It was imposed to inhibit cheaper sources of ethanol available to refiners from places like Brazil, which is the world's largest ethanol producer, from taking advantage of the VEETC. However, there is also a 2.5% ad valorem tariff charged for all imports. The import tariff has seen two extensions, the latest of which was in the 2008 farm bill adding two years to its implementation.

On the supply side, financial incentives to produce ethanol amount to a degree of risk sharing by the public sector with private sector processors. If a market for ethanol was previously a mirage, the demand has been established by the RFS. And while many investors may view the risk to benefit ratio too high for building a new ethanol plant, the government has also set aside funding in the form of loan guarantees and grants. Currently, grants are bestowed upon worthy projects which demonstrate the viability of advanced ethanol from biomass refining. Corn ethanol is included as well. Biorefinery Assistance Program ensures loan guarantees of up to 90% of principal and interest, not exceeding $250 million, for building new and modifying existing bio-refineries. These guarantees are subject to review on a project by project basis, but funding has been mandated in set-asides for this program through fiscal year 2012.

New Bioenergy Development

This review would not be complete without mentioning the support for developing new bioenergy sources. Corn ethanol is actually only the first and fastest growing segment of the biofuel industry. But corn ethanol only makes up 42% of the final year of the RFS. The other 58% is dedicated to coming from so-called advanced biofuels, which are produced from cellulosic sources such as wood waste and corn stover. Whereas in previous years, biofuel funding was directed to developing the corn ethanol industry, that research and development has been shifted in the direction of developing advanced biofuels. The commercial feasibility of these fuels is limited because of the inefficient chemical technologies which now exist to break the cellulosic bonds in plant materials. These chemical bonds must be broken down before the sugars can be fermented into ethanol. Therefore, the research and development funding has been aggressively placed into the pursuit of more efficient technologies. The funding for these programs have been articulated in many legislative bills, including the Bio-Based

Markets Program, the Bioenergy Program for Advanced Biofuels and the Biomass Research and Development Program. These are contained in the farm bill legislation of 2008 but others have also been implemented through other avenues.

Much of the support for ethanol has materialized into legislation. Whether or not this reflects the public sentiment toward ethanol is uncertain, but the legislation is so vast and so brawny, that it has a definitive impact on the ethanol industry. Regardless of the commercial feasibility of these ventures, the U.S. government has actively created a demand-side market for ethanol and propped up the supply side through risk sharing. The RFS creates a stable market for the fuel which may not be as predictable without the legislative supports. The VEETC which refiners enjoy also sets a premium on ethanol over other competitive fuel additives (note: ethanol is used as an octane enhancer and used to replace substances such as Methyl-tert-butyl-ether. This is discussed below). The import tariffs also protect the domestic industry. The effects of these policies on the feasibility of the ethanol industry will be discussed in a later chapter, but future research might be directed toward analyzing the stand-alone viability of the U.S. ethanol industry without these financial and market supports.

U.S. Energy Use

In 2007, the United States consumed more than 100 quadrillion BTUs of energy from all sources (EIA, 2008). Of this, only 7 percent was produced from domestic renewable sources. Energy sources considered to be renewable include solar, hydroelectric, geothermal, wind and biomass. Of all renewable energy produced in 2007, biomass accounted for 53%. This equates to approximately 3.7% of the nation’s total energy supply being derived from biomass. Energy produced from biomass in primarily converted into transportation fuels. Although a small portion is devoted to electricity production, most is used to produce transportation fuels in the form of ethanol or biodiesel. The majority of biomass converted into biofuels is produced from the conversion of corn starch to ethanol. In 2008 a record 9.2 billion gallons of ethanol were produced, primarily from corn, representing less than 1% of all energy consumed and about 5% of gasoline consumption (EIA, 2007). On the other hand, nearly 23% of the 2007 13.1 billion bushel corn crop was used for ethanol production (RFA, 2008). This is compared to 1.1 billion bushels used in 2002/2003 of a 9.5 billion bushel corn crop which is roughly11.5%.

Ethanol Production

Ethanol is generally categorized by the source from which it is produced; these two categories are corn ethanol and cellulosic ethanol. Currently, the majority of ethanol is produced from the starches in corn kernels. However, a large amount of research is being devoted to developing technologies which can efficiently convert cellulose, hemicelluloses and lignin into simple carbohydrates for further conversion into ethanol. The presumed benefits of this so-called cellulosic ethanol is that dependence on corn grain for fuel is reduced by using crop residues and other waste such as corn stover and straw. In addition, alternative crops are being considered as potentially efficient supplies of ethanol such as switchgrass, poplar trees (Steeves, 2006) and many others. The RFS stipulates that at least 21 of the 36 billion gallons of renewable fuel be derived from cellulosic and other sources while 15 billion gallons be derived from corn (RFA, 2008). Altogether the total production capacity of the industry is 12.3 billion gallons and will continue to increase to meet the RFS. It is expected to increase to 13.5 billion gallons by the end of 2009.

Currently, commercial ethanol is produced from corn in one of two processes: wet milling or dry milling. Most of the 178 ethanol plants presently in operation use dry mill processes (ACE, 2008). In the wet milling process, corn is soaked in sulfuric acid to assist the separation of the kernels into the individual components comprised of the germ, gluten and starch. The germ is then separated and used as the source of oil extraction. The remaining starch and gluten goes through an additional separation process which frees each part from each other. The starch is then processed into various products or fermented into ethanol. The resulting products from the wet mill process are corn oil (from the germ), dry gluten meal and ethanol. Corn gluten meal is used as a feed ingredient for poultry production.

Dry milling is dedicated to producing ethanol and results in various byproducts. This is in contrast to wet milling whereas the results are three *co-products* of corn. With regard to ethanol production, therefore, dry milling is considered to be much more efficient than wet-milling which is the reason that dry milling is the industry standard today. In dry milling, the corn is immediately ground into flour without separation of the individual parts. The meal is then mixed with water and a blend of enzymes which decompose the starches into dextrose which is a simple carbohydrate. The slurry is heated to reduce bacteria in the mix then cooled before having yeast added for fermentation. After 48 hours, the alcohol is distilled out of the mash and concentrated to 190 proof and further dehydrated to reach a 200 proof level (100% alcohol). When the alcohol is distilled out, the remaining *stillage* is eventually processed and dried to produce dried distillers grains with solubles (DDGS). DDGS is considered to be a highly desirable feed component in livestock rations because of its high protein and energy value. In the most recent reports, dry milling has achieved a conversion rate of approximately 2.7 gallons of ethanol per bushel of corn with 17 pounds of by-product remaining in the form of DDGS.

Ethanol is a highly competitive industry with a five firm ratio of 41% and a ten firm ratio of 51% in terms of present production capacity (RFA, 2008). Large diversified corporations such as Archer Daniels Midland Company (ADM) have entered the market as well as numerous specialty producers. Currently 22 plants are under construction and are expected to add an additional 2.2 billion gallons in capacity. In December 2008, RFA listed 132 separate ethanol producing firms with a current capacity of 12.3 billion gallons and a future capacity of 13.5 billion gallons when plants under construction were included.

Ethanol Consumption

Ethanol demand has expanded rapidly in the past 5 years. Due to the government mandated RFS, fuel refiners are required to blend increasing amounts of ethanol into gasoline. The VEETC of $0.45 per gallon of ethanol used has supported blending in proportions of up to 10%. This fuel mixture, called E10, is safe for use in all vehicles currently in the United States (ACE, 2008). At this level, ethanol increases the fuel mixture's octane rating as well as engine performance. The reason ethanol was initially introduced as an octane booster was to replace the outdated Methyl-tertiary-butyl-ether (MTBE) which has been shown to be highly pollutant to air and groundwater supplies (Duffield, 2006). At levels higher than 10%, ethanol becomes highly corrosive to conventional engines and reduces fuel efficiency.

Vehicles which can run on higher blends of ethanol are available. The most common ratio is E85 where 85% of the fuel is ethanol and the remaining 15% is conventional gasoline. These vehicles are called Flex-Fuel Vehicles (FFVs) because they are capable of running on fuel blends as high as E85 or as low as E10. The parts are specially manufactured to be highly resistant to the corrosive nature of ethanol. There were approximately 297 thousand FFVs in use in 2006 compared to 179 thousand in 2003 (EIA, 2008). This number is expected to increase as car manufacturers address the growing demand. EIA estimated that in 2007, 1.27 million FFVs would be "made available" to the nation. Despite the growing number of FFVs on the road, the substitutability of ethanol for gasoline is limited. The National Ethanol Vehicle Coalition (NEVC) estimates there are a total of about 1860 locations which offer E85 in 44 States. However, 71% of these locations are concentrated in the Midwest and in just 10 states. Minnesota alone accounts for 356 of the E85 stations counted in the national total (NEVC, 2008). One reason for the limited availability of E85% is that it must be transported by individual trucks or train cars specifically suited for the corrosive nature of this blend. E85 cannot be transported via pipeline like conventional gasoline.

Because the ethanol is still in its infancy, it faces many challenges in the future to remain viable. One of the key issues relating to the growth of the industry is the ability of the current infrastructure to cope with the increasing volumes and proposed increased blending rates. Significant capital will have to be spent on specialized rail cars, tanker trucks, car engine parts and even the components used in fuel pumps at gas stations. There will also be the issue of a sustainable supply base. Although I will briefly address this topic in the next chapter, the question should be asked if a sustainable supply or corn crop can be produced to meet the 15 billion gallon portion of the RFS on an ongoing basis. It may be possible to supply the 5.5 billion bushels of corn, but what is given up as a result?

At the time of this writing, there is also a contractionary change taking place within the industry. The collapse of the U.S. economy and crude oil prices has strained the economic value of ethanol to refiners. This has led to numerous plants idling and/or declaring bankruptcy. An inability to generate cash flow and/or to pay down principal on capital expenditures has incapacitated at least 20-25 plants and has contributed to the halting of operations on plants under construction. This includes the bankruptcy of the largest ethanol producer firm, Versasun, which was forced to shut the doors at its 17 ethanol plants in November 2008.

What is unique to the ethanol industry is the role it has played in expanding the demand side for the U.S. corn supply. In just 5 years, the industry has grown from utilizing 1 billion bushels of corn, about 10% of production to utilizing 23% of the largest corn crop in history. It has single-handedly shifted the demand curve outward to such a degree as has not been observed in history. In the coming years it will continue to play perhaps the most prominent role in grain marketing compared to any other channel of the agricultural sector.

Chapter 3 - Literature Review

Agricultural markets in the United States have experienced unprecedented changes since 2005. While exogenous factors such as economic trends, oil prices and others have all influenced these changes, none is as significant as the Renewable Fuel Standard (RFS) initially signed into law in 2005. By so creating such a large artificial demand for fuel ethanol as stipulated by the RFS, the government has sought to achieve certain goals while the law of unintended consequences has been observed. The first introductory sentence in FAPRI's Model of the U.S. Ethanol Market states (FAPRI, June 2008, p3):

> The United States ethanol market has become an epicenter of shocks to agricultural commodity markets and a focal point of farm policy that defies precise quantitative analysis.

This purpose of this chapter is to explore and analyze the arguments noted by the antagonists and proponents of ethanol production from corn. Current literature is reviewed to articulate these arguments and implicitly explain whether or not the goals of the ethanol mandates are being achieved. Other issues are also addressed by referencing academic, government and industry literature.

The extensive market for ethanol today in the United States would not exist without the RFS formulated by the federal government of the United States. It is valid to state that ethanol was in production long before the mandates of 2005, but the majority of ethanol from corn was used for industrial purposes and its production was driven by open market forces. But many industry groups contest that the benefits of ethanol far outweigh the costs.

The Renewable Fuels Association exists to “[promote] policies, regulations and research and development initiatives that will lead to the increased production and use of fuel ethanol (RFA, 2008).” The association represents the majority of investors and other stakeholders who have a vested interest in the expansion of ethanol markets. They are also the most prevalent and reasoned representatives of the ethanol industry. The RFA provides numerous reasons why ethanol is beneficial. The reasons they cite as benefits realized from ethanol use are environmental impacts, energy security, reduction of fuel costs for consumers, boosting the economy and stimulating farmer income (RFA, 2009).

Energy Contribution of Ethanol

Energy security as a priority in the United States has gained increasing attention and support due to rising crude oil prices and escalating turmoil in oil-rich regions of the world. Biofuels have been viewed not only as a cheap alternative to oil-based fuels, but also as a means of securing energy independence. An important key to understanding the potential for biofuels to contribute to energy independence and the role which ethanol might play is the net energy balance of ethanol production.

A variety of studies have been performed to estimate the net energy balance of corn based ethanol since the late 1980s. Despite the number of studies performed, a wide range of results have been produced and therefore no general consensus has been reached on the matter. For example, Ho estimated the net energy balance of corn ethanol at around 4000 British Thermal Units (BTUs) per gallon in 1989. This is compared to an estimate of -33,562 BTUs per gallon by Pimental in 2001. Yet another study estimated the energy balance at 30,589 BTUs per gallon (Lorez, 1995). The results from these specific studies roughly represent the outcome from other related studies.

A study aimed at establishing the true Net Energy Value (NEV) of ethanol in 2002 indicates that discrepancies between the studies are probably a result of using “various assumptions about farm production and ethanol conversion (USDA, 2002).” Furthermore, USDA notes that previous research may have been done using different data from changing time periods. In the same study, USDA attempts to address each of these issues and accurately estimate the NEV of ethanol. The result was a positive NEV of 21,105 BTUs per gallon of ethanol.

What sets the USDA study apart from others is the use of an expansive dataset for their calculations which is compiled from the nine highest corn and ethanol producing states. Their methods employ weighted and moving averages throughout. In contrast, the other studies generally use data from specific locations and a specific set of localized criteria for corn and ethanol production. While the USDA study considered the factors which create the variability between studies, the individual estimates may be more accurate for estimating NEV in individual localities and production chains.

Therefore, it may be implicitly inaccurate to state whether or not corn ethanol exhibits a positive NEV based on a given set of assumptions. Where NEV is critical to the argument of whether or not corn ethanol contributes to domestic energy security, the only way to answer this point is to take a national accounting of ethanol production thus far and estimate what the NEV of current and past ethanol production is. Only then can we truly know if dependence oil-based fuels has been reduced and to what extent.

A critical point regarding the energy security contributed by corn ethanol is that of the potential for corn to displace current and expected fuel consumption of traditional fuels. A popular way of assailing this case is to describe how much ethanol could be produced if every acre in the U.S. was dedicated to corn production. A more realistic perspective may be to estimate the amount of ethanol which could be produced from current corn yields since these are at all time historic highs.

In 2008, the United States corn crop amounted to 12.02 billion bushels (NASS, 2009), a drop of over 7% from 2007. Using the most recent and highest conversion rate of 2.7 gallons per bushel (www.ethanolmarket.com) there is a potential production of 33.66 billion gallons of ethanol from 12 billion bushels of corn. In 2007 the U.S. consumed over 140 billion gallons of gasoline (EIA, 2009). If all of the potential ethanol were blended into gasoline, roughly 24% of gasoline consumed today would be displaced. However, this notion is wholly unrealistic. It is based on the assumption that the entire U.S. corn crop at current levels would be devoted to ethanol production at the expense of all other domestic demand. The RFS also does not stipulate that in the future all ethanol should be derived from corn. The mandate is that a maximum of 15 billion gallons be converted from corn when the RFS matures. Even if the conversion ration were improved to 3 gallons per bushel, it will still require 5 billion bushels of corn to meet which would represent about 38% of the corn crop in the record crop marketing year 2007 (NASS, 2009). These levels would be equivalent to about 12% of domestic gasoline consumption being displaced by a domestic source of energy.

But if we return to the idea of an NEV for ethanol, this amount of energy security achieved is vague at best. The best USDA estimate of an energy ratio for a dry milling operation is 1.11 for corn to ethanol conversion. This would imply that a mere 11% net benefit is realized in terms of energy from ethanol due to the energy inputs required to make it. From a 15 billion gallon production level, we can then infer that nearly 13.5

billion gallon equivalents of energy were used to produce the alternative, leaving a net displacement of the energy equivalent to 1.5 billion gallons of ethanol. Adjusting the total impact on energy security, we arrive at a 1.05% reduction of dependence on energy from sources other than ethanol (i.e. crude oil products, etc.) while at the same time nearly doubling the energy consumption in pursuit of corn ethanol. Appropriately, Carriquiry, Hayes and Rubin (2008), show that energy security is more efficiently attained by investing in an alternative such as green coal technology.

Environmental Impacts

In contrast to the issue of net energy balance, there seems to be some agreement on the GHG emissions of ethanol when used as transportation fuel. In a life-cycle analysis, ethanol production and combustion may reduce GHG by as much of 88% compared to the energy equivalent of gasoline (Hill et al., 2006). Measuring directly, Wang (2005) reports that ethanol blends of 85% ethanol and 15% gasoline (E85) emit up to 23% less GHG than pure gasoline in flex-fuel vehicles. Furthermore, the more common blend of E10 was reported to emit up to 2% less GHG than regular gasoline.

However, the GHG considerations extend beyond ethanol as a fuel. The production of ethanol seems to increase GHG overall due to land use changes. Babcock, Feng and Rubin (2008) show a 35% increase in GHG emissions from corn production when cropland is used to grow successive corn crops. Typically, corn is grown in rotation with soybeans, reducing the need for additional fertilizer applications. But most of the expanded corn crop is being produced in succession on cultivated lands (Babcock, 2008). In addition, although proper cultivation practices can aid in sequestering GHG from the atmosphere into the soil (Hill, 2006) poor production practices can actually lead to the release of additional GHG into the atmosphere (Brenner et al., 2001).

When evaluating the environmental impact of ethanol beyond GHG emissions, the effects are complex and extensive. In a working paper commissioned by The World Bank, it is pointed out that biofuel-related impacts on the environment include issues such as increased soil erosion, reduced water quality, increased resource diversion and chemical contamination from expanded use of pesticides and herbicides (Rajagopal and Zilberman, 2007).

For example, Beckman, et.al. (2008) performed research on future land-use changes as a result of broad biofuel mandates. They predicted that by the year 2015 there would be a 9.8% increase in land used for corn production in the United States alone. A prediction of a 10.0% decrease in land used for production of other grains may imply a "shifting" of these crops to corn, but two practical issues arise. First, the major grain corn growing centers are agronomically distinct from the major growing centers of other grains. In the United States corn is grown in areas where it can be economically rotated with soybean production. But this same model actually predicts an increase in oilseed production generally. Secondly, the number of acres on which corn is grown in the United States represented approximately 33% of all cultivated land in 2005. This is compared to nearly 27% for wheat, barley and oats combined (ERS, 2008). The Beckman, et.al., study was done in 2008 at a time when corn acres had already been expanded by 6.3% to 87.3 million acres since 2005.

This debate regarding the concept of land-use change has also now entered the public arena. On March 5, 2009, the California Environmental Protection Agency

(CEPA) Air Resources Board released a set of proposed legislation to implement California's "low carbon standard." In that document, ethanol from corn is actually tagged as releasing more CO_2 than conventional gasoline. For every mega-joule of energy which gasoline releases, approximately 95 grams of carbon-dioxide is emitted. But in the case of corn ethanol, 69 grams are emitted from direct ethanol production, and an additional 30 grams from supposed land-use change (CEPA, 2009). At the time of this writing, there is also considerable debate taking place between the USDA and the EPA. The USDA would like to see the blending floor raised for refiners but the EPA is delaying a ruling on that issue to further explore the ideas of land-use change and the merits of life-cycle analysis (EPA, 2009).

Although one bushel of corn will yield 2.7 gallons of ethanol, it requires anywhere from four to eight gallons of water to produce (Broz, 2008). Therefore, the rapid expansion of ethanol processing plants is contributing to the pressure on an already strained water supply. Concerns have been raised regarding the sustainability of local aquifers facing this additional withdrawal of water (Pimental, 2003; O'Brien, 2008; Higgins, Outlaw and Richardson 2008).

The attempts of current research to estimate the far-reaching environmental impacts of ethanol are limited. Pimental (p130) summarizes the data by stating:

> "…corn production uses more herbicides and insecticides than any other crop produced in the U.S. thereby causing more water pollution than any other crop. Further, corn production uses more nitrogen fertilizer than any crop produced and therefore is a major contributor to ground water and river water pollution."

At the time of this review, no quantitative analysis could be found which measured these impacts resulting from the expanded corn production. However, the claim necessitates further investigation into the degree to which ethanol production impacts the environment. It is too narrow an argument to focus on the life-cycle GHG emissions of ethanol fuel compared to gasoline. Indeed, expanding corn production, increasing the intensity to which agricultural land is farmed and the ethanol production processes themselves have wide environmental implications.

