ETHANOL AND ITS EFFECT ON THE U.S. CORN MARKET: HOW THE PRICE OF E-85 INFLUENCES EQUILIBRIUM CORN PRICES AND EQUILIBRIUM QUANTITY

Except where reference is made to the work of others, the work described in this thesis is my own or was done in collaboration with my advisor committee. This thesis does not include proprietary or classified information.

Jared Andrew Pincin

Certificate of Approval

Michael Stern
Assistant Professor
Economics

John D. Jackson, Chair
Professor
Economics

Norbert L. Wilson
Assistant Professor
Agricultural Economics and
Rural Sociology

Joe Pittman
Interim Dean
Graduate School

ETHANOL AND ITS EFFECT ON THE U.S. CORN MARKET: HOW THE PRICE OF E-85 INFLUENCES EQUILIBRIUM CORN PRICES AND EQUILIBRIUM QUANTITY

Jared Andrew Pincin

A Thesis

Submitted to

the Graduate Faculty of

Auburn University

in Partial Fulfillment of the

Requirements for the

Degree of

Master of Science

Auburn, Alabama
August 4, 2007

ETHANOL AND ITS EFFECT ON THE U.S. CORN MARKET: HOW THE PRICE OF E-85 INFLUENCES EQUILIBRIUM CORN PRICES AND EQUILIBRIUM QUANTITY

Jared Andrew Pincin

____

Signature of Author

____

Date of Graduation

VITA

Jared Andrew Pincin, son of Michael Richard Pincin and Ivelyn Ann (Jenkins) Pincin, was born on June 19, 1982, in Allentown, Pennsylvania. He graduated from Whitehall High School in 2000. In August 2000 he entered American University in Washington, D.C. and in May 2004 graduated magna cum laude with a Bachelor of Arts in Economics and Political Science. After working as a Sales Representative for Nabisco, he entered Graduate School, Auburn University, in August 2006. He plans to pursue his Doctorate in Economics at West Virginia University starting in August 2007.

THESIS ABSTRACT

ETHANOL AND ITS EFFECT ON THE U.S. CORN MARKET: HOW THE PRICE OF E-85 INFLUENCES EQUILIBRIUM CORN PRICES AND EQUILIBRIUM QUANTITY

Jared Andrew Pincin

Master of Science, August 4, 2007
(B.A., American University, 2004)

90 Typed Pages

Directed by John D. Jackson

This study analyzes the impact the market price of E-85 has on equilibrium price and quantity exchanged of corn in the U.S. market. After presenting the political history of federal interest and intervention in the ethanol market, this study employs reduced form equations and a multiplicative heteroskedasticity approach to show that the price of E-85 has a statistically significant impact on the equilibrium price of corn. The analysis also uses a derived demand argument to show that political intervention, which has encouraged the growth of the U.S. corn ethanol market, has a statistically significant effect on the equilibrium quantity exchanged of corn. The author concludes that an increase in the price of E-85 increases the equilibrium price of corn but due to capacity constraints in the ethanol market does not yet have a statistically significant effect on the equilibrium quantity exchanged of corn. The author also concludes that the political intervention that has fueled the growth of the domestic corn ethanol market increases the

equilibrium quantity exchanged of corn but does not have a statistically significant effect on the equilibrium price of corn.

ACKNOWLEDGEMENTS

The author would like to thank the committee members of Dr. John D. Jackson, Dr. Michael Stern, and Dr. Norbert L. Wilson, whose valuable suggestions, beneficial advice, immeasurable patience, and stimulating conversations, lead to the fruition of this work. Special thanks are due to the author's parents, Michael and Ivelyn Pincin, whose support has been critical for my academic and professional pursuits as well as personal development. The author would also like to thank his Lord and Savior Jesus Christ, whose life, death, and resurrection are the reason for his eternal salvation and joy and to Whom all glory, honor, and power rightfully belong.

Style manual or journal used: *The American Economic Review*

Computer software used: *Microsoft Word 2007 and LIMDEP 8.0*

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

In the fall of 2008, the state of Alabama will open its first ethanol production plant in the rural town of Dadeville. Taylor (2007) reports this facility will produce 55 million gallons of ethanol a year, consume approximately 20 million bushels of corn a year, and employ 40-50 people directly with the anticipation of further job gains in related business in the surrounding areas. Though small by industry standards, local politicians and residents anticipate this new ethanol production facility will diversify the area's economy, an economy historically dependent on the fading textile industry. Besides producing ethanol, the plant will produce the byproduct distilled grain (a high-protein feed supplement for livestock), which will help the state's livestock sector. Already in 2007 Alabama farmers are expected to increase the amount of corn acreage planted to 300,000 acres (NASS Database 2007) as farmers substitute away from cotton and into corn thanks in large part to some farmers being able to secure as much as $4.40 per bushel in the futures market as reported by Mary Orndorff (2007). This increased corn acreage could produce 30 million bushels of corn, a dramatic increase from 2006 when the state produced only 12 million bushels of corn (NASS Database 2007).[1]

The town of Dadeville, Alabama is not alone in fastening their hopes of economic diversity and prosperity on the rising tides of ethanol. Lavelle and Schulte (2007) report

[1] In comparison Arkansas is expected to plant 66 percent more corn than in 2006 and Iowa, the nation's largest corn producer, is expected to increase corn acreage by 10.3 percent to roughly 13.9 million acres.

the rural town of Galva, Iowa opened an ethanol producing plant in 2002 and has witnessed more than $13 million spread to local farmers and investors who own and operate the plant. Stuertz (2006) writes that the small Texas town of Hereford is opening a $186 million ethanol plant that will generate 105 million gallons of ethanol a year and operate on cattle manure instead of the traditional fuel used to operate ethanol production facilities, natural gas.[2] Stories such as these are found throughout rural America and in particular the Corn Belt where ethanol is literally changing the agricultural and energy landscape.

Rural America isn't the only segment of the country investing in the ethanol boom. Ethanol refineries are being proposed and constructed in various states, including Oregon and New York, states where abundant corn harvests do not exist. The Northeast and Mid-Atlantic are looking towards ethanol in hopes it will alleviate gasoline prices and reduce air pollution caused by motor vehicle exhaust in the heavily traveled corridor. According to Pelton (2006), the state of Maryland is entertaining offers from 8 companies to build the state's first ethanol plant (estimated at $136 million) in