Economic Impacts

As more ethanol plants are built and the production capacity of the industry is expanded, local economies are impacted. New jobs are created, inputs are purchased and investments are made. There may be more literature available regarding the economic impacts of ethanol production than any other individual topic. Ethanol plants are purported to be large employers, use large amounts of energy, contribute to the local tax base, utilize government subsidies and purchase large amounts of inputs from local suppliers. The economic impact of ethanol production should be large locally if not nationally as well.

The general public has implicitly taken an interest in ethanol supply and use. Through the VEETC, import tariffs and loan guarantees, that interest is materialized into the financial realms. Overall, Koplow estimated that government support for ethanol topped $5.1 billion in 2006. This included all support activities related to then-current ethanol production including feedstock producer support, capital development, blending, etc. Urbanchuk estimated that direct support for ethanol production and consumption, through the volumetric excise tax credit and the small producer subsidy, totaled $3.4

billion in 2007. This excludes the indirect subsidization of capital financing and feedstock supplies included in the Koplow study. Other estimates are higher as noted earlier in this paper. In contrast, the ethanol industry generated more than $4.6 billion in taxes for the federal government. Therefore, disregarding the indirect support of ethanol production, the industry produced a net surplus to the public coffers (Urbanchek, 2008).

At the *micro*-economic level, it is impractical to estimate the cumulative effects of all ethanol production. However, it is useful to estimate the impacts a new or existing plant might have on local economic activity. Generally, the studies which have estimated local economic impacts of ethanol plants have used input-output modeling programs such as IMPLAN for their analysis. These programs are capable of estimating the relative changes in employment, tax revenues and total business product for a defined economic region. They are especially useful because they analyze direct, indirect and induced effects of economic changes through multipliers.

Capital expenditures for new plants are substantial. Flanders et. al. (2007) estimated the costs for a 100 MGY facility in Georgia to be over $170 million. The same research indicated annual net returns of over $59 million. The total economic contribution to the state would be $314.2 million and all tax revenue through the state level would accrue a total of $4.572 million. In the study by Isserman and Low (2008) total revenues for a comparable plant were $203 million and $121 million for a smaller 60 MGY capacity plant. Wage creation for the Isserman and Low (2008) study were $2.4 million for an estimated 35 direct full-time equivalent employees.

The average ethanol plant capacity is currently around 64 million gallons per year (RFA, 2008). The largest of these has a capacity of approximately 115 MGY while the smallest is around 5 MGY. Most of the studies done to estimate the local economic impacts of plants make the assumption of a 50-60 MGY plant, 100 MGY plant or a combination of the two. Most of the studies have similar results. Over half of ethanol plants employ between 20 and 49 workers (Isserman and Low, 2008). Swenson (2008) used a 41 MGY year plant in his study and found that 135 new jobs were created from an ethanol plant built in 2003. Flanders et. al. (2007) estimated 408 new jobs resulting from a newly constructed 100MGY plant. Isserman and Low (2008) estimate that for a 100MGY plant, new job creation ranges from 152 to 248 in various counties. One of the most comprehensive studies found which measured job creation was Leatherman, Peterson and Schlosser (2008). They cite the Minnesota Department of Agriculture as estimating a total of 154 direct jobs created from 4 new facilities and 2,784 jobs altogether. The research also concludes that predicting the impacts in the future, especially with respect to jobs, is “risky and uncertain.” In any case, most of the predictions have fallen in line with each other and seem to be accurate over time.

Typically, ethanol plants are built in the most rural portions of the United States. The reason for this is because the most expensive input for these plants, corn grain, becomes quite expensive to transport much further than 100 miles away (Isserman and Low, 2008). In fact one of the most important economic impacts of the ethanol mandates is related to transportation. After feedstock and energy costs, freight is the next highest cost to an ethanol facility (Flanders, et. al., 2007). In one county from the Isserman and Low (2008) analysis, 250 jobs were created from all effects in the input-output model, including direct, indirect and induced effects. Of these, 57 were created in the transportation sector. This is presumably from the increased freight delivery of grain to the plants and additional transport of ethanol to customers outside of the region.

The expansion of corn production has also increased the demand for suitable land on which to grow crops. The increased demand has in turn bid up rental rates on viable cropland. Using a Ricardian rent theory, Du, Edwards and Hennessy (2008) found no significant impact on rental rates resulting from ethanol expansion. However, data from Illinois Society of Professional Farm Managers and Rural Appraisers shows cash rents increased 10 % from 2006-2007 and between 10% and 20% the following year (ISPFMRA, 2007). The same data indicated a premium on acres which were closer to ethanol plants.

Whether due to higher land values or increased local grain demand, Schill (2007) also reported an increase in crop prices. This is consistent with the laws of supply and demand considering that corn producers have additional marketing choices when ethanol plants open in their area. This is supported by Babcock and Feng (2008) which demonstrated a "trickling down" effect on prices for other related crops. They said that as land allocation shifted in response to higher corn prices, soybean and other grain prices were also stimulated.

Certainly the effects of job creation, capital investment, tax generation, plant revenues, rental rates and crop prices are significant. And if one considers these individual effects for each plant multiplied for all plants across the country, the ethanol industry is measurably making an impact on the national economy.

Thus far we have discussed the various aspects of corn ethanol most often cited by ethanol advocates. With respect to energy issues and the potential for ethanol to contribute to domestic energy security, I have shown that the potential is limited given the NEV as calculated by current research. In essence, fossil fuels which are mostly foreign sourced are still consumed to produce ethanol. Environmental impacts resulting from ethanol production are vague at best. While ethanol fuel has lower GHG emissions than convention gasoline, expansion of the corn supply and ethanol industry induces a number of collateral environmental effects which may more than offset the GHG reductions by using ethanol as a substitute for gasoline. Further research should aim to document these environmental changes in quantitative ways in order to be inclusive in environmental analysis. Finally, I have shown that diverting a substantial share of the U.S. corn crop into ethanol production does drive a sizeable economic footprint. Federal tax revenue likely outpaces subsidies, new jobs are created and multiplied impacts contribute greatly to local, regional and the national economies. I have not yet addressed the issue of reduced consumer energy prices or whether or not farm income has been stimulated. These points will be visited later in a discussion about creating a new artificial demand through the RFS and how farm prices are now inextricably linked to energy.

Arguments Against Ethanol

In the case of corn producers, ethanol is naturally a desired market in which to sell the crop. It opens up a large market channel for value-added products and thereby decreases the price-taking anomaly which farmers face. In turn, the new demand for corn as an input for ethanol may drive corn prices higher which should benefit farmers. On the other hand, higher corn and grain prices in general adversely affect the livestock industry and even ethanol producing firms. The livestock industry often claims that since the introduction of the RFS, already slim profit margins have shrunk and increased market volatility has made business activities more difficult. Ethical complications have also arisen lately as consumers claim that ethanol has caused an artificial price bubble. The historic price levels have far-reaching implications for food consumers around the world. This is the common “food vs. fuel” debate which is rarely explored very comprehensively but has ethical implications tied to it. One final argument set forth against ethanol is that without subsidies, it is not a viable industry. Therefore the large capital costs and investments in plants, infrastructure, etc. are “sunk” costs. Opponents of ethanol also dispute the benefits of ethanol fuel but this discussion was had previously.

Impacts on the Livestock Industry

Before EISA 2007 increased the RFS defined mandates from previous legislation, the National Cattlemen’s Beef Association sent a letter to congress on behalf of beef producers in the United States. Their position was as follows (Truitt, 2007):

> Due to the incredible expansion that has recently taken place within the corn-based ethanol industry, ranchers and cattle feeders are expanding their use of alternative feedstuffs, and doing their best to respond to the rapidly changing marketplace. However, corn is and will remain an essential input for their business. Mandating additional corn ethanol production will only serve to exacerbate an already difficult situation for cattle producers across the country.

At the time of this letter, Corn prices had already increased by over 100% since three years prior (ERS, 2009). Indeed NCBA fears were confirmed after EISA 2007 was signed into law as prices peaked 87% higher eleven months later.

The nature of beef markets in the U.S. is a key to understanding the position of NCBA. Most cattle destined for meat production are placed into a feedlot where 85% of feed rations are typically energy intensive feedstuffs like grain corn (NCBA, 2009). The traditional reason for this is the abundant surpluses of corn which have been produced in the United States since the 1950s. Corn has been relatively cheap compared to other feed components and this is what gave rise to grain feeding cattle.

But cattle are not the only livestock species dependent on corn and other grains in their production processes. The National Pork Producer's Council (NPPC) takes the position that ethanol impacts will settle in the long-term but the short term implications jeopardize the industry's competitiveness (NPPC, 2009). In a letter similar to the NCBA's, the National Chicken Council (NCC) told the Environmental Protection Agency (EPA) that "the Renewable Fuel Standard has distorted the market and has imposed severe economic harm on companies in our industry through dramatically higher input costs and is imposing harm on the general public in the form of higher prices, present or impending, for food products (NCC, 2008)." The NCC represents roughly 95% of broiler producers in the country.

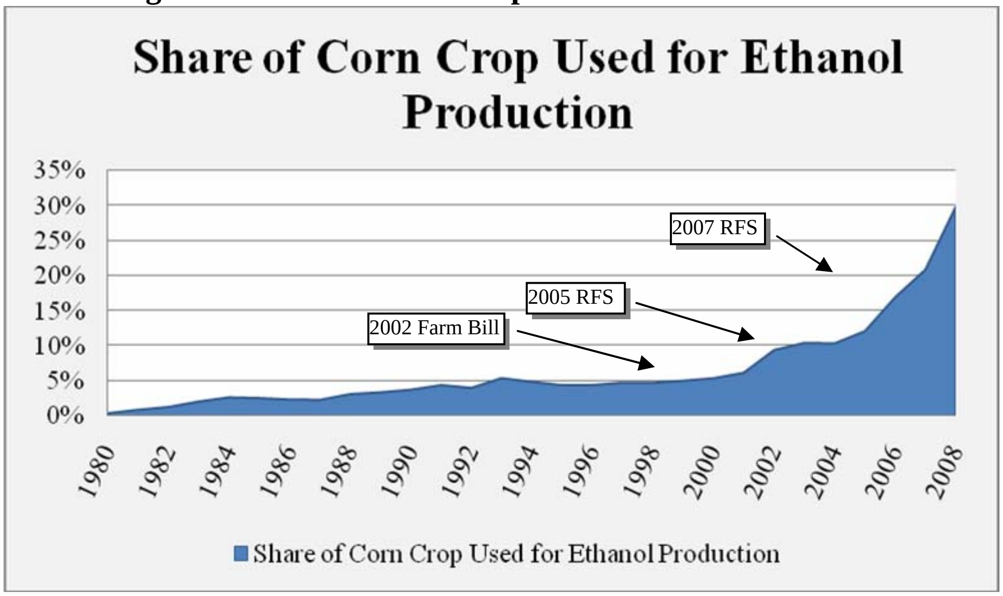
Similar to the environmental impacts, many of the impacts ethanol has had on the livestock industry were unforeseen and heretofore minimally assessed. Most of the research attempting to objectively measure these notions tends to support the statements made by these three organizations.

The problems which the livestock industry faces as a result of ethanol are rooted in the basic principles of supply and demand economics. By explicitly mandating the supply of corn ethanol, the RFS implicitly creates an artificial demand for the feedstock.

Ceteris paribus, if the corn market is in equilibrium, this new demand would exhaust supplies and the price of corn would invariably increase. The rate at which it would increase would only be limited by its own price elasticity of demand. Rosegrant (2008) agreed in a testimony to lawmakers regarding the sharp increase in food prices. He also indicated that in addition to the strain on commodity supplies, new competition is introduced to produce corn. Several simultaneous factors have also influenced commodity prices in recent years. Global weather conditions, developing economies and declining stocks have all contributed to the inflation. The proportional influence of each of these factors is difficult to measure and is often compared to growing global demand for biofuels (Rosegrant, 2008).

But the livestock industry may be right to tag ethanol as the primary culprit behind rising commodity prices for two reasons: 1. The other factors are exogenously controlled while ethanol is an optional enterprise artificially imposed by the U.S. government, and, 2. A growing share of the corn crop is diverted to ethanol production. The portion of the corn crop diverted away from available supplies is substantial as shown by Figure 2. Before 2002, corn used for ethanol increased but never exceeded 7% of the current year's production. Since 2002, the rate at which corn has been diverted into ethanol has accelerated (NCGA, 2008). In 2006, the year following the first RFS, the portion of the corn crop used for ethanol jumped from 14% to 20%. In 2008, roughly 31% of 12.1 billion bushels was consumed by the ethanol industry (ERS, 2009).

Figure 2. Share of Corn Crop Used for Ethanol



Source: Economic Research Service

The corn industry may say that this dramatic shift has essentially not adversely affected corn supplies because the annual corn crop has expanded to meet the ethanol demand for corn. A record 13.37 billion bushels was produced in 2007 (ERS, 2008) and despite a smaller crop in 2008, the remaining amount of corn has remained stable. The corn left after ethanol has remained steady at around 8.7 billion bushels (FAS, 2009). Therefore, the ethanol industry is simply “skimming the cream” off the top and not affecting corn price. On the other hand, beginning stocks have been declining since 2004 (FAS, 2009) and are approaching historic lows. This combined with a growing global demand for grains may actually be the true driver behind grain prices.

The reason for this is the price discovery mechanism used for setting price levels of commodities in the U.S. and subsequently in the world. Prices for commodities are determined in futures trading centers where contracts for future delivery are bought and sold. The price levels are determined by a number of commercial and non-commercial participants buying and selling in large part based on *future* expectations. Generally, prices paid to farmers are based on these markets and adjusted for a transportation basis. If future expectations of grain supplies relative to demand are waning, and this due to a rapidly growing ethanol sector and declining worldwide stocks, then speculation about the trends might contribute to rapid price increases. One of the purposes of this manuscript is to explore the extent to which these markets drive price discovery, but the livestock industry may be right in pointing to ethanol as a primary cause for the increase in commodity prices. This will be addressed in chapters 4 and 5.

Yet even with all the gross diversion of acres and corn grain to the ethanol industry, the loss is not complete. Recall in chapter 1 the discussion regarding ethanol production. In both wet and dry milling, ethanol production generates byproducts. One of the main byproducts from dry milling, which accounts for 95% of all ethanol plants and nearly all new ethanol facilities, is Distillers Dried Grains with Solubles (DDGS).

Of each 56 pound bushel of corn used for ethanol, roughly 17.4 pound is recovered in the form of DDGS (Baker and Zahniser, 2006). While it is not a perfect substitute for corn in livestock rations, it is highly sought after in ruminant feed (University of Minnesota, 2008). Nutritional analysis shows that DDGS has 91% of the digestible energy value of corn, which is the property desired by corn feeding. It is also high in protein, vitamins and is highly palatable to beef cattle (Kansas Ethanol, 2008).

Approximately 80% of DDGS sold for feed are consumed by cattle (University of Minnesota, 2008). This is due to the fact that cattle are best suited to consume DDGS considering its low starch and high fiber contents (Babcock and Clemens, 2008). But there is a growing demand in the swine industry which has begun to feed DDGS at a rate of 10% in pig diets (Noll and Shurson, 2005). DDGS in swine rations is acceptable up to

20% of dry matter (Fabiosa, 2008). The poultry industry has also begun to include DDGS in broiler rations and is acceptable up to 10% of dry matter (Noll and Shurson, 2005). The biggest obstacle for poultry to use DDGS in rations is the concentrated level of fiber from the ethanol milling process (Maddy et. al., 2008).

Economically, it is vital to understand that the consensus indicates no deterioration of carcass quality for cattle fed DDGS (Babcock et. al., 2008; Kansas Ethanol; Maddy et. al., 2008). Therefore, cattle producers and feeders should not be concerned about a loss in quality when substituting DDGS for some other feed component. In addition, there may be evidence that switching to DDGS in rations may have economic benefits to livestock producers. Tonsor (2006) performed an analysis which indicated hog production would benefit from DDGS inclusion. Other such studies support the idea that a cost savings is realized when switching to DDGS in light of the higher corn prices (Lawrence, 2006). The economics results for feeding DDGS to cattle are mixed. Lawrence (2006) indicates that the profitability of switching to DDGS depends on the ration inclusion rate and the weight of cattle at which they are started on DDGS. Daley (2007) performed research which indicated feed costs would be reduced by DDGS. But Babcock et. al. (2007) contends that the rapid loss of corn supply shifts to an increase demand for DDGS to such a degree that DDGS prices track corn prices. Their study states that it will happen to such a degree that producers will shift back to corn and soy based rations which had previously been deferred for cheaper DDGS (Babcock et. al., 2007). In the same study, Babcock et. al. predicts that commodity price shocks resulting from ethanol are permanent, and cattle production will have adjust or beef prices will rise to reflect the increased costs of production.

Efforts to research the economic and nutritional benefits of DDGS as a feed are growing. It would appear that the nutritional characteristics are indisputably beneficial to cattle and DDGS is highly valuable as a livestock feed, especially in cattle. However, the economic tradeoffs between feeding corn and DDGS at equal prices are uncertain and should be explored further. Regardless of the substitutability of DDGS for corn, the ethanol mandate has fueled rising commodity prices and adversely affects the livestock industry. The extent to which this has occurred is ambiguous, but livestock production will have to adjust to a changing market structure.

Impacts on Other Grain Markets

Perhaps a more dramatic effect which ethanol has made is that on other grain markets. When discussing the impacts ethanol has on the livestock industry, we really approach the issue from an issue of cost changes from a new demand sector competing for the same input – livestock and ethanol producers competing for corn. But this dramatic change to the profile of corn demand has also put pressure on the supply side.

In 2006, Elobeid et al. performed a study to analyze the impacts of the then-current RFS (as stipulated by the Energy Policy Act of 2005) on external markets. The first measure of the study was that the breakeven price for corn would reach $4.05 per bushel in order to be sufficiently high enough to entice farmers to grow enough corn to satisfy the projected ethanol production. Corn ethanol production would expand to 31.5 billion gallons by 2015 and a plethora of other effects would take place. Under the defined assumptions of the study, corn production would expand mostly at the expense of soybean acres. Additionally, demand for feed wheat would increase as a substitute for the diverted corn, putting added strain on wheat markets around the world. Therefore, wheat exports would fall along with corn exports and pork and poultry production (Elobeid, 2006).

The study is careful to point out that its precise measures should not be considered actual predictions of statistical adjustments. But the study is very useful in thinking through the scenario by which outside grain markets are affected. Because arable land in the U.S. is finite, we should consider what acreage shifts would occur as a result of increased corn demand. It also makes sense that wheat as an inferior feed product, implied by the apparent preference for corn, would find demand-side support from the livestock industry. Considering the idea that in many parts of the country corn is often cultivated in rotation with soybean crops, it also makes sense that additional corn demand will decrease the incentive to plant soybeans. In a previous section, the effect this would have on land fertility was examined and should be noted. Raising corn after corn in the same plot of land deteriorates the yields made possible by the resident soil.

These are only specific effects which would inherently be observed by tracking the consequences of the RFS. But it actually presents an example of a very simple economic principle. Resources are limited and must be rationed. A valid question is who should be the steward in deciding how to ration those resources and how do we justify their impacts throughout the general economy.

In July 2007, before the expanded RFS was signed into law later that year, Babcock, et al. updated and improved upon the 2006 study by Elobeid, et al. Their models used more tempered the assumptions and produced measures of ethanol impacts which I will review here. In the first place, they projected corn ethanol production to increase to 14.77 billion gallons by 2011. In order for the industry to sustain this production, corn acres would have to increase to 94 million and average prices would have to be at $3.40 per bushel. Following these estimates, the livestock sector decreases production, exports decline and commodity prices increase. But the most interesting insight from their study is an analysis of the exposure to risk of an unforeseen event such as a major drought. Babcock, et al. (2007) showed that in case of a major sudden strain on supplies, that ethanol plants would operate until the price of corn was too high to operate a margin. But they point out that the result in the case where ethanol was operating under a mandate, the adjustments would take place externally to ethanol. Livestock and export markets would invariable be faced with the prospect of being forced out of competition for the available commodity supplies.

The literature which discusses the consequences imposed on outside grain markets as a result of corn ethanol is limited. This is one of the primary questions I seek to address in the following chapter. However, as opposed to projecting the effects of corn ethanol into the future, I will show what implied effects have already taken place as it correlates to the expansion of the ethanol industry.

Food Vs. Fuel

There are also ethical ramifications for analyzing current U.S. biofuel policy. While some consider the environmental side of ethanol to be an ethical issue, a far more serious issue is the criticism that it violates societal morals to use food to produce fuel. Many group studies have begun to emerge which point to the ethical violation of producing biofuels before helping to feed the developing nations of the world. Those who subscribe to this criticism claim that biofuels have caused food price inflation making it more difficult for poorer nations to afford food products. They also say that those precious resources used to produce food - such as seed, commodities, credit and capital – should go directly to satisfy hungry populations.

Both the Farm Foundation (2008) and Babcock, et al.(2007) cite biofuels as a concern for food production. They both assign some causality to biofuels for rising food costs. The subject they really bring into perspective is that in a world where population growth is inevitable and accelerating, food demand is at an all time high. They also point to flat-lining world food production and ever-tightening global food stocks. For example, in six out of the last eight years, wheat consumption has outstripped wheat production (FAS, 2009; ERS, 2009). And while it may be difficult to blame biofuels for reduced global wheat production, it begs the question as to what we will produce and for which demand. In chapter 4 I will explore this idea of whether or not ethanol has diverted resources away from wheat production.

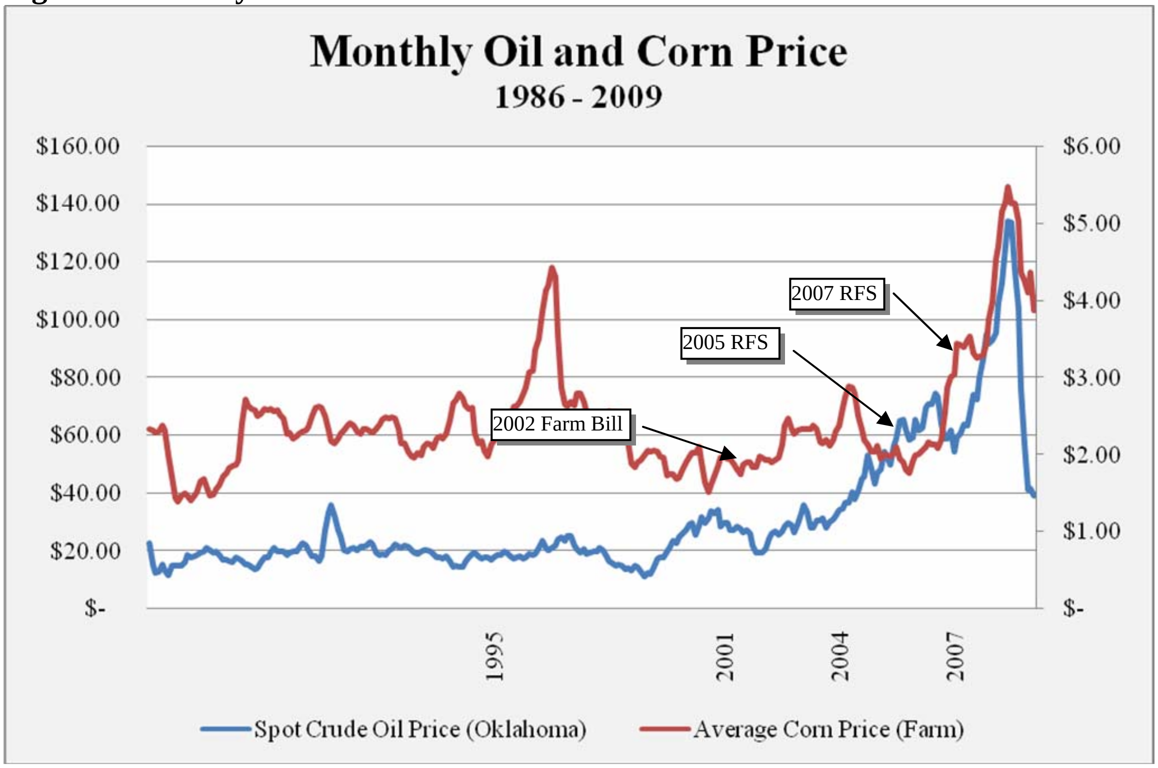
The food vs. fuel debate is difficult to argue because the supporting data is vague. It also is so complex, that econometric analysis will produce mixed results at best. What is important is to raise the idea of a fuel vs. food war when considering the law of unintended consequences. After all, this paper is exploring the unintended consequences of creating the RFS, which was designed to address climate change, energy independence and rural prosperity.

Linking Agriculture to Energy

Thus far I have discussed the merits of ethanol and the relative economic impacts of imposing the RFS onto the transportation fuel sector. But these changes and impacts are only the direct effects of the current biofuels policies. The more direct impact of the RFS is a structural change in the way which agricultural markets behave to exogenous factors. Before 2005, the energy industry and policies were distinctly separate from agriculture. The extent to which the two markets were linked was limited by the cost of fuel and fertilizers as inputs for farm production and perhaps competition for capital resources. But beyond this, the two industries have not typically competed over land use or entry to consumer markets. Prices for these sectors' respective goods were discovered in separate marketplaces and the factors which affected their trade were unique. Today, current literature shows a new and exceptional linkage between two fundamentally different markets.

Figure 3 illustrates the linkage between corn price and crude oil. It is apparent that before 2005, the prices of each commodity moved independent of each other. But, since that same year, corn price has moved in a pattern very consistent with crude oil.

Figure 3. Monthly Oil and corn Price.



Source: Energy Information Agency, Department of Energy; Economic Research Service, USDA

This has been documented by numerous researchers. Taheripour and Tyner (2008) report that the correlation coefficient between corn and crude oil from 1982 – 2007 is roughly .16. In the same study, they show that the correlations between crude and other energy products such as gasoline and ethanol range from .86 to .98. This is logical and the differences would be expected when calculating the correlation between distinct markets. As another example, the same study shows a .72 correlation coefficient for the corn and soybean complex. But since corn has become a major input in energy markets via ethanol, this has changed. Consider the fact that in 2000, about 604 million bushels were used to produce 1.63 billion gallons of corn ethanol. At the time, this represented 6.1% of the total U.S. corn crop. By 2008 the portion of the corn crop going to produce corn ethanol was nearly 25% of an historically large corn supply. If energy now represents one-quarter of all U.S. corn demand, we should certainly see a measurably increased correlation between the two sectors of the economy.

Ethanol Producer Magazine (2008), an industry publication, reports that the correlation between crude and corn now stands at 75% since 2007, up from their own estimate of 65% since 2003. Other reports are more staggering. In a publication by the Kansas Farm Bureau in June 2008, linear regression modeling was used to estimate the R-squared coefficient for several commodities and crude oil. Their approach was to analyze the impact which a rise in crude oil price now has on variable costs of production per acre for dryland and irrigated corn, grain sorghum, wheat and soybeans. They concluded that all variable costs were highly sensitive to a change in crude oil price. For data ranging from 1992 to 2007, they show that costs of production for dryland corn and irrigated corn rise by $1.02 and $0.56 respectively. In addition, they report that the correlation for these costs to crude oil are .88 for dryland corn and .93 for irrigated corn.

Mitchell (as cited in Delgado, 2009) shows that since oil has been above $50 per barrel of crude, that the R-square with corn price has been .75. He also shows a less impressive correlation of .52 when crude is below $50 per barrel, but this only substantiates the reports earlier cited because crude has not been below $50 since 2005 when the first version of the RFS was signed into law. In the same year, corn used for ethanol had not yet exceeded 12% of the domestic corn supply.

Commodity Futures Markets

As stated in the introductory chapter, one of the primary purposes of this thesis is to explore what effect the introduction of the RFS has had on agricultural markets. One of the main centers of activity within the agricultural sector are the futures markets. These are more commonly referred to as Board's of Trade (BOT), but are the center of activities revolving around the trading of futures contracts for delivery of commodities at a later date.

The various BOTs are used as points of price discovery in the agricultural community. Commodity suppliers, user's, brokers and processors alike utilize these center to find relative values for their commodities and to manage the risks associated with price fluctuations in the future (CFTC, 2008). A detailed explanation of how futures markets are utilized and the mechanics thereof is not presented here, but the reader may find myriad material reviewing the concepts relating to them, such as Koontz and Purcell (1999).

As a background, speculators play a vital role in the futures market. Their most cited benefit is that they bring added liquidity to futures trading. They voluntarily enter futures trading for the chance at arbitraging profits while taking on risk the other participants would not. They provide an immediate buyer to a seller of futures contracts and/or act as an immediate seller of contracts when a buyer is present. There is little dispute as to the benefits of having these additional market participants.

A topic of recent interest affecting the stakeholders of these trading centers is the effectiveness to accomplish their purpose which is described by the Commodity Futures Trading Commission (CFTC). Many have questioned the ability of futures markets to not only discover commodity values, but whether or not the ability to assist in risk management has been diminished since the introduction of the RFS. There have been many claims regarding increased volatility and lack of price convergence at the expiration of contracts. Many BOT participants have claimed that speculation in the futures markets has led to this problematic pricing action in the futures markets.

Since 2005, historical and implied volatilities for world commodities have reached unprecedented levels (FAO, 2008). Bange (2008) supports this calculation and attributes part of the volatility to linking agriculture to energy markets and the accelerated production of biofuels in the U.S. and abroad. Others within industry circles have assigned blame for the volatility to increased speculation in the marketplace (Seeking Alpha, 2009). But the Government Accountability Office (2009) released a publication in which eight empirical studies were reviewed. GAO concluded that none of these studies found significant statistical evidence which pointed to speculation as a cause of the recently increased price volatility in agricultural markets. Furthermore, a study done on behalf of various BOTs by Informa Economics (2008) makes a pointed insight. The study points out the difiiculty in assigning causality between speculation and volatility as the one may attract the other. Speculators are often drawn to volatile markets where arbitrage may take place and conversely, the increased participation in a market may contribute to grater price swings from period to period.

The same research by Informa and other studies (Irwin, Merrin and Sanders, 2008) have found that the market participation rates have changed in recent years. Nearly all the studies reviewed used some version of the Commitment of Traders report put forth by the CFTC. The data in this report which is released to the public is a weekly sample of the full dataset which is considered private. The report details the participation of groups distinguished as large traders and classified as either commercial or non-commercial. It tracks each segment's ownership of open interest in the futures markets. It further categorizes the non-commercial into various groups such as indexers, money managers and general non commercial participants. All of these groups are considered speculators.

Irwin, Merrin and Sanders (2008) measured two time period in the COT dataset, the first ranging from 1995 through 2005 and the second covering 2005 through 2008. They found that between the two periods, open interest held by non-commercial participants (speculators) increased from 28% to 39%. The commercially-held open interest remained relatively steady at 46-47%. Interestingly, the non-reporting segment (which consists of traders who trade a small enough volume to be exempt from the reporting process) showed a decrease from 25% to 15%. This would lend credit to the idea that most of this participation change may have resulted as a result of this non-reporting group trading substantial volume so as to lose exemption from the reporting criteria. Informa also contributed yet another useful insight to the trader participation. It essentially showed that while the participation rates may have changed, the relative behavior of each group throughout the life of a futures contract did not. Overall, both studies recorded sizeable increases in volume of open interest which will be evaluated by this paper as well in chapter 4.

The role which the RFS has played in the futures markets is difficult to quantify. In the following chapter, I will present my theoretical approach on what might be expected by introducing such a large artificial demand for agricultural commodities. It may be summed up by the idea that when such a shock takes place in any market, there must be an initial period where the long known equilibrium is lost and must re-adjust. Where the futures markets are the central point in which price discovery takes place, these centers must invariably be the first to adjust and at times in the most unprecedented ways.

Conclusion

The issues related to ethanol and the effects of the RFS are so broad in scope that many researchers have conceded that it would be difficult to truly quantify the effects of U.S. biofuel policy. What is certain, however, is that the RFS and the sheer scale on which ethanol is currently being produced, and that which will be produced in the future, has lasting ramifications for agriculture and energy markets, as well as environmental and social clusters. It would be difficult to objectively measure each of the unique facets of ethanol production in one single paper.

Chapter 4 – Theoretical Discussion, Methods of Analysis, and Data

Economic Theory

Thus far the issues which surround the introduction of corn ethanol as a major substitution for transportation fuel in the United States have been examined. The RFS essentially creates a new demand for ethanol and stipulates the volume as well. But as far as the market structure is concerned, how should we expect the forces of supply and demand to interact? More specifically, what will happen to the commodity markets as this new demand places increased pressure on corn supplies and raises the level of competition for inputs? What will be the response by suppliers and what should that mean for market participants? These questions will be the subject of this chapter.

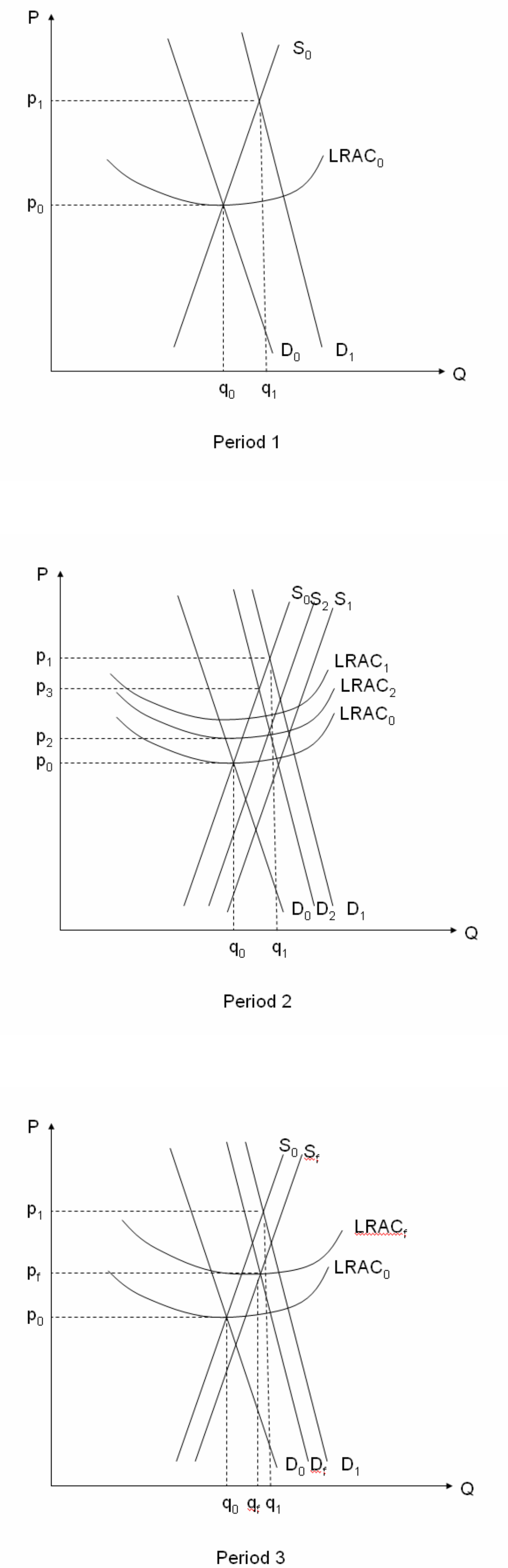
I emphasize again that the RFS does not mandate ethanol production. Rather, it creates a blending floor – the minimum amount of ethanol which a blender must mix into the gasoline supply from year to year. It also stipulates that by 2022, 15 billion gallons of the total 36 outlined in the RFS must come from corn-ethanol. Therefore, it is essentially a mandated purchase of ethanol produced from corn. This purchase of corn ethanol inevitably translates into purchases of corn. The corn purchase raises the first economic issue of derived demand.

The first laws of supply and demand are simple. The economic community universally recognizes that as supply increases, so does downward pressure on prices, *ceteris paribus*. If supply decreases, prices will increase *ceteris paribus*. Conversely, if demand increases price will follow by increasing as well. If demand decreases, there is a relative oversupply of goods and therefore prices will fall.

When the U.S government introduced and implemented the RFS, they essentially created an indirect demand for a proportional quantity of corn. It is reasonable to apply the assumption that the demand for corn is proportional for two reasons: 1) The conversion efficiency of corn to ethanol has basically flat-lined at 2.7 gallons of ethanol per bushel of corn, and 2) The RFS defines fixed minimum blending amounts for refiners. For example, in 2015, the RFS commands that 15 billion gallons of corn ethanol be used in the national transportation supply. Therefore, this also mandates the use of approximately 5.55 billion bushels of corn. Unless, the conversion ratio improves considerably, this is a direct and proportional level of corn use, tied to the RFS.

In that case, assuming no other demand factors change, the effects of the RFS on supply and demand can be illustrated through the charts in Figures 4. The changes can be summarized in three basic events or periods. The first event will be an initial shock to the demand profile for corn. This will result in the demand curve shifting outward, causing price to increase substantially and generating real economic profit to corn producers. The second period will mainly be a period of price discovery. This will include incremental adjustments in supply, demand and long run average costs and prices will be quite volatile as the market searches for a new equilibrium price. Finally, as supply adjusts to meet demand at the minimum long run average cost, equilibrium price will be discovered at a level greater than the preceding period. In the long-run, industry profits will fall again to zero and the market as a whole will face the fundamental challenges inherent to agriculture, such as the technological treadmill. An important assumption to this analysis is that the change in demand is a one-time event in slight contrast to the ongoing expansion of the RFS. The perspective will be that from the final results of the maximum

Figure 4. Theoretical Changes in Supply, Demand and Costs.



defined amount of corn based ethanol in the RFS, i.e. in 2015 and beyond. In stating this assumption, it would be plausible for these changes to occur periodically, each time the RFS is adjusted. However, the net effect will be the same, although the short-run impacts will be drawn out over a longer period. The assumption is also made that aside from the RFS, normal growth or contraction (as affected by continuous economic conditions) will occur in the other corn-demand centers. A more detailed explanation of each period now follows.

Period 1

I have already described how the RFS defines a direct quantity of corn usage. The net effect of this action is an outward shift in the demand curve shown in Figure 4. The effects here do not yet transpire into the marketplace. At the current historic levels of corn production around 10 billion bushels, this demand shift will be by an amount of 50% or more after including the whole 15 billion gallon ethanol mandate. This will create a major deficit in corn supply.

The more noteworthy change is a loss of stable equilibrium price. The new temporary equilibrium price at the intersection of the original supply and the new demand is well above the industry long run average cost. Thus, there is economic profit in the industry and from the theory of competitive markets, this can not exist in the long run.

Period 2

Period 2 is really a period of adjustment. After the demand has been established, higher prices and higher profits signal to producers that the quantity supplied is too little to meet demand. Existing producers expand production by increasing acreage, buying higher-yielding seed or intensifying cultivation practices. New entrants also seize the opportunity to take advantage of profit taking in the new environment. These are the firms which may have been priced out of the market in the past due to production costs which exceeded the market price. In agriculture this may equate to bringing acreage into production that is marginally productive, but essentially new supply is added to the industry. The new supply is driven by more attractive prices that formerly discouraged added production.

The defining aspect of this behavior is uncertainty. The relationship between the supply and demand functions are determined by what Adam Smith termed "the invisible hand." In this day and age, many of the invisible fingers of the hand have been identified and it is their behavior which remains imperfectly detectable to economists today. I submit that the uncertainty factor may actually be the arm to which the invisible hand is attached.

For example, if I am a corn producing farm in a stagnant market, it is fairly simple to determine my production costs and profitability. If input costs are stable, financing is acquired and my operating procedures established, I can predict within narrowly defined expectations what effect the weather and other uncontrollable risks will have on my farm. This is only possible because the uncertainty of the future of my production is limited. It is also facilitated by my expectations for a stable market in which to sell my corn, if we make the assumption that it is so.

However, even if the market is established or expanded, such as it is with the RFS, the uncertainty may cause me to over or under-react in my production practices. For example, if I know that demand has shifted outward, I no longer know how the cumulative supply base is composed. I will be uncertain about the production of corn producers in neighboring markets whereas before, the market was stable. Will they produce more in response to the new demand? How much more? Perhaps other areas will more than compensate the new demand with increased supply. In that case, if my farm increases output, then I have overproduced and the market will respond with depressed prices. If the total supply hesitates, and I keep my production steady, then I will have under produced, contributing to higher market prices but for a smaller quantity than I otherwise could have been compensated.

A difficult phenomenon perpetuates this cycle of uncertainty in agriculture. Grain crops throughout the world are produced once a year. Excepting weather, crop production cannot be altered for that marketing year once planting has taken place. In the current year, prices may be exceptionally high, signaling to producers to expand production. During the idle months farmers may accumulate inputs, operating loans and labor in preparation for taking advantage of the higher prices the next year. However, if the industry as a whole increases output in the next year, then there may be a surplus. The surplus will conversely discourage increased output or lead to decreased production. While other industries may be able to react more quickly, output in agriculture is mostly determined once a year.

There is another issue of uncertainty especially relating to corn production. In many parts of the corn belt, corn is grown in rotation with soybeans or cotton. If more acreage is devoted to corn at the expense of these other crops, then there may be a shortage in those markets. This will drive prices for soybeans and cotton higher and possibly lead next year's producers to favor them over corn. The market will go through a "learning curve" as it attempts to find the equilibrium price for each of these commodities as well as the right supply. This also occurs on the demand side. If I am a food processing firm, how much should I pay for corn as an input? If I pay the current price with the expanded demand, I may not get enough corn because the market will have bid the prices higher in light of the deficit. However, if I pay a higher price, I run the risk of paying too much and overcompensating what the market dictates.

The crux of the problem in both of these cases is a lack of an established equilibrium perpetuated by uncertainty. The individual effects will be multiplied thousands of times on both the supply and demand side causing the market to take huge swings in each direction. It will continue as long as the future outcome of prices and the overall supply-demand relationships are unknown and unreliable. In fact, each action will lead to lesser reactions over time and this will continue until the market equilibrium is settled. These over and under reactions are what lead the trading centers to be characterized by increased volatility. It is the law of unintended consequences in play. While the RFS aims to address climate change, farmer income and energy independence, it says nothing of uncertainty or volatility.

These responses will also set off chain reactions in the farm input markets. While resources are limited, the demand for inputs will increase sharply over existing supply. For farmers, cash rents will rise, fertilizer prices will increase, seed will cost more labor will be strained and farm equipment will have to stretch to increase output.

But all firms and all land are not created equal. In the case of new producers, they are only enticed to enter the market by the higher prices. They would have previously been excluded from the supply because their marginal costs of production were too high. Likewise, the land which was previously not used for corn, was either more valuable being used for the previous crop, or as sitting idle in the CRP. Because of these two factors, the supply will only expand until it is no longer profitable for new firms or new acres to enter the corn market.

But the price signals in each period will determine the outcome of these effects. With the level of demand established, each time there is a supply response, the market will transmit a signal in the form of a temporary equilibrium price. In the next production period, the signal will either deter or entice a change in corn production accordingly, opening up to or excluding additional supply. This continues until the equilibrium supply is settled and the relative price is discovered. But this price discovery will most likely be multidirectional until the market settles, as explained by the uncertainty and behavior of equilibrium levels. It would seem that at the time of the writing of this thesis, the corn market is in this period 2 of price discovery.

Period 3

Period three is characterized by a few simpler but identifiable events. In the first case, a new equilibrium is established. This is made possible by a decrease in the fluctuations in supply and the new supply base sufficiently meeting the existing demand. The volatility in the market is now limited to what the historical factors have always been, such as weather, technology, etc.

In Figure 4, the most intriguing aspect of the new equilibrium is revealed. The new price is actually very near the old price. The new price should not settle below the old price. The new price would likely by higher than the old price, but only insomuch as production functions of producers and corn buyers have been changed by the general economy. Although a detailed analysis of the mathematical properties of the supply and demand curves will not be given here, it suffices to say that any increase in the new equilibrium price will be limited by these factors. The price cannot magically increase over historic levels beyond inflationary support and the nature of the supply, demand, and long run average cost curves.

Method of Analysis

The three specific objectives of this thesis as set forth in chapter one are to:

1. determine if there has been a structural change in the supple, demand and price relationship in the corn industry;

2. determine if commodity brokers believe that the futures market is still effective tool manage price risk for their clients; and

3. determine how farm profitability and risk has changed as a result of ethanol policy with its intended and unintended consequences.

The methods to achieve each of the objectives are now discussed. There is a separate subsection for each objective.

Structural Change

The theoretical discussion above suggests that there should have been an initial period of rapid price increase in period one, following the passage of the RFS ethanol mandates. This should then be followed by a lengthier period of price volatility in period two. At the time of this thesis being written, the corn market is in period 2. Empirical evidence exists to substantiate the theory. Monthly corn futures prices for the nearby contract on the Chicago Board of Trade will be evaluated over the last ten years. A plot of these prices is instructive to look at the price increase following the ethanol mandates.

The standard deviation of the monthly prices will also be calculated for the time period prior to the 2005 RFS and then for the period following that time period.

From the theoretical discussion, it was also postulated that there would be shifts in supply in period two as producers responded to increased profitability. The most quantifiable change which commodity producers have in their power is how much acreage to plant. Production is defined as yield per acre times acres, but yield is out of the control of the farmer. Yield varies by technology and weather. It is true that producers are able to influence yields through farm practices, especially fertilizer applications, but as a general rule, commodity yields increase at a steady rate from year to year.

Acreage planted, on the other hand is in direct control of the producer-farmer. If prices go up, for example, and lead the producer to increased potential for higher returns, the response will typically be to expand production through plantings. This expansion may come in the form of reduced acreage of other crops, or may extend into cultivating marginal fields which were previously left idle (including CRP acres). But fundamentally, there may be no better approach to measuring market behavior on the supply side than to analyze acreage shifts. Planted acreage will be used, as this is the factor which a producer has in his control and, therefore, it is a good measure of market behavior. Harvested acres also provide good insight, but are less reliable since factors out of producer control influence these numbers.

Actual acreage, the change in acreage, and the percent change in acreage from 1996-2008 will be evaluated for the top ten major crops grown in the US. Then corn acreage changes will be evaluated over the same time period. Since corn in the south is frequently grown in rotation with cotton and in the north in rotation with soybeans, acreage changes of these three crops will be looked at as well. Wheat and corn do not typically compete for the same acres. However, an analysis of wheat acreage will also be undertaken to see if those acres have been altered by changing corn acres.

The theoretical section suggested that during period two, supply, demand and costs may all be changing simultaneously. Many of our economic tools, such as measures of elasticity, are only valid when one thing changes and everything else is constant. A primarily graphical analysis will be conducted on the corn, soybean and wheat market evaluating the ratio of price to supply. This measures the historical relationship between these two variables and establishes the historical norm for proportional changes. The statistic is calculated by dividing the average price received for the corresponding crop marketing year by total supply of each commodity in bushels from 1970 through 2008. In order to smooth the fluctuations in these numbers, a three-year moving average is calculated resulting in new data for 1972 through 2008. This three-year moving average is in the analysis.

The data are divided into two time periods: Pre-RFS (1972 – 2005) and Post-RFS (2006-2008). First, the mean is calculated for all data points in the group. Then, the standard deviation of the set is measured. Recall the RFS was signed into law in July 2005, after that year's crop decisions had been made. For each of these time periods, the average deviation from the overall mean is calculated. A more localized time period is also evaluated from 2000 – 2008 while still segregating the pre and post RFS periods.

Many participants in the corn industry have used ending stocks, or expected ending stocks, as a key measure to predict corn price. Expected ending stocks are defined as:

Expected ending stocks = beginning stocks + production + imports - seed & industrial – exports – feed & residual

where expected ending stocks are the bushels expected to remain in storage at the end of the marketing year; beginning stocks are the prior years ending stocks; production is the crop year annual production; imports are total imports; seed & industrial are the quantity of the crop used for seed and for all industrial use; exports are total crop exports; and feed & residual is the quantity used as feed. All measures are in bushels.

A smaller ending stocks or expected ending stocks are generally expected to increase price while a larger ending stocks are expected to decrease price. The relationship is also not likely to be linear. When stocks are expected to be very small, price may increase substantially to effectively ration the smaller supply. On the other hand, there has generally been some level of price support to prop up prices when the ending stocks are very large.

The following equation is estimated using OLS regression to determine the nature of this relationship:

(1) $PC_i = b_0 + b_1*ES_i + b_2*ES^2_i + e_i$

where PC is the price of corn in dollars per bushel, ES is the ending stocks in 1,000 bushels, ES^2 is ending stocks squared, e is an error term and i is a subscript for crop year from 1989-90 to 2008-09. Prior government policy had resulted in huge stock of corn in the mid 1980's. This policy was changed and stocks were drawn down in the late 1980's. That is why stocks are evaluated since 1989. The first 14 years of data will be used to estimate the equation and then the last six years will be predicted based on the parameter estimates of the equation. The mean square error, MSE, will be determined and compared for the estimation time period, for the 2003-04 to 2005-06, and for the 2006-07 to 2008-09 time periods. MSE is defined as follows:

(2) $MSE = (PC_i - \text{predicted } PC_i)^2/n$.

Evidence of structural change will be noted if the MSE substantially differs for either of the predicted time periods.

The ending stocks to use ratio is a key measure used by industry participants to make price forecasts and to help guide production, storage and other marketing decisions. It is defined as the total ending stocks divided by the total use for a particular crop. This ratio is essentially designed to determine the number of days which an agricultural industry could operate into the current crop year given the level of ending stocks of the previous year. Implicitly, a smaller ending stocks should support prices because falling stocks might indicate a shortage. Conversely, rising stocks would depress prices because this trend might indicate an oncoming surplus. A graphical analysis will be undertaken for corn, soybeans and wheat evaluating the stocks to use ratio and price for each of these crops.

While ending stocks is an often used measure to predict price, it is not effective for evaluating individual supply or demand components impact on price. The following equation is used to evaluate the individual components impact on price and to determine if the government mandates on ethanol use has impacted these relationships:

(3) $PC_i = b_0 + b_1*BS_i + b_2*PROD_i + b_3*IND_i + b_4*FEED_i + b_5*EXP_i + b_6*MDATE_i + b_7*INDxMDATE_i + e_i$

where PC is the price of in dollars per bushel, BS is beginning stocks in 1,000 bushel, PROD is production in 1,000 bushel, IND is food, seed and industrial use in 1,000 bushel, FEED is feed and residual use in 1,000 bushel, EXP is exports in 1,000 bushel, MDATE is a 0/1 dummy variable that takes on the value of one for the crop years 2002-03 though 2008-09 when federal mandated for ethanol use were imposed, INDxMDATE is an interaction term between the government mandate and the food, seed and industrial variable, and e and i are as previously defined in equation 1. A priori expectations are that the parameter estimates for BS and PROD will be negative and that the parameter estimates for IND, FEED and EXP will all be positive. If either of the parameter estimates for MDATE or INDxMDATE are significantly different from zero, than this will indicate a structural change in the model; MDATE being a change in the intercept and INDxMDATE being a change in the slope of the IND parameter.

Futures Market Use

One of the objectives of this thesis was to determine if the structural changes in the corn market and the perceived increase in volatility by industry participants were impacting the futures market. More specifically, are traders able to still use the futures market to hedge corn or are speculators dominating this market. Primary data will be collected via a survey to various commodity futures brokers throughout the United States. The survey in full can be reviewed in Appendix A. The justification for the survey is to gauge the perspective of those closest to the market trading activities to answer the question posed by the objective.

The brokers to be surveyed were selected from a list of those most likely to service commercial trading demand, i.e. commodity producers, traders and users. By selecting survey participants from this group, whether or not the commercial side of the market is overwhelmed by new speculation may be determined. The results of the survey should expose whether or not there has been a tangible shift in trading activity since the RFS. If there has been such a shift, then the claims by market participants regarding speculation and its influence on price increases may be founded to a certain degree.

Overall, the survey was distributed to 88 country brokers selected from various online phone directories. The criterion was to select as many as contact information was available for independent or small brokerage firms in 17 major agricultural states. The survey was sent via regular US mail and also via email to those brokers who had an email address listed on their contact information. The survey could be completed on paper and returned in the US mail or it could be completed in an on-line interactive PDF file and returned electronically. A follow-up letter and email were also sent out to those who had not responded, requesting their response to the survey.

Once the surveys were returned the data were entered into a spreadsheet to check the data. Means and proportions were determined for the variables that were appropriate. A qualitative analysis was also undertaken, as some of the questions were requesting a written response from those surveyed.

Farm Sector

An enterprise budget for corn production from University of Arkansas Cooperative Extension Service is employed to estimate the effects of the RFS on farm income. A per acre analysis of costs is used in the budget. The budget was compiled for center-pivot irrigated corn in loamy soils and includes a breakdown of variable costs and fixed costs. Net return is calculated by subtracting variable costs plus fixed costs from total revenue. Total revenue is calculated by multiplying yield per acre in bushels times the price per bushel received.

The analysis is performed for two distinct periods representing the pre RFS and post RFS market conditions. The most significant differences between the two periods as indicated by national data are farm-gate price received, fertilizer costs and fuel price. To account for these changes, the same method is used for each of the three variables as follows.

First, all factors other than price received, fertilizer price and fuel costs defined by the published budgets are left to remain constant as given by the author. These factors are considered relatively constant throughout both periods by the author of this thesis. Second, for each of the variables of interest, summary statistics are calculated for the two periods.

For the pre RFS period, an average farm gate price and the standard deviation for monthly data is calculated from January 2000 through January 2005. For the post RFS period, the average is calculated from January 2008 through November 2008 while the standard deviation from January 2005 through November 2008 is used. The reason for this difference is that the period of interest being measured here is the year 2008. Average prices received in 2008 were higher than in 2007 and 2006. However, the relative volatility, as measured by the standard deviation here was relatively constant from 2005 through 2008. These two statistics are more relevant to each other from a practical standpoint. Fertilizer costs are calculated in the same way as corn prices.

Fuel price calculations are slightly different. For the pre-RFS period, the mean used is from March 2005 through October 2005 while the standard deviation is calculated from November 2000 through October 2005. For the post RFS period, the mean used is for March 2008 through November 2008 and the standard deviation is calculated for

November 2004 through November 2008. The justification lies again in practicality. While fertilizer and corn prices are commonly contracted and locked in throughout all times of the year, fuel is typically purchased on an ongoing and as-needed basis. Because use of farm machinery is typically being used from March through November from year to year (the planting to harvest months), this mean is chosen to represent more accurate costs. The standard deviations are more uniform for the whole periods, however, which make them more relevant to the calculations.

The Arkansas corn budget is analyzed by Simetar®, simulation and econometrics to analyze risk. This program is an add-in for Microsoft® Excel and allows for built in Monte Carlo simulation of outcomes based on historical data. The statistics described for the variables above are allowed to change within the budget based on a defined distribution. The distributions used in this analysis are all normal distributions based on the means and standard deviations calculated by the methods described previously. The simulation program uses the given distributions of the variables then runs a numbers of simulated outcomes for the number of times defined by the user. The number of iterations used in this analysis is 500. This is meant to represent 500 possible outcomes in net return per acre based on the distribution and means of the fluctuating components with their own calculated variability.

Data

Most of the data used in this analysis is compiled from public sources such as various U.S. government agencies. Researchers are fortunate in this country to have access to the vast array of data available from organizations like the USDA and others. Most of this is secondary data and the author gives credit to the sources. Primary data was also collected for the market analysis section below. All the data used in this thesis are national in scope except for the data collected from the survey.

Fundamental Analysis

All data used in the analysis of acreage shifts are compiled from the National Agricultural Statistics Service. The agricultural statistics database was queried to obtain statistics of the planted and harvest acres, production in bushels and the marketing year average farm price.

The price analysis is primarily performed using price data from the Economic Research Service at the USDA. Prices are marketing year averages for farm gate prices received. The corn utilization for this analysis is also collected from the ERS. In all cases, the data may be accessed at the feed grains database custom query on the internet. The data for beginning stocks and total supply are compiled from the Foreign Agricultural Service production supply and demand estimate online query.

The charts and data of ethanol other uses of corn were gathered from the feed grains database at the ERS. The same price data is used as for the previous analysis.

Futures Market Analysis

The main analysis of the futures market was performed by a direct survey to 88 commodity brokers throughout 17 crop producing states. The states included in the list were: Colorado, Idaho, Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, Ohio, Oklahoma, Oregon, South Dakota, Washington and Wisconsin. The list was compiled using phone directories for each state in the covered area. While the list was not perfectly random, the recipients of the survey represented most of the country brokers which could be found in local telephone directories.

Farm Income Sensitivity

Farm gate prices used in the sensitivity analysis are gathered from the NASS quick stats database for individual states. These prices are the monthly average farm price for the corn in Arkansas. Fuel prices are gathered from the U.S. Department of Energy Information Agency. The EIA maintains a database of retail level prices for various types of fuel on a regional basis. Fuel prices used here are for PADD II, the Midwest region. Retail diesel prices are used in place of farm diesel prices for two reasons: the price difference will vary from state to state according to local tax schedules and these prices will follow the exact pattern of farm diesel prices in each locality. The prices changes are what are important in the analysis. Finally, fertilizer prices are compiled from the ERS index of fertilizer prices accessible online.

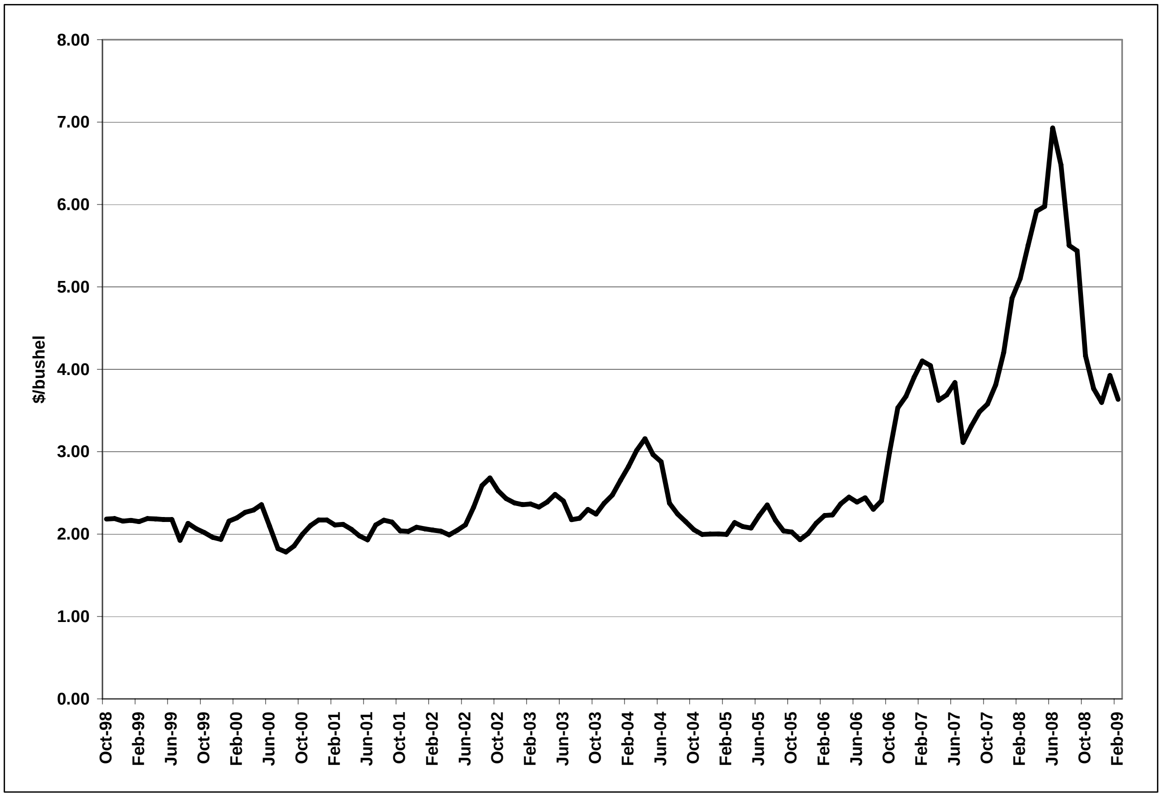
Chapter 5 – Results

This chapter will begin with an analysis of the shifts in fundamental factors of the corn and related crop markets. This will begin with a look at historical corn prices, followed by an overview of the acreage profile, a statistical analysis of the relationship between supply and price and finally a simple breakdown of corn use and supply, segregating ethanol use from other domestic uses of corn. Following the fundamental analysis will be an analysis of the volatility in the corn futures market and a synopsis of the changing structure of the futures markets from the survey of futures brokers. The last section will review the results of sensitivity analysis performed on farmer enterprise budgets for corn production in different producing regions.

Structural Change

This section will begin with the empirical representation of what was expected in the theory for period one and two following the demand shock: a chart depicting a rapid increase in monthly prices followed by a period of volatility is displayed in Figure 5. It is quite apparent that prices rose rapidly following the 2005 and 2007 RFS mandates. This is what was expected based on the theoretical discussion in the initial period. However, prices have also fallen recently, indicative of moving into a period of changing supply and demand as the market searches for a new equilibrium. It is true that general economic conditions have deteriorated and have influenced this drop as well, but perhaps this was only enhancing the expected effects as outlined above. The standard deviation of these monthly prices was also calculated for the period prior to the 2005 RFS introduction and for the period since then. The standard deviation for the pre-RFS period was 0.263 and it was 1.326 for the post-RFS period. This empirical evidence supports the theory that

Figure 5. Monthly average corn futures price for the nearby contract, Oct 1998-Feb 2009.



suggested prices would become more volatile as the market searched for a new equilibrium.

Acreage Analysis

Table 3 summarizes the acreage changes from 1996 – 2008 for a ten crop set. The ten major crops included in this group (as defined by the ERS) are all barley, corn for grain, all cotton, oats, all potatoes, all rice, sorghum for grain, soybeans, sugar beets and all wheat. These crops represent the majority of food and feed commodities produced throughout the United States which is why they were chosen. The most striking aspect of this table is that from year to year the changes in total acres fluctuates no more than 2-3%. In fact, from 1996 through 2008 there was actually a decrease of approximately 9

Table 3 . Ten Crop* Acreage Changes 1966-2008 *(thousands of acres).*

Year	*Total Acres*		*Year to Year Change*		*Year to Year Percent Change*	
	Planted	*Harvested*	*Planted*	*Harvested*	*Planted*	*Harvested*
1996	264249.1	238687.5				
1997	262546.4	242375.3	-1702.7	3687.8	-0.6%	1.5%
1998	259866.9	234682.9	-2679.5	-7692.4	-1.0%	-3.2%
1999	255415.8	234721.4	-4451.1	38.5	-1.7%	0.0%
2000	259133.5	232084.4	3717.7	-2637	1.5%	-1.1%
2001	252209.4	227620.8	-6924.1	-4463.6	-2.7%	-1.9%
2002	254374.2	222284.3	2164.8	-5336.5	0.9%	-2.3%
2003	253957.9	230768	-416.3	8483.7	-0.2%	3.8%
2004	252502.2	228548.4	-1455.7	-2219.6	-0.6%	-1.0%
2005	246983.7	226448.9	-5518.5	-2099.5	-2.2%	-0.9%
2006	247187.7	218104	204	-8344.9	0.1%	-3.7%
2007	250532.1	226823.6	3344.4	8719.6	1.4%	4.0%
2008	255662.9	220912.1	5130.8	-5911.5	2.0%	-2.6%

Source: NASS, USDA
**Crops included: barley, corn for grain, all cotton, oats, all potatoes, all rice, sorghum for grain, soybeans, sugar beets and all wheat*

million acres planted. One would expect that with the RFS, there would be a net increase in planted acreage in order to sustain the added demand. The 9 million acre decreased acreage is about a 3% drop overall. While this does not directly represent total supply of crops due to yield improvements over these years, it serves as a good starting point for our analysis.

As we move toward the implementation of the RFS in 2005, we begin to see larger swings in acreage overall, with a net increase of 3.5% from 2005 to 2008 (about 8.6 million acres). But the industry still falls short of 2000 acreage and the highest in the set at approximately 264 million acres in 1996. But overall, we *do* observe three consecutive years of increasing planted acreage from 2005 onward. We might say that this is the market responding to increased profitability by expanding supply.

Of course, the commodity of primary interest here is corn, summarized in table 4. As we correlate the corn plantings with overall acreage, there is an ambiguous link. We would expect to find that corn acreage increases concurrently with overall plantings since corn is the crop used to meet the RFS. But the planted acreage shows a decrease, then an increase followed by another decrease in planted acres from 2005 to 2008. This is a contradictory signal in that one would expect there to be a continued acreage expansion in corn. This can not be explained perfectly by the data here, but it is noteworthy that from 2005 to 2006 there was a 4% drop in planted acres, the very year after the RFS was first implemented. One might suspect that it may have been enacted after it was too late to change 2006 planting decisions, but the Energy Policy Act of 2005 (which outlines the

Table 4. Acreage Shifts in Corn 1996 – 2008 *(thousands of acres)*

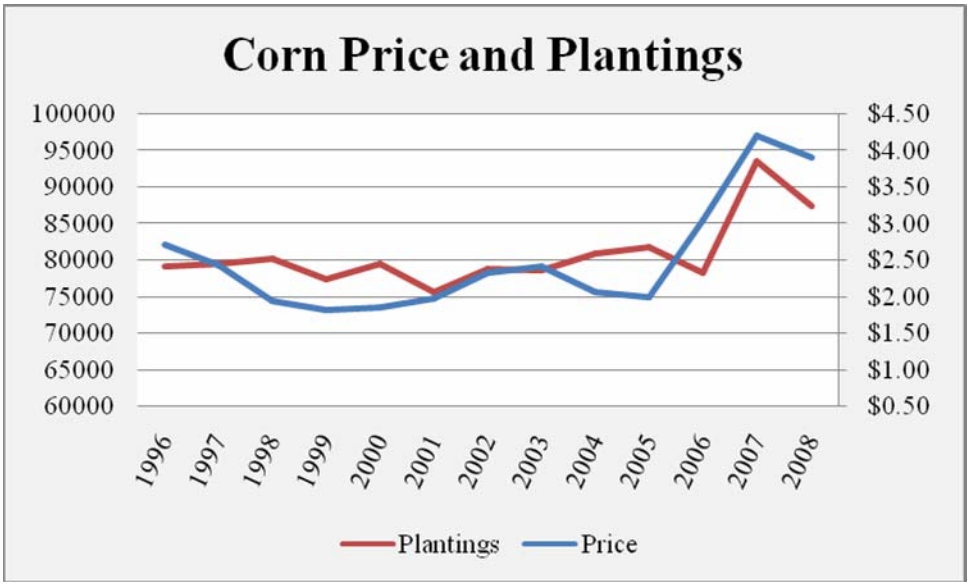
Year	***Total Acres***		***Year to Year Change***		***Year to Year Percent Change***	
	Planted	*Harvested*	*Planted*	*Harvested*	*Planted*	*Harvested*
1996	79229	72644				
1997	79537	72671	308	27	0%	0%
1998	80165	72589	628	-82	1%	0%
1999	77386	70487	-2779	-2102	-3%	-3%
2000	79551	72440	2165	1953	3%	3%
2001	75702	68768	-3849	-3672	-5%	-5%
2002	78894	69330	3192	562	4%	1%
2003	78603	70944	-291	1614	0%	2%
2004	80929	73631	2326	2687	3%	4%
2005	81779	75117	850	1486	1%	2%
2006	78327	70648	-3452	-4469	-4%	-6%
2007	93600	86542	15273	15894	19%	22%
2008	87327	78940	-6273	-7602	-7%	-9%

Source: NASS, USDA

RFS) was signed in July of 2005. There would have been plenty of time to prepare for the new demand.

This may explain the dramatic reaction in 2007 plantings. Here we see that planted corn acreage was 19% higher than 2006 in 2007. In figure 6 we can also observe that the average price of corn was $2.00 in 2005, not a signal to significantly increase output. Therefore, acreage declined in 2006. However, in that year the average price of corn increased to historic highs at $3.04 per bushel, a modest 50% increase over the previous year. This would at least partially explain the rapid response in acreage in 2007. The price-leading behavior is illustrated in the chart well. It is quite obvious, especially in the most recent years that planted acreage positively responds to a change in price. What is not explicit here is the decline in acres following a peak in prices for the 2007 point. But the prices here are the average for a marketing year, whereas the plantings are formulated once in the springtime. Although the average for 2007 may have been the historical high, the last half of the marketing year would have fallen, leading to a lower price in 2008. This falling price would be the signal to producers to cutback production and decrease output in the following year. There are agronomical reasons for this behavior as well. Soybeans and cotton are often grown in rotation with corn. Even when a price is higher than average, farmers recognize the scientific advantages in the long-term of continuing this rotation in spite of better current prices. The acreages related to this phenomenon are analyzed following here. Prices continued to improve, especially in the spring of that year into the new crop marketing year, yet acreage fell by 7%. It may be too early to tell, but was this more of a response to the anticipated feedback that 2007 was an overreaction to market signals? There must be other factors involved. A key to

Figure 6. Corn Price and Plantings 1996-2008.



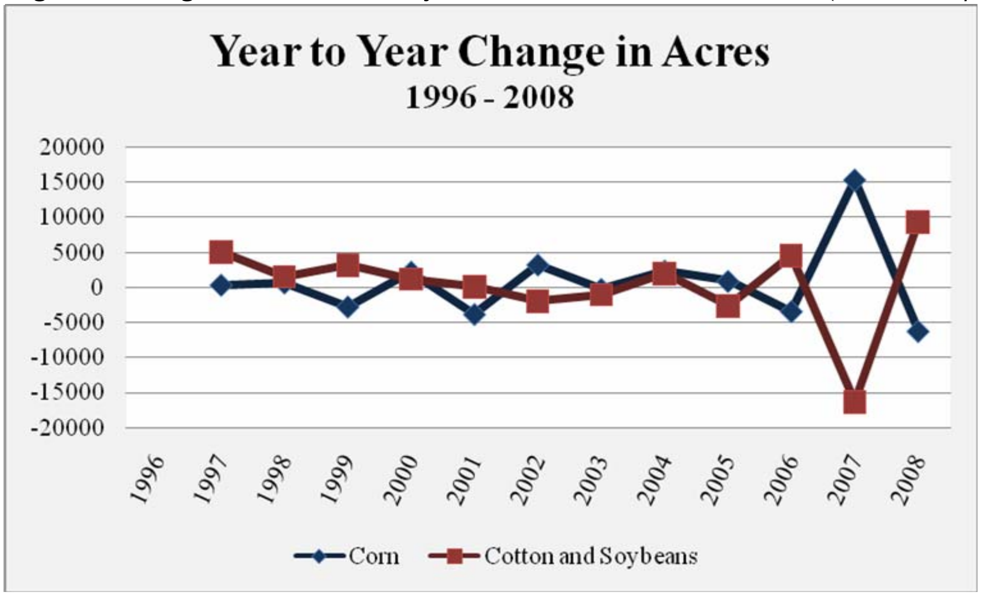
Source: NASS, ERS

answering this question is in part revealed by the harvested acres in 2007. Favorable conditions led to a 22% increase in harvested acres over 2006, which would have increased supply more than anticipated. This may have led to the decline in 2008.

Returning to the inconsistent behavior of the ten crop set and corn, I will mention again the relationship between soybeans, cotton and corn. Crops are traditionally grown in rotation with a complementary commodity. In the case of corn, this relationship is met by soybeans and cotton. Therefore it is necessary to explore the behavior in these market segments as well. Figure 7 shows the inverse behavior between corn and the cotton-soybean complex. This graph plots the percentage changes in planted acreage from year to year for corn and the sum of soybeans and cotton acres.

A quick observation can be made that these changes in acreage are almost exactly opposite each other and would explain where the additional corn acres would be coming from. In fact, in the most dramatic year of acreage changes for corn, 2007, we see a

Figure 7. Changes between Corn, Soybean and Cotton Acres 1996-2008 *(thousands of acres)*



Source: NASS, USDA

nearly exact offsetting of acreage in the cotton-soybean complex. Table 5 shows that while 15 million additional acres of corn were planted, cotton and soybean acres were reduced by 16.3 million. These proportions are not always as close as this, but the fact that this fit occurred in the sharpest year of acreage shifts is significant to note.

Concerns have also been raised in the biofuels debate regarding the effects of the RFS on the food supply and influencing prices in the wheat markets. It is vital to understand that corn is not typically grown in the same areas as wheat. Hence the domestic terms “corn belt” and “wheat belt.” Agricultural markets recognize that the growing conditions required for these two starkly different crops are just as distinct as the crops themselves. But table 6 at least confirms that the corn acreage changes have not been in sync with changes in wheat. At the same time that corn acres experienced years of ups and downs in planted acreage, wheat followed the trends of the 10 crop set, for all twelve years of these datasets. Note the 19% increase in corn plantings (15 million acres)

Table 5. Planted Acreage Shifts in Corn, Soybeans and Cotton 1996 – 2008 *(thousands of acres)*

Year	*Total Acres*		*Year to Year Change*	
	Corn	*Cotton and Soybeans*	*Corn*	*Cotton and Soybeans*
1996	79229	78847.5		
1997	79537	83903	308	5055.5
1998	80165	85417.5	628	1514.5
1999	77386	88603.5	-2779	3186
2000	79551	89783.2	2165	1179.7
2001	75702	89843.5	-3849	60.3
2002	78894	87920.9	3192	-1922.6
2003	78603	86883.6	-291	-1037.3
2004	80929	88866.6	2326	1983
2005	81779	86277.4	850	-2589.2
2006	78327	90796	**-3452**	4518.6
2007	93600	74458.2	15273	-16337.8
2008	87327	83779	-6273	9320.8

Source: NASS, USDA

Table 6. Planted Acreage Shifts in Wheat 1996 – 2008 *(thousands of acres)*

Year	*Total Acres*		*Year to Year Change*		*Year to Year Percent Change of 10 Crops*	
	Planted	*Harvested*	*Planted*	*Harvested*	*Planted*	*Harvested*
1996	75105	62819				
1997	70412	62840	-4693	21	-6.2%	0.0%
1998	65821	59002	-4591	-3838	-6.5%	-6.1%
1999	62664	53773	-3157	-5229	-4.8%	-8.9%
2000	62549	53063	-115	-710	-0.2%	-1.3%
2001	59432	48473	-3117	-4590	-5.0%	-8.7%
2002	60318	45824	886	-2649	1.5%	-5.5%
2003	62141	53063	1823	7239	3.0%	15.8%
2004	59674	49999	-2467	-3064	-4.0%	-5.8%
2005	57229	50119	-2445	120	-4.1%	0.2%
2006	57344	46810	115	-3309	0.2%	-6.6%
2007	60433	51011	3089	4201	5.4%	9.0%
2008	63457	56586	3024	5575	5.0%	10.9%

Source: NASS, USDA

in 2007. The biofuel antagonists suggest that this cuts into acreage available for wheat but in the same year wheat expanded by 5%. From 2005 - 2008, while corn decreases, increases, then decreases again in terms of planted acreage, wheat increases for all three years. This would suggest that the link between biofuels and raw supply of wheat is non-existent domestically. It does not however address the issue of substitutability between corn and wheat use. There may be an increase in wheat for livestock feed and other uses, decreasing its availability for food. This demand side tradeoff is not explored here but may support the food vs. fuel debate.

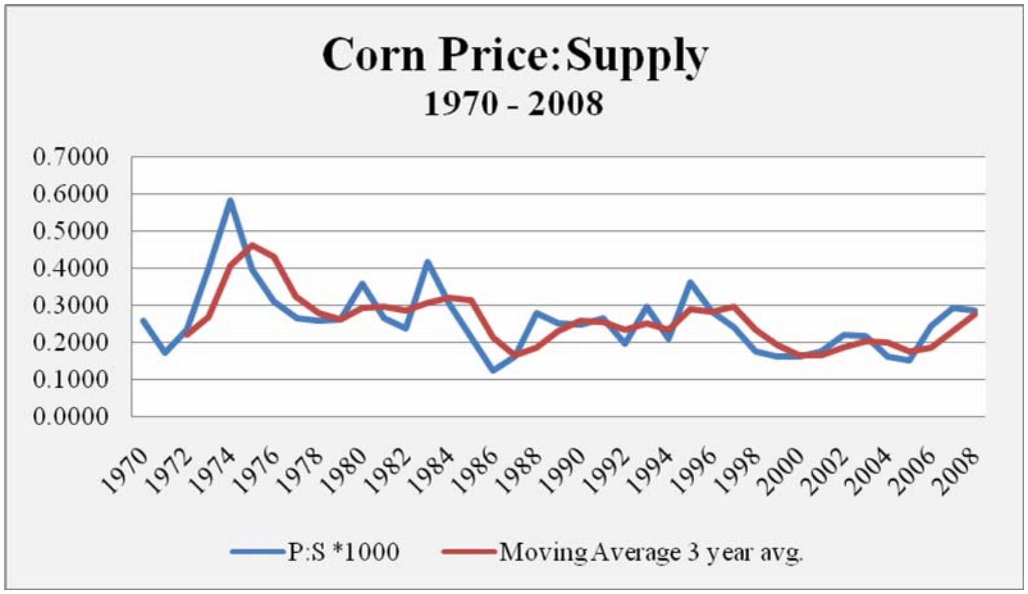
Price to Supply Ratio

A stark contrast between the pre-RFS and post-RFS periods is revealed. Structural change in each of the markets is identified where the average deviation from the mean after the RFS is much larger than before the mandates. This level of change varies somewhat from crop to crop, but the difference is dramatic. The tables and datasets for each crop may be found in Appendix B.

Figure 8 is a visual illustration of the price to supply ratio for corn. The fact that this is the least dramatic of the three crops analyzed here will be shown below. But the keys to understanding this chart are found in the spikes at different points. The peak in 1974 reflects the current events of the time. The Soviet Union was going through a period of grain shortages and U.S. farmers were obliged to accommodate them with supplies. That increased demand to such a point that prices increased faster than supply, raising the ratio from lower levels. Subsequently, smaller spikes occurred in the 1980's and 1990's as a result of droughts or minor changes in farm policy. The increase in 2006 is far less dramatic. This is reflected in the production shifts outlined in the acreage analysis above.

As price ballooned after 2006, supply expanded to the point of keeping in line with the historic proportions of the ratio. Again, this is very different from what is observed in soybeans and wheat.

Figure 8. Corn Price to Supply Ratio 1970-2008.



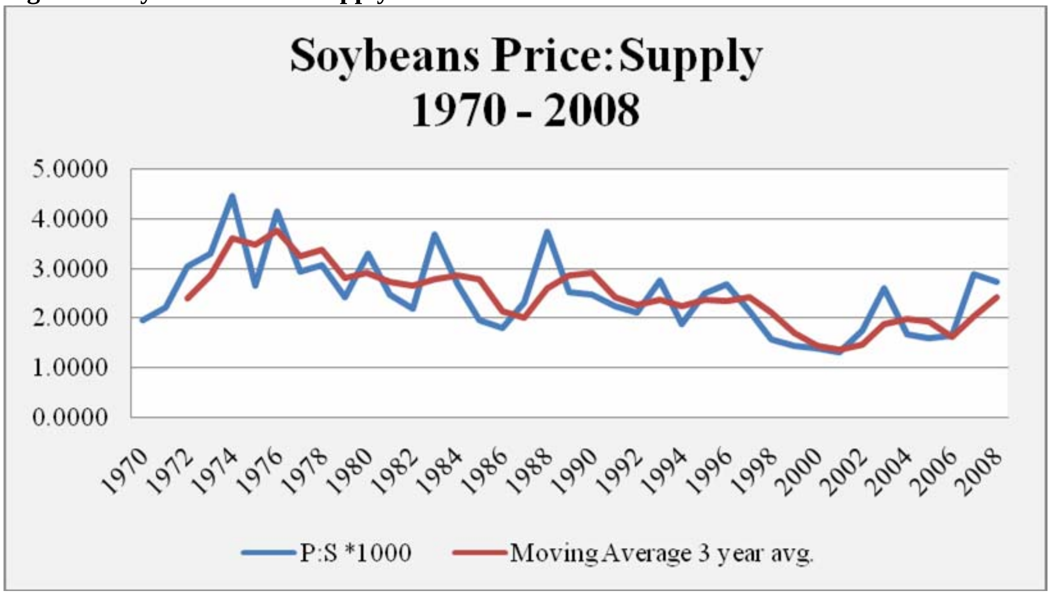
Looking on the surface, there is no identifiable structural change. But statistically speaking, we might say there is an identifiable structural shift. For the 35 year group, the mean was calculated at 0.2585. The standard deviation was 0.0705. In the first period from 1972 – 2005, the average deviation from the mean was 0.04. But for the period after the RFS, the average deviation from the mean was -0.41, indicating that the rate of change from the mean had changed to negative compared to all 35 years and at a similar proportion. However, this -0.41 average deviation was for 3 years versus the 0.4 for 32 years, suggesting that there might be a stronger adjustment in the later time span.

Looking at the short-term, we can see that this is true. The mean for the 9- year group was calculated to be 0.198. The standard deviation was 0.0348. For the period before the RFS was in place (2000-2005), the average deviation from the mean was -

0.37. But in the period after the RFS it strengthened to 0.80. This is more than twice as large as the previous period. It is an indication that a significant change has taken place in the market structure after the corn ethanol mandates have been made.

Moving over to soybeans, there is some consistency with what is happening in the corn market (see figure 9). Over the 35 year group, the mean of the price supply ratio in the moving average is 2.471 with a standard deviation of 0.5946. For the years leading up to the RFS, the average deviation from the mean was 0.07 compared to -.074, suggesting that price shrank faster than supply in the years after the RFS compared to previously. But again, the results are different when the time frame is shortened to reflect more relevant market conditions to the time which RFS began.

Figure 9. Soybean Price to Supply Ratio 1970 – 2008



The mean of the moving average from 2000-2008 was 1.806 with a standard deviation of 0.3423. The average deviation from the mean for the 9 year group before the RFS (through 2005) was -0.25. But after the initiation of the RFS, an average deviation of 0.37 from the mean is observed from 2006 to 2008 compared to the 9 years as a whole.

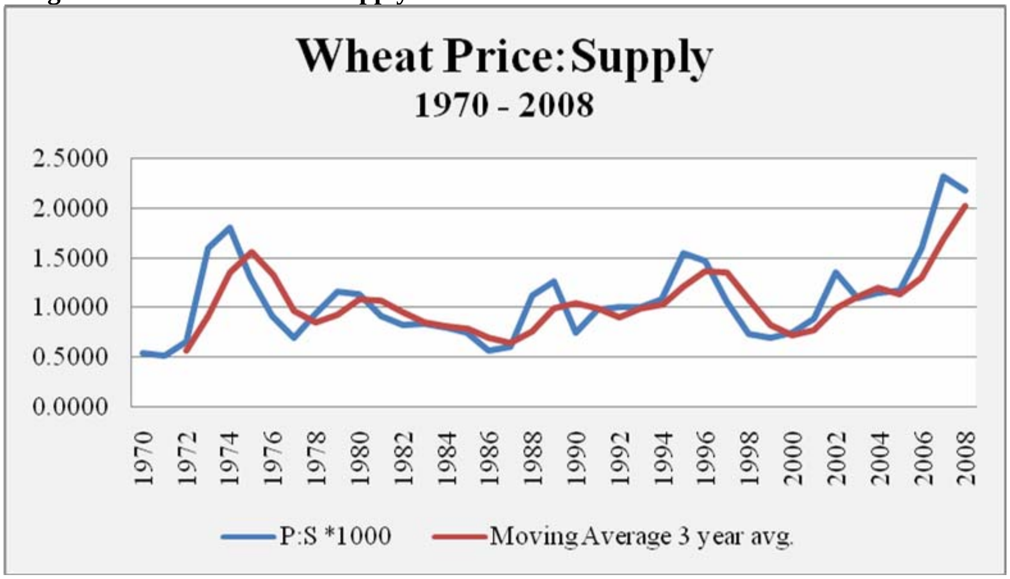
This implies that at least for the most recent decade, soybeans have likewise gone through an uncharacteristic structural change in the relationship of price to supply. It is no surprise when recalling that soybeans and corn are grown in concert with one another. Often the production of one is at the expense of another which is why it is vital to do the analysis on soybeans as well as corn. The consistency is evidence that there is actual behavioral and structural change taking place, at least in the corn-soybean complex.

The same analysis must be performed with wheat. The justification is to, again, review the possibility that the unintended effects of the RFS have transpired into other markets, especially the other grains. For the 35 year group of data in wheat, the mean of the moving average was 1.052 with a corresponding standard deviation of 0.2999. The average deviation from the mean from 1970 through 2005 was -0.18. But in the case of the years after the RFS, there is a stark difference to corn and soybeans. From 2006-2008, the average deviation from the mean was 2.08. Of course, this would demonstrate that the years after the RFS are sharply different for wheat than for corn and soybeans. This does not imply causality of the RFS to the changes in wheat, but it does represent the possible correlation between the two. Of course, as outlined below, this can be partially explained away by the stocks to use ratio for wheat in the next section, but it is an important question to ask. Figure 10 represents these changes for wheat.

In fact, the 9 year group may also explain away the relationship by diminishing the significance of the correlation to wheat market changes after the RFS. The mean of the moving average for 9 year group of wheat price to supply ratio was 1.22 and a standard deviation of 0.4168. The average deviation from this mean was -0.50 from

2000-2005 compared to 1.20 from 2006-2008. This presents an overall shrinkage of the price to supply ratio changes for the decade leading into the years of the RFS compared

Figure 10. Wheat Price to Supply Ratio 1970-2008.

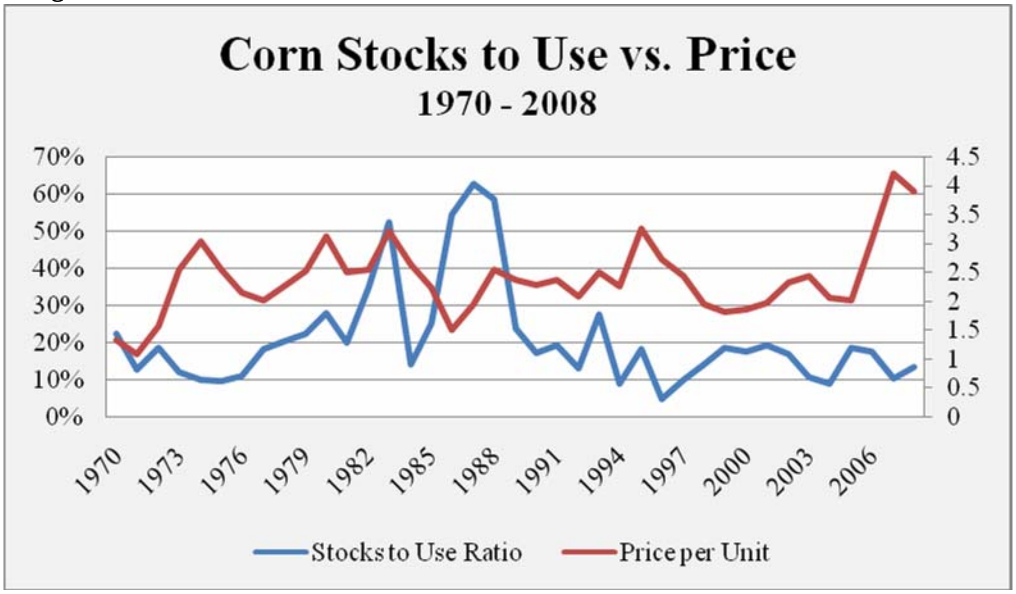


to the 35 year history of wheat. There is a simple reason that these changes would be different from corn and soybeans – they are based in agronomy. Wheat is grown in drier areas compared to corn and soybeans. The varying production conditions required for the three crops have led to the delineation of a corn belt versus the wheat belt regions of the United States agricultural profile.

Stocks to Use Ratio

The stocks to use ratio history for corn is different than the price to supply history of corn. For the years from 1970 through 1999, the stocks to use ratio averages 21%. Changes to the farm bill removed the huge stocks that were built up in the late 1980's, when stocks peaked in 1987 at 63%. The average for the current decade, 2000-2008, falls to 15%. Looking closer, the low was in 2004 at 9% followed by 10% in 2007. The ratio for 2007 would partially explain the upward support for prices that year and the rebound of stocks to use in 2008 to 14% would explain the slight slipping in prices there. Figure 11 illustrates these statistics very well. Notice the inverse relationship between

Figure 11. Corn Stocks to Use Ratio vs. Price 1970-2008.

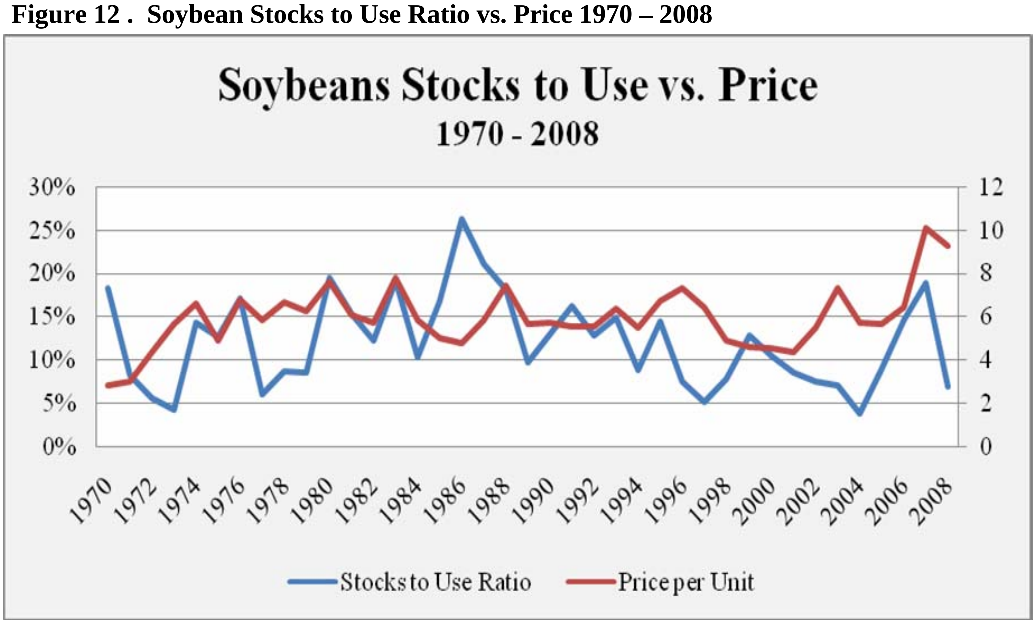


price and the stocks to use ratio. When the ratio is high, prices fall and when the ratio is low, prices rise. This behavior confirms the laws of supply and demand. Note however, the degree to which prices rise after the RFS from 2006-2008 as related to the stocks to use ratio. This dramatic swing in price would support the evidence of structural change as measured by the price to supply ratio.

Tying the stocks to use ratio into the price to supply ratio might indicate that although the statistical change in the price to supply ratio is limited, the dramatic upswing in price may not be fully explained. The proportion of price to supply increases at a slower rate than in previous periods of market upheaval, but the stocks to use ratio would indicate that there have been years with similar levels of stocks with less drastic price changes. One would assume that the demand has been sufficiently met and the 100% price increase is unaccounted for by a supply or demand analysis. It begs the question as to whether the $4 average price for a bushel of corn in 2007 is justified, and what other factors may be influencing price changes. The correlation to the price of crude oil has already been presented, and the reader is encouraged to refer back to chapter two where that behavior is described.

But the stocks to use data are sharply different for soybeans, Figure 12. The average ratio was 12% from 1970 through 2008. This includes only a couple of insignificant outlier years in the 1980s when the ratio rose above 20%. Recall that in corn, there were years in the 50% range. Additionally, in the most recent decade, the average ratio only fell to 10%. In fact, after 2005, the average stocks to use werr 13%. In the two years immediately following the RFS, the stocks to use ratio climbed from 15% to 19% respectively and fell sharply to 7% in 2008. Interestingly, this is directly related to the large decrease in soybean acres in support of corn as reviewed earlier. This would have given way to a decreased soybean supply in 2007, decreased stocks leading into 2008, and therefore an historically low stocks to use ratio of 7%.

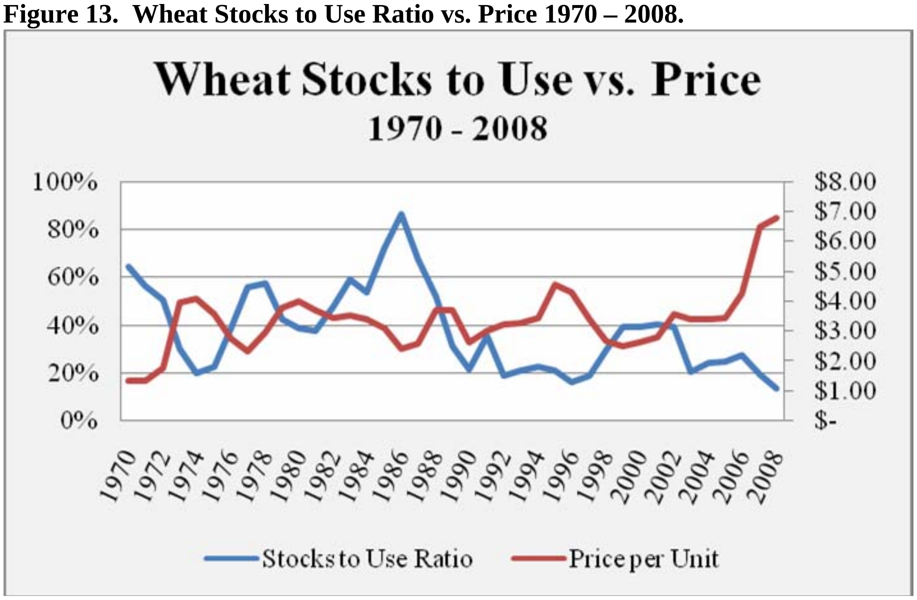
Figure 12 . Soybean Stocks to Use Ratio vs. Price 1970 – 2008



When price is compared to the stocks to the stocks to use ratio, we observe a major inconsistency from 2006 – 2008. At a time when stocks are rising to near-historic levels, price is led to unforeseen increases. What we saw in corn, and what we would expect to see in this relationship, is an inverse relationship between the two. But what this data suggests is that a fundamental change is taking place within the soybean markets. It also begs the question as to whether or not the supply and demand analysis can account for the price swing. In this case, the stocks to use ration certainly does not. What will be interesting to observe in 2009, is whether the dramatic decline in the ration will inversely or directly correlate to price?

Wheat is more consistent with traditional economic laws. Figure 13 shows a regular inverse pattern between price and the stocks to use ratio. What is significant about wheat, however, is the dramatic increase in price after the RFS. There may not be more to explore in this market when simply looking at the stocks to use ratio because the highest

Figure 13. Wheat Stocks to Use Ratio vs. Price 1970 – 2008.



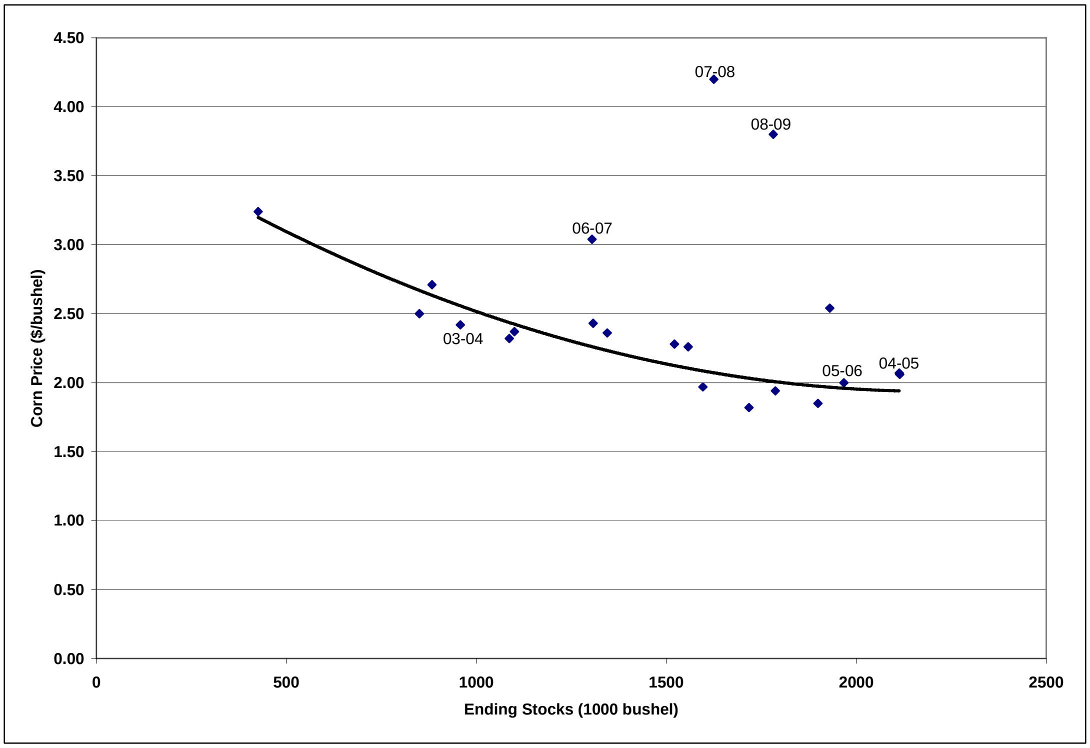
wheat prices ever seen directly correlate to the lowest stocks to use ratio in 38 years. Compare a 38 year average stocks to use of 38% with a 29% average from 2000-2008 and 20% from 2006-2008. Again, in the lowest stocks to use ratio in 38 years of 14% in 2008, we saw the highest price ever in the same year of $6.80.

Ending Stocks and Price

Equation 1 in the methods section was estimated to determine more formally the relationship between ending stocks of corn and corn price. Please note Figure 14 uses ending stocks as opposed to the stocks to use ratio. Data from 1989-2002 were used to estimate the curve depicted in Figure 14. This time period was chosen because it was after the huge stocks were eliminated through specific farm program changes in the 1980's. The estimated equation was:

$$\text{Price} = 3.8728 - 0.00175 * \text{ending stocks} + 0.0000004 * (\text{ending stocks})^2$$

Figure 14 Estimated Relationship between ending stocks and price of corn.



That equation was used to predict price for the three crop years prior to the 2005 RFS mandate, and for the three crop years since that mandate. The mean square error of the residuals for the estimation and two predicting time periods are displayed in Table 7.

Table 7 – Mean Square Error for Predicting Corn Price from Ending Stocks

Crop Years	***Mean Square Error***
1989-90 to 2002-03	0.017
2003-04 to 2005-06	0.012
2006-07 to 2008-09	2.782

It is fairly evident from Figure 14 and Table 7 that the relationship between ending corn stalks and corn price as changed since the RFS ethanol mandates were implemented. Is this a fundamental change or is this the result of increased speculation from outside of agricultural driving prices higher?

Corn Supply, Demand and Price

The supply of corn for each crop year is determined by the beginning stocks on hand and prodution for that year. Imports of corn are very small averaging about .1 percent. Demand for corn is measured by three broad categories: Food, Seed and Industrial Use; Exports; and Feed and Residual Use. Equation 3, from the Methods section was estimated to determine the relationship of each of these broad supply and demand categories on the price of corn. The impact of the government mandate on ethanol use in fuel via the RFS was also included in the analysis. The results are depicted in Table 8.

Table 8 - Regression results for predicting the price of corn.

	Parameter Estimate	***t Value***
Intercept	3.43171	5.11**
Beginning Stocks	-0.00097	-6.69**
Production	-0.00079	-4.94**
Seed & Industrial	-0.00012	-0.19
Feed & Residual	0.00106	2.15*
Exports	0.00098	5.17**
Government Mandate	-4.19771	-2.45*
Mandate * Industrial	0.00186	2.25*
Model Adj. R Squared	0.92	

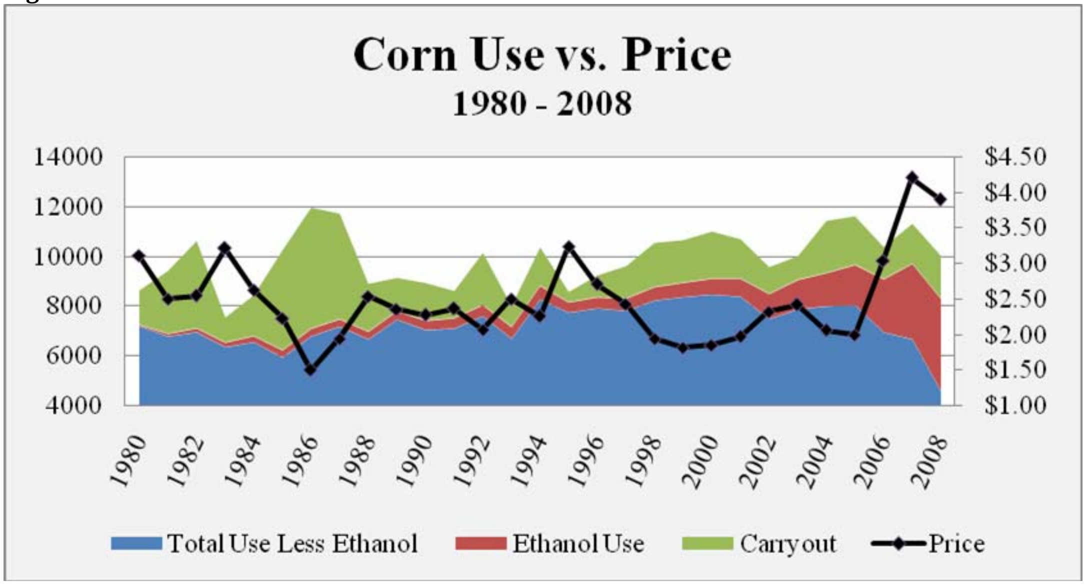
Note: * and ** denote significance at the 0.05 and 0.01 level, respectively.

As economic theory would suggest, an increase in supply (Beginning Stocks and Production) lead to a decrease in price. Both of these parameter estimates are negative and significant at the .01 level. On the demand side, Feed & Residual and Exports are both positive and significant. Again, that would be expected from theory. However, Seed and Industrial is non significant and has the incorrect sign. The Government Mandate dummy variable is significant and the interaction term between the government mandate and the food, seed and industrial category (Mandate * Industrial) is positive and significant. The implication from this analysis is that prior to the RFS mandates on ethanol use the food, seed and industrial category of demand had no impact on price. This is likely due to the fact that this category changed very little from year to year. However, since the RFS mandate, this category has had a positive and significant impact on the price of corn. From the standpoint of the corn growers who have lobbied incessantly for ethanol policy, it has been a success. Corn prices have increased because of the RFS ethanol mandates.

Segregated Use and Price

One question that this paper is trying to answer is if the recent rise in commodity prices are justified at their current levels. It has been shown in this paper that ethanol production has expanded rapidly, increasing the demand for corn as an input into that process. As implied by the stocks to use ratio, beginning stocks have remained relatively stable in the years since the RFS. However, one observation in the chart depicted in Figure 15 is the rapid decline in use or corn for non-ethanol purposes. This may be a function of the price rises since 2005 causing the quantity demanded of corn in the feed and other sectors to decline. This raises two new issues regarding the unintended structural changes in the corn market: 1. Has the RFS *caused* the prices to rise and, 2. If it is determined that RFS caused price increases, is the RFS therefore responsible for the contracting of other sectors dependent on corn? Or, in other words, has the RFS been implemented at the expense of other goods? How do we determine which sectors to support and how to divert resources? Is this the role of government? The RFS is

Figure 15 – Corn Use vs. Price 1980 – 2008



explicitly enforced to address climate change, rural economy and energy independence issues. But who should decide what benefit to cost ratio is sufficient to support the RFS?

Futures Market Survey Results

Before continuing, the reader should review the methods employed in distributing the survey and compiling the results to better understand what the statistics mean and how they were calculated. In chapter 3, a study performed by Informa Economics detailed the changing profile of futures trading participants in the BOTs as a whole. While the Informa study was inconclusive as to the relationship between speculation and volatility, it confirmed that there have been significant changes in the trading centers after the RFS was implemented. The purpose of this survey was to measure those changes on commodity futures broker activities for those who serve the commercial traders. Again, if changes have occurred, we may identify an additional characteristic of the structural adjustments which are the result of the RFS mandates. We may not prove causality, but we may strengthen the notion that a correlation exists.

Overall, the survey was distributed to 88 country brokers randomly selected from various online phone directories. The criteria was to select as many as contact info was available for independent or small brokerage firms in 17 major agricultural states. 25 responses were received for a 28.5% response rate. 95% of respondents were registered with the National Futures Association as introducing brokers (IB) and 1 was a certified trading advisor (CTA). All respondents marked that their primary business activity was brokering, except for the CTA which chose storage as their main business. No other significant differences were documented in any of the other survey questions. The ranking of commodity volume traded through these firms was as follows: 1. Corn, 2. Soybeans, 3. Wheat, 4. Live Cattle, 5. Hogs, 6. Dairy, 7. Oats, and, 8. Barley.

The respondents were first asked for whom they acted as broker in the futures market. For all surveys returned, 91.3% said they trade for commodity producers, 73.9% said commodity users, 69.6% said non-commercial traders, 65.2% said they trade in-house and 47.8% said storage firms. This broadly reflects the group of brokers surveyed in that they were desirably rural brokers who were closest to the commercial futures trading activities. The responses were also consistent for the ranking of volume traded through the firms on behalf of the customers. For all responding firms, the ranking was: 1. Producers, 2. Users, 3. Non-commercial, 4. In-house, and, 5. Storage firms. In the hedonic coding, commodity user trading and non-commercial volume had very similar rankings with averages of 2.65 and 2.7 respectively. There seemed to be no correlation to geographical location or any other variable and the profile of these brokers' customers. Again, this affirms that the target group was reached by the survey.

One of the chief changes to BOTs since the RFS has been the dramatic increase in trading volume. But a serious question which has been posed and was addressed by the Informa study is who is responsible for the increase in volume. If purely speculators, then extended research should be done on the effects of those participants on the price volatility and inflationary pressure. In any case, this particular relationship should be explored more, but this survey aimed to answer whether or not this increased volume was partially attributable to the commercial group. In this survey, there was an overall increase in volume across all respondents. The hedonic variable approaches 1 at 0.739. Three respondents said there was an uncharacteristic change in volume since 2006 while only two reported a slight decrease in volume. Of those who reported an increase in trading volume, 69.5% said the increased volume was for corn futures contracts. This could be based in the expanded corn production and use as presented earlier. We can not tell from this data. But across all data, 47.8% said these increases were from producers, 21.7% said from users, 13% said speculators and 8.69% said storage firms and another 8.69% said all traders equally. It is interesting that 47.8% said the volume increase came from producers, given that it is producers who produced more corn recently. It is equally significant that only 21.7% said users, as the corn use increased as much as corn production. It may be that the users serviced by these brokers are millers or feedlots and not ethanol plants, as those two sectors would not change their usage levels immediately as a result of the RFS.

Participants were also asked if there had been a decrease in trading volume in any of the major commodity futures contracts. 28.6% said they saw a decrease in live hog contracts traded, 19.04% for both wheat and dairy contracts, and appropriately only 14.3% for corn. For the decreases in wheat and corn volume, the respondents universally said this was from producer trades. It may be that these particular producers chose to assume more risk in the cash market instead of hedging their crops. It would make sense since futures and cash prices reached historic levels in the most recent few years. It also suggests that corn trading volume has increased in considerably more firms than it has decreased when compared to 69% saying corn trades have increased, corresponding with the Informa study of the CFTC data.

A question regarding the volume of commodity which was hedged through these brokers was also asked. This portion of the survey aimed to address whether or not commercial traders were changing their attitudes toward risk. Overall, brokers reported that producers slightly increased the proportion of their crops which they hedged. The hedonic coefficient for this question was 0.5 with only two respondents reporting a slight decrease in hedged commodity. For storage firms, the proportion of their inventory hedged increased by the same level, 0.5. But the largest increased in hedged commodity was attributed to agribusiness clients with a slight increase and a hedonic coefficient of 0.69.

Another interesting component of this survey was whether or not these rural brokers had seen a change in new accounts opened in their brokerage from year to year. The average responses would indicate that there have been no radical changes in this regard, but there was a more variable response than in other portions of the survey. The responses ranged from uncharacteristic increases to uncharacteristic decreases. For those responsible for opening the new accounts, 69.5% said they came from producers, 17.3% said from speculators and 13% from users. The 17.3% new accounts from speculators would draw special attention as the profile of respondents indicates they mostly cater to the rural, commercial trader. If there is a significant increase in the non-commercial traders through independent, rural brokers, additional investigation may be merited to discover the affiliation of these participants.

Those surveyed were also asked two open-ended questions. The first was whether or not they felt that the futures markets were functioning sufficiently to fulfill the purposes for which they were established. These purposes are mainly price discovery and risk management. The responses could be easily segregated into two groups of equal size. Half of the respondents answered that the markets are running well while the other half said no. The explanations for the answers varied but there was some regularity of specific objections. For those who said the markets were dysfunctional, 5 of 9 said there were basis or convergence problems. Another 3 felt speculators, especially hedge and index funds, were contributing to the problem. Other explanations included volatility and problems with delivery points. There was limited specificity, but it is clear this half of the brokers surveyed feel the markets have lost functionality. The second question dealt with whether or not the respondents felt the level of regulation of the markets was sufficient. In contrast, those who responded that the futures markets were accomplishing their mission mentioned some problems which need to be addressed but the total number who named a problem were less overall. The most common named problem was from 4 of the 9 in this group who said that the increased volatility was an issue.

The second question was meant to determine the group's attitude was toward regulation of the markets. There was very limited response to this question and very erratic answers.

Clearly the results of this survey indicate that there has been a disruption of the futures markets. A large concession is made that a major disadvantage of this survey is that is has no method of comparing real data from the time period before the RFS. However, as the survey is reviewed, the instructions were explicit in that each response was to be how the broker compared the current market conditions to the prior period. An important aspect of the survey is that all of the respondents have noticed a marked change in market behavior and at least half feel the markets are falling short of their reason for existence. When considering the pool of brokers reached, namely the rural independent brokers who are most likely to serve the commercial commodity traders, serious concern is raised regarding the ability of the BOTs to function efficiently.

Changes to Farmer Income

Seldom in the world of economics does one thing change while all else remains equal. This is also the case for farmers who have been the recipients of the higher commodity prices in recent years. While we make the connection between the higher prices and the RFS, it is difficult to directly single out the effect the desirable prices have on net income received. In the previous chapter, the results of an increased demand for corn were discussed. It was argued that during period 2 of the transition to accommodate the RFS that increased demand for corn would transpire into increased pressure for inputs. It was argued that land rents would be bid up as well as limited resources such as fertilizer.

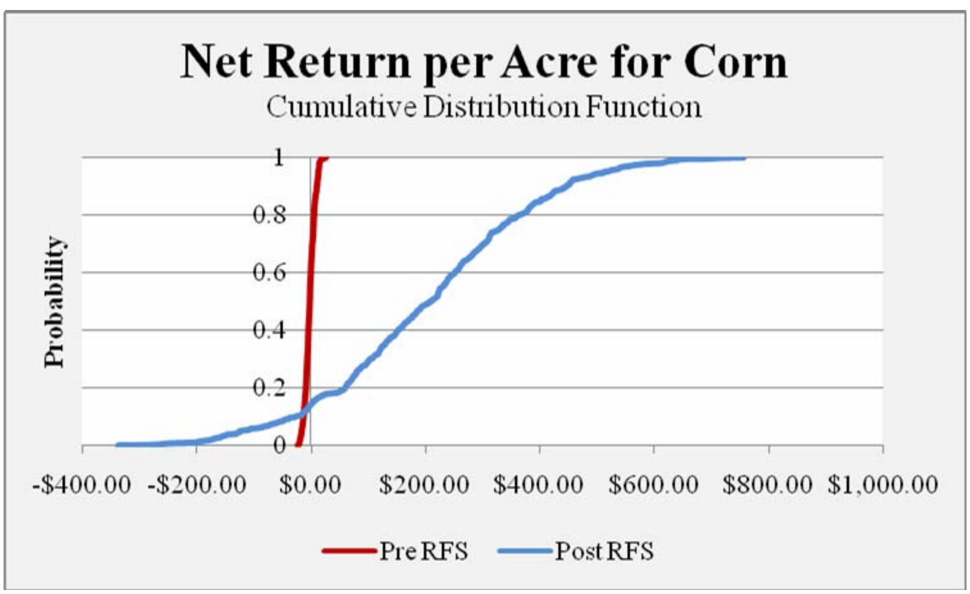
This is precisely what took place from 2005 to 2008. The ERS index of fertilizer prices paid by farmers more than doubled from an average 168 to 433 in 2008. Fuel prices reached similar levels during the same period as well, although fuel had been increasing since before 2005. While the fertilizer price increases may be a direct result of the RFS, fuel price increases are most likely to have increased due to macro demand factors. In any case, these dramatic swings in cost must be accounted for when analyzing the net income changes from pre to post RFS periods.

One characteristic of the markets of interest here is the changing structure of risk. Here we will define risk as the exposure to variability in outcome. As the variability increases, so does the risk. If variability increases, the market is more stable and risk has decreased.

Figure 16 is a graphical representation for the expected net return per acre for a corn farm in Arkansas as plotted by a cumulative distribution function. The vertical axis represents the total number of outcomes accounted for as moving across the horizontal axis as measured in percent. The horizontal axis is expected net return per acre in dollars. Statistically, the data offered here indicates that for the pre RFS period, an average loss of $2.66 could be expected for the farms represented in this example. On the other hand, in the post RFS period, or in 2008, the farms represented here might expect an average return of $204.24 per acre.

The most striking characteristic of this graph is the relative difference in slope between the pre and post RFS periods. If we consider the definition of risk offered above, we would say that the risk structure between the two periods is dramatically different. The sheer range of possible outcomes is much broader in the post period than before the RFS. One of the ways this can be measured statistically is the coefficient of variance. It is calculated by dividing the mean value for a data set by its standard deviation. A smaller

Figure 16. Net Return per Acre for Corn.



coefficient of variance would imply a wider distribution of outcomes. The coefficients for the pre RFS and post RFS periods here are 3.26 and .92 respectively, indicating that the exposure of farmers to variability in net returns after the RFS is roughly 3.5 times larger than before.

In some cases, this would cause the level of risk aversion to increase. Farmers who focus solely on increasing costs might be deterred from excpanding output to avoid the potential losses. In the cases analyzed here, fuel prices increased by 180% and fertilizer prices by 142%. It is certainly true that costs have significant bearing on net return. In fact, as a percentage of overall operating costs, fuel and fertilizer costs increased from 12% and 22% to 26% and 29% of variable costs in these scenarios. These input costs do seem extraordinarily high and would jusitfy farmers avoiding taking on this risk exposure. However, the anal;ysis overall shows that the farm price increased sufficiently to compnesate these higher costs. The most important result of this analysis here, is the proportional effect each of these variable have on net returns. Even though fuel and fertilizer have more than doubled, their carry into overall costs is limited by some smaller proportion. On the other hand, when farm prices received increase, it is a direct enhancement on total revenue.

While the outsomes in this section may seem unreasonable, recent data released by the USDA would support these findings. The ERS records that from 2005 to 2008, gross farm income rose from $115.2 billion to $182.1 billion. For feed crops this rose from $24.7 billion to $61.4 billion. Fertilizer costs for all farms rose from $12.8 billion to $27.5 billion. Fuel also increased from $10.3 billion to $16.3 billion. But after factoring in all costs, the United States farm net income rose from $79.3 billion to $89.3 billion. At the time fo this writing, no specific data regarding the net income changes for a more specific set of crops, but the author submits that most of the national increase would have come from feed grains, substantiating the analysis done on the corn enterprise budget above.

Chapter 6 – Conclusions

The RFS is the single largest change to come to American agriculture in at least 30 years. Although it directly affects the market for corn because of the demand for corn ethanol, it has certainly sent reverberations throughout the farm sector. Perhaps the most important complication of the RFS is the fact that it is such a complex issue. It is so tied to economical, political, environmental and social issues that to measure the implications is challenging at best.

Summary

The most obvious change to come to ag markets since the RFS was introduced is price inflation. Never have prices for agricultural commodities reached levels as were seen in the most recent three years of commodity marketing. In addition, Prices have become more volatile. Whether or not this can be assigned to a causal relationship with ethanol is not certain, but the increased correlation to the volatility of the crude oil market is indisputable.

In addition, we may not necessarily attribute these price structure changes to the fundamentals of commodity markets alone. Acreage shifts in each respective commodity have been within the historical norms of behavior in terms of tradeoffs and year to year changes. Production has seemed to keep pace with demand in the corn sector, except in the most recent years where non-ethanol demand has slipped, most likely due to increased prices. However, it would also seem that U.S. farmers are not responsible for the increases in wheat prices considering that wheat acreage has not been affected by the response to ethanol mandates. We may not know whether or not demand substitution between corn and wheat has been a contributing factor, but production behavior has not changed significantly in wheat. All these changes were predicted in our discussion of theoretical changes in chapter four, and were greatly confirmed. In fact, the price responses were more irregular on the fundamental side than would have been expected, leading to the idea that some other factors were largely responsible for the structural change. Again, while these primary responses may have been predictable and expected, there have been other changes not intended or foreseen by policy makers.

The futures broker survey was significant in that it confirmed trading activity changes even down to the commercial side of commodity markets. It was inconclusive as to whether the futures markets still perform effectively, but a serious question is raised when half of the respondents note a problem with their functioning. This may settle in the long-term, but during this period of adjustment, trading participants must struggle to find their feet while confirming that environments, energy security and rural economies in general are not all that are affected by sweeping government mandates.

Finally, we have also shown a partial explanation of the USDAs findings that farm income has increased in the most recent production years. At the same time, farm income has become more variable from period to period and from farm to farm. Again, this is a result of the increased uncertainty as influenced by crude oil prices and the mandates linking farm economies to energy markets.

Implications

What is indisputable is that since the implementation of the RFS, ag markets and especially corn have experienced volatility not observed in recent decades. This is in part due to the inextricable link which now ties agriculture to energy. Although the energy markets may not be so much influenced by the farm sector, agriculture producers and users are now exposed to the variability in energy markets. While crude oil was once a determining factor in farm production costs, it is now also a determining factor in farm revenue, more so than ever before.

The RFS was implemented as U.S. energy policy for many reasons. Without order of importance, the first of these was domestic energy independence. It is difficult to reconcile this notion, however, when considering the contrasting data regarding the energy contribution of ethanol. The research done in this field is yet in its infancy, but policy has jumped to the assumption that research was supportive of expanding corn ethanol. This is still a debated issue and it should give pause to lawmakers that three years after the initial introduction of the RFS, the topic is still not settled and has not reached a consensus.

Perhaps more intriguing is the idea that the RFS and corn ethanol are meant to address global climate change. Just like the energy issues, there is still no consensus regarding the greenhouse gas emissions of corn ethanol. In fact, if longitudinal trends are any indication of an approaching agreement, we might assume that the GHG emissions alone are worse than gasoline. The more recent research tends to lean this way. Additionally, there are all the other unintended environmental impacts discussed in chapter 3 which go beyond climate change. Again, this topic is not yet settled either.

On the issue of farm income, this goal of the RFS has been attained, at least temporarily. It has been shown, according to the economics discussion in chapter 4, that we would expect farm incomes to increase as a result of the RFS. To add to this, the research reviewed in chapter 3 supports the notion that rural economies have been positively affected by corn ethanol expansion. This was all substantiated by the analysis given in the previous chapter. However, a daunting question remains unanswered. We predicted that in period 3 after the market equilibrium has been settled, long run profits would return to zero. The first two periods in the theoretical discussion have been validated. It will only be a few years before we know whether or not our predictions of the third period will come to pass.

Compounding the concern is the notion that the EPA may reconsider the effectiveness of corn ethanol to battle climate change. Remember it is the EPA which has the authority to implement the RFS, but the EPA is primarily concerned with environmental issues and, as in the case of ethanol, not how various enterprises affect the economy. Should the EPA reverse U.S. RFS policy, particularly the portion met by corn ethanol, the effects on the farm sector should be considerable.

The one true economic lesson in this thesis is that, irrespective of free market forces, government has an enormous ability to affect economic sectors. Additionally, when government intervenes in the marketplace on behalf of a political agenda (whether that agenda is worthy or not), the market reacts in complex ways not addressed by the original policy. The environmental issues related to ethanol are the perfect example of this. In the name of curbing global climate change, the U.S. energy policy was adjusted once in 2005 then drastically more in 2007. Now, there is a new argument which says corn ethanol harms the environment more than the fuels they were attempting to replace. Governments can create demand, but it will always be an artificial demand not supported by the free market. A fundamental question in economics is implicitly answered in these cases as to how scarce resources should be rationed. The RFS decides how capital, land and other resources are allocated and clearly has broad economic ramifications. But in the end, we must decide what the proper role of government should be and seek the correct balance between social issues and issues of commerce. This thesis clearly illustrates that the two aspects are not wholly separable and that we cannot know all the effects of one particular policy before implementing it. These situations create unintended consequences which eventually diminishes the efficiency of the marketplace.

Chapter 7 – Reflections

When I first began this thesis, I really had no direction on how to approach the topic. I was frustrated to see so many different sides of the ethanol debate focus solely on the facts that would support their particular position. I had a personal interest in the topic and in doing simple fact finding research I was always left wanting for information because there was no single source which addressed the debate in full. I have come to find that in addition to individual bias for each groups' position, the scope of ethanol and biofuels in general is so large that it is truly impractical to sufficiently cover all the aspects related to it. The problem with this inherent complexity, however, is that the socio-economic truth is in danger of being diluted in a soupy mixture of ideas and philosophies.

What have I learned from this experience? That when an idea which has the potential to affect so many sectors of society and economic conditions in general is put forth, the value of forethought in implementation of related policy is inestimable.

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Appendix A

Survey Questions

Futures Broker Survey
Applied Economics Department
Utah State University

The purpose of this survey is to gain an understanding of the effects that major changes in grain markets have had on hedging and speculative activity in the futures markets. Identifying the source and impacts of recent market changes is also of interest. Individual survey responses will not be reported in any manner, so as to maintain complete confidentially.

General

You or your organization are/is registered as a (Select all that apply):
FCM IB CPO CTA

The primary business (respecting agricultural commodities) of your organization is:

For whom do/does you or your organization trade agricultural futures (Select all that apply):
Producers Storage firms Grain Users Non-commercial
Self I don't trade agricultural commodities

Please rank the following trading entities, in terms of volume handled, for whom you act as a broker in the futures market (1 – highest volume, 5 – Lowest volume):
Producers Storage firms Grain Users Non-commercial Self (in house)

On average, how would you say the volume of agricultural commodities traded through your firm has changed since 2003?

Which commodity contracts have experienced the most increases in volume at your firm?

Which trading party is most responsible for these increase in volume at your firm for that commodity?

If any commodity contracts experienced significant decreases in volume traded by your firm, which has been the most notable?

Which trading party is mostly responsible for these decreases in trading at your firm for that commodity?

Hedging Issues

As a proportion of a typical producer's annual crop (for accounts handled by your firm), the volume of contracts producers use for hedging purposes has:

As a proportion of a typical elevator company's storage capacity (for accounts handled by your firm), the volume of contracts elevators use for hedging purposes has:

As a proportion of a typical agribusiness account handled by your firm, the volume of contracts agribusinesses employ for hedging purposes have:

Since 2003, the number of new individual trading accounts opened at your firm annually has:

Which market trading entity represents the largest portion of these new accounts?

For non-commercial traders, which agricultural commodities are most traded through your firm (please rank 1 – highest, 8 – lowest)
Corn Wheat Soybeans Barley Oats Live Cattle Hog Dairy
Compared to the years before 2003, most current hedging strategies now have taken positions that are in duration.

<u>Explanation section</u>
According to the Commodity Futures Trading Commission (CFTC), the futures market "serve the important function of providing a means for price discovery and offsetting price risk." In your opinion, how well do you feel this function is being performed in recent years? Please explain.

Do you feel the current level of regulation is sufficient or insufficient to manage the futures markets? What regulatory changes could be made to assure the integrity of the futures markets? Please Explain.

The purpose of this survey is to gain insight and understanding regarding the recent market volatility and changes in market behavior. It also serves as a foundation to further measure real changes in market activities and seek understanding of the implications of the current market conditions. Further and more in depth analysis will require real data on a firm by firm basis. Would your organization be willing to participate in a more detailed survey by providing specific proprietary data to enhance the accuracy of such a study? Any data received will be kept in the strictest confidence.
Yes No
If yes, who is the best person to contact?___________________________________

If you are interested in receiving a summary report of the findings of this survey, please complete the address below. Once again, no attempt will be made to tie the address to the answers given. Information from this last page will be coded in a separate file from the data.

Name ____

Address ______________________________________

Address ______________________________________

City, ST Zip ___________________________________

Appendix B

Analysis Data

Corn –
Planted Acres, Production, Supply, Use, Price and Ratios

Year	***Planted Acres (1000 acres)***	***Beginning Stocks (1000 bu.)***	***Production (1000 bu.)***	***Imports (1000 bu.)***	***Total Supply (1000 bu.)***	***Use (1000 bu.)***	***National Average Price (U.S. dollars)***	***Price:Supply (times 1000)***	***Price:Supply 3 Year Moving Average***	***Deviations from the mean***
1970	66863	1003	4144	4	5151	4495	1.33	0.2582		
1971	74179	662	5634	1	6297	5187	1.08	0.1715		
1972	67126	1124	5568	1	6693	6000	1.57	0.2346	0.2214	-0.53
1973	72253	706	5659	1	6366	5896	2.55	0.4005	0.2689	0.15
1974	77935	483	4692	2	5176	4826	3.02	0.5834	0.4062	2.09
1975	78719	557	5829	1	6387	5767	2.54	0.3977	0.4606	2.87
1976	84588	632	6276	2	6910	5789	2.15	0.3111	0.4307	2.44
1977	84328	1133	6491	2	7627	6207	2.02	0.2648	0.3246	0.94
1978	81675	1433	7253	1	8687	6995	2.25	0.2590	0.2783	0.28
1979	81394	1706	7912	1	9618	7604	2.52	0.2620	0.2620	0.05
1980	84043	2030	6625	1	8656	7282	3.11	0.3593	0.2934	0.50
1981	84097	1389	8102	1	9491	6975	2.5	0.2634	0.2949	0.52
1982	81857	2531	8218	0	10750	7249	2.55	0.2372	0.2866	0.40
1983	60207	3516	4166	2	7683	6693	3.21	0.4178	0.3061	0.68
1984	80517	1004	7656	2	8662	7032	2.63	0.3036	0.3196	0.87
1985	83398	1645	8857	10	10511	6494	2.23	0.2121	0.3112	0.75
1986	76580	4031	8209	2	12241	7385	1.5	0.1225	0.2128	-0.65
1987	66200	4871	7116	3	11991	7757	1.94	0.1618	0.1655	-1.32
1988	67717	4250	4918	3	9171	7260	2.54	0.2770	0.1871	-1.01
1989	72322	1926	7516	2	9444	8120	2.36	0.2499	0.2295	-0.41
1990	74166	1342	7917	3	9262	7761	2.28	0.2462	0.2577	-0.01
1991	75957	1518	7459	20	8997	7915	2.37	0.2634	0.2532	-0.08
1992	79311	1098	9457	7	10562	8471	2.07	0.1960	0.2352	-0.33
1993	73239	2109	6324	21	8454	7621	2.5	0.2957	0.2517	-0.10
1994	78921	848	10029	10	10887	9352	2.26	0.2076	0.2331	-0.36
1995	71479	1555	7385	16	8956	8548	3.24	0.3618	0.2884	0.42
1996	79229	425	9213	13	9651	8789	2.71	0.2808	0.2834	0.35
1997	79537	881	9188	9	10078	8791	2.43	0.2411	0.2946	0.51
1998	80165	1305	9738	19	11062	9298	1.94	0.1754	0.2324	-0.37
1999	77386	1783	9411	15	11209	9515	1.82	0.1624	0.1930	-0.93
2000	79551	1714	9894	7	11615	9740	1.85	0.1593	0.1657	-1.32
2001	75702	1895	9483	10	11388	9815	1.97	0.1730	0.1649	-1.33
2002	78894	1593	8948	14	10555	9491	2.32	0.2198	0.1840	-1.06
2003	78603	1084	10066	14	11165	10230	2.42	0.2168	0.2032	-0.78
2004	80929	956	11781	11	12748	10661	2.06	0.1616	0.1994	-0.84
2005	81779	2110	11089	9	13207	11268	2	0.1514	0.1766	-1.16
2006	78327	1963	10509	12	12484	11207	3.04	0.2435	0.1855	-1.03
2007	93600	1301	13011	20	14331	12737	4.2	0.2931	0.2293	-0.41
2008	87327	1621	12076	15	13712	12000	3.9	0.2844	0.2737	0.22

Soybeans – Planted Acres, Production, Supply, Use, Price and Ratios										
Year	***Planted Acres (1000 acres)***	***Beginning Stocks (1000 bu.)***	***Production (1000 bu.)***	***Imports (1000 bu.)***	***Total Supply (1000 bu.)***	***Use (1000 bu.)***	***National Average Price (U.S. dollars)***	***Price:Supply (times 1000)***	***Price:Supply 3 Year Moving Average***	***Deviations from the mean***
1970	43082	42249	246	1127.1	1451	1345	2.85	1.9644		
1971	43476	42705	106	1176.101	1363	1286	3.03	2.2229		
1972	46866	45683	77	1270.608	1435	1372	4.37	3.0443	2.4105	-0.10
1973	56549	55667	64	1547.543	1718	1536	5.68	3.3054	2.8575	0.65
1974	52479	51341	183	1216.287	1483	1282	6.64	4.4774	3.6090	1.91
1975	54590	53617	201	1548.344	1857	1595	4.92	2.6499	3.4776	1.69
1976	50269	49401	262	1288.608	1640	1530	6.81	4.1534	3.7602	2.17
1977	58978	57830	110	1767.267	2000	1827	5.88	2.9406	3.2480	1.31
1978	64708	63663	172	1868.754	2170	1983	6.66	3.0686	3.3876	1.54
1979	71411	70343	188	2260.665	2605	2222	6.29	2.4148	2.8080	0.57
1980	69930	67813	383	1797.543	2305	1970	7.6	3.2969	2.9268	0.77
1981	67543	66163	335	1989.11	2461	2189	6.07	2.4661	2.7259	0.43
1982	70884	69442	272	2190.297	2614	2245	5.71	2.1845	2.6492	0.30
1983	63779	62525	368	1635.772	2117	1929	7.83	3.6980	2.7828	0.52
1984	67755	66113	188	1860.863	2178	1840	5.84	2.6817	2.8547	0.65
1985	63145	61599	338	2099.056	2582	2009	5.05	1.9560	2.7786	0.52
1986	60405	58312	573	1942.558	2650	2183	4.78	1.8039	2.1472	-0.54
1987	58180	57172	467	1937.722	2540	2216	5.88	2.3153	2.0251	-0.75
1988	58840	57373	323	1548.841	1983	1789	7.42	3.7413	2.6202	0.25
1989	60820	59538	195	1923.666	2254	1998	5.69	2.5243	2.8603	0.65
1990	57795	56512	256	1925.947	2319	1967	5.74	2.4756	2.9138	0.74
1991	59180	58011	352	1986.539	2479	2182	5.58	2.2505	2.4168	-0.09
1992	59180	58233	298	2190.354	2642	2329	5.56	2.1046	2.2769	-0.33
1993	60085	57307	313	1869.718	2318	2095	6.4	2.7605	2.3719	-0.17
1994	61620	60809	224	2514.869	2918	2560	5.48	1.8778	2.2476	-0.38
1995	62495	61544	358	2174.254	2687	2491	6.72	2.5005	2.3796	-0.15
1996	64195	63349	196	2380.274	2751	2610	7.35	2.6722	2.3502	-0.20
1997	70005	69110	141	2688.75	3021	2807	6.47	2.1417	2.4381	-0.06
1998	72025	70441	214	2741.014	3147	2775	4.93	1.5663	2.1267	-0.58
1999	73730	72446	373	2653.758	3214	2904	4.63	1.4404	1.7161	-1.27
2000	74266	72408	310	2757.81	3263	2998	4.54	1.3915	1.4661	-1.69
2001	74075	72975	265	2890.682	3358	3136	4.38	1.3043	1.3787	-1.84
2002	73963	72497	222	2756.147	3174	2984	5.53	1.7421	1.4793	-1.67
2003	73404	72476	191	2453.845	2820	2700	7.34	2.6026	1.8830	-0.99
2004	75208	73958	120	3123.79	3466	3193	5.74	1.6560	2.0003	-0.79
2005	72032	71251	273	3068.342	3558	3077	5.66	1.5909	1.9499	-0.88
2006	75522	74602	480	3196.726	3908	3294	6.43	1.6453	1.6308	-1.41
2007	63631	62820	614	2677.117	3486	3267	10.1	2.8970	2.0444	-0.72
2008	74533	72121	219	2959.174	3393	3195	9.25	2.7264	2.4229	-0.08

					Wheat – *Planted Acres, Production, Supply, Use, Price and Ratios*					
Year	***Planted Acres (1000 acres)***	***Beginning Stocks (1000 bu.)***	***Production (1000 bu.)***	***Imports (1000 bu.)***	***Total Supply (1000 bu.)***	***Use (1000 bu.)***	***National Average Price (U.S. dollars)***	***Price:Supply (times 1000)***	***Price:Supply 3 Year Moving Average***	***Deviations from the mean***
1970	48739	1051	1446	1	2498	1618	1.33	0.5325		
1971	53822	880	1731	1	2612	1558	1.34	0.5131		
1972	54913	1053	1653	1	2707	2069	1.76	0.6501	0.5652	-1.62
1973	59254	638	1829	3	2471	2107	3.95	1.5988	0.9206	-0.44
1974	71044	364	1905	3	2272	1807	4.09	1.8002	1.3497	0.99
1975	74900	465	2274	3	2742	2030	3.55	1.2948	1.5646	1.71
1976	80395	712	2297	3	3012	1822	2.73	0.9064	1.3338	0.94
1977	75410	1190	2187	2	3379	2120	2.33	0.6895	0.9636	-0.29
1978	65989	1259	1898	2	3160	2172	2.97	0.9400	0.8453	-0.69
1979	71424	988	2282	2	3272	2308	3.8	1.1614	0.9303	-0.41
1980	80788	964	2546	3	3513	2455	3.99	1.1359	1.0791	0.09
1981	88251	1058	2978	3	4039	2799	3.69	0.9137	1.0703	0.06
1982	86232	1240	2956	8	4204	2584	3.45	0.8207	0.9567	-0.32
1983	76419	1620	2587	4	4211	2716	3.51	0.8335	0.8559	-0.65
1984	79213	1495	2774	10	4280	2756	3.39	0.7921	0.8154	-0.79
1985	75535	1524	2592	17	4133	2096	3.08	0.7452	0.7903	-0.87
1986	71998	2037	2235	23	4295	2348	2.42	0.5635	0.7003	-1.17
1987	65829	1947	2254	17	4218	2870	2.57	0.6094	0.6393	-1.38
1988	65529	1348	1938	24	3310	2560	3.72	1.1239	0.7656	-0.95
1989	76615	750	2178	24	2952	2378	3.72	1.2603	0.9978	-0.18
1990	77041	574	2919	39	3531	2603	2.61	0.7391	1.0411	-0.04
1991	69881	928	2117	44	3089	2581	3	0.9712	0.9902	-0.21
1992	72219	508	2637	75	3220	2653	3.24	1.0062	0.9055	-0.49
1993	72168	567	2562	116	3246	2638	3.26	1.0043	0.9939	-0.19
1994	70349	608	2482	98	3188	2646	3.45	1.0823	1.0309	-0.07
1995	69031	542	2334	73	2948	2546	4.55	1.5434	1.2100	0.53
1996	75105	402	2435	99	2936	2461	4.3	1.4647	1.3635	1.04
1997	70412	474	2653	101	3229	2456	3.38	1.0468	1.3516	1.00
1998	65821	772	2724	110	3606	2595	2.65	0.7349	1.0821	0.10
1999	62664	1011	2454	101	3567	2551	2.48	0.6953	0.8257	-0.75
2000	62549	1015	2382	96	3494	2557	2.62	0.7499	0.7267	-1.08
2001	59432	937	2082	115	3134	2303	2.78	0.8871	0.7774	-0.91
2002	60318	831	1717	83	2631	2105	3.56	1.3533	0.9967	-0.18
2003	62141	525	2507	67	3099	2515	3.4	1.0970	1.1124	0.20
2004	59674	584	2306	75	2966	2388	3.4	1.1464	1.1989	0.49
2005	57229	577	2249	87	2913	2303	3.42	1.1739	1.1391	0.29
2006	57344	611	1934	130	2675	2187	4.26	1.5928	1.3044	0.84
2007	60433	488	2193	120	2801	2474	6.48	2.3134	1.6934	2.14
2008	63457	327	2672	128	3128	2366	6.8	2.1741	2.0268	3.25

Ten Crop Set *–*
Planted Acres (1000 acres)

Year	*All Barley*	*Corn for Grain*	*All Cotton*	*Oats*	*All Potatoes*	*All Rice*	*Sorghum*	*Soybeans*	*Sugarbeets*	*All Wheat*	*Total*
1970	10476	66863	11945	24410	1450	1826	16957	43082	1478	48739	227226
1971	11061	74179	12355	21831	1432	1826	20547	43476	1406	53822	241935
1972	10567	67126	14001	19990	1301	1824	17035	46866	1420	54913	235043
1973	11045	72253	12480	18605	1330	2181	18994	56549	1280	59254	253971
1974	8713	77935	13679	17013	1422	2550	17588	52479	1252	71044	263675
1975	9373	78719	9478	16434	1299	2833	18080	54590	1595	74900	267300
1976	9301	84588	11636	16620	1404	2489	18143	50269	1525	80395	276370
1977	10778	84328	13680	17732	1399	2261	16636	58978	1273	75410	282474
1978	9989	81675	13375	16407	1401	2993	16197	64708	1305	65989	274040
1979	8116	81394	13978	13960	1295	2890	15277	71411	1161	71424	280906
1980	8320	84043	14534	13381	1175	3380	15639	69930	1231	80788	292422
1981	9618	84097	14330	13632	1255	3827	15930	67543	1252	88251	299735
1982	9549	81857	11345	13951	1303	3295	16028	70884	1054	86232	295498
1983	10411	60207	7926	20289	1271	2190	11880	63779	1081	76419	255454
1984	11934	80517	11145	12414	1334	2830	17254	67755	1124	79213	285520
1985	13139	83398	10685	13235	1407	2512	18285	63145	1125	75535	282465
1986	13024	76580	10045	14671	1257	2381	15339	60405	1232	71998	266931
1987	10929	66200	10397	17907	1317	2356	11756	58180	1267	65829	246138
1988	9831	67717	12515	13907	1285	2933	10343	58840	1327	65529	244227
1989	9125	72322	10587	12085	1305	2731	12642	60820	1324	76615	259556
1990	8221	74166	12348	10423	1400	2897	10535	57795	1400	77041	256226
1991	8941	75957	14052	8653	1408	2884	11064	59180	1427	69881	253447
1992	7762	79311	13240	7943	1339	3176	13177	59180	1437	72219	258784
1993	7786	73239	13438	7937	1390	2920	9882	60085	1438	72168	250283
1994	7159	78921	13720	6637	1422	3353	9787	61620	1476	70349	254444
1995	6689	71479	16931	6225	1401	3121	9429	62495	1445	69031	248246
1996	7094	79229	14653	4638	1455	2824	13097	64195	1368	75105	263658
1997	6706	79537	13898	5068	1384	3125	10052	70005	1459	70412	261646
1998	6325	80165	13393	4891	1416	3285	9626	72025	1498	65821	258444
1999	4983	77386	14874	4668	1376	3531	9288	73730	1561	62664	254060
2000	5801	79551	15517	4473	1383	3060	9195	74266	1564	62549	257360
2001	4951	75702	15769	4401	1247	3334	10248	74075	1365	59432	250524
2002	5008	78894	13958	4995	1300	3240	9589	73963	1427	60318	252692
2003	5348	78603	13480	4597	1274	3022	9420	73404	1365	62141	252654
2004	4527	80929	13659	4085	1192	3347	7486	75208	1346	59644	251423
2005	3875	81779	14245	4246	1108	3384	6454	72032	1300	57214	245638
2006	3452	78327	15274	4166	1139	2838	6522	75522	1366	57334	245941
2007	4018	93527	10827	3763	1142	2761	7712	64741	1269	60460	250220
2008	4234	85982	9470	3217	1058	2995	8284	75718	1091	63147	255196

Appendix C

Corn Production Budget

Enterprise Budget for Corn Production in Arkansas – *University of Arkansas, Division of Agriculture, 2009*

	AMOUNT	UNIT	PRICE	PRODUCER SHARE	TOTAL
GROSS RETURNS PER ACRE					
Corn	170	bu	$ 5.71	100%	$ 970.70
producer share of yield	170				
VARIABLE COSTS PER ACRE					
Fertilizer					
0-75-75	1	acre	$ 139.92	100%	$ 139.92
Urea 46%	217	lb	$ 0.45	100%	$ 97.65
32% N	375	lb	$ 0.31	100%	$ 116.25
Herbicides					
Glyphosate Plus	2	pt	$ 4.25	100%	$ 8.50
Atrazine 4L	4	pt	$ 1.38	100%	$ 5.52
Irrigation pipe, install / remove	0	acre	$ 10.30	100%	$ -
Seed	33	thous	$ 2.06	100%	$ 67.98
insecticide seed treatment	33	thous	$ 0.20	100%	$ 6.60
Drying	0	bu.	$ 0.19	100%	$ -
Custom Hire					$ -
Ground Appl Fertilizer	1	acre	$ 5.00	100%	$ 5.00
Ground Appl Herbicide	2	acre	$ 5.00	100%	$ 10.00
Custom Haul	170	bu.	$ 0.21	100%	$ 35.70
Labor: Irrigation	0.0974	hrs	$ 8.19	100%	$ 0.80
Labor: Operator	0.6885	hrs	$ 9.45	100%	$ 6.51
Labor: Hand	0.1433	hrs	$ 8.19	100%	$ 1.17
Fuel	31.1759	gal	$ 4.00	100%	$ 124.70
Repairs	1.00	acre	$ 26.32	100%	$ 26.32
Interest (1/2 year)	1.00	acre	$ 21.21	100%	$ 21.21
TOTAL VARIABLE COST					**$ 673.83**
RETURNS ABOVE VARIABLE COST					**$ 296.87**
FIXED COSTS/ACRE					
Depreciation & Interest on equipment					$ 38.96
Land Rent / Acre					$ -
TOTAL FIXED COST					**$ 38.96**
RETURN TO OPERATOR LABOR, LAND, CAPITAL, AND MGT*					**$ 257.91**
*above returns do not include government payments					
Producer break-even price:					**$ 4.19**
Break-even yield:					**124.8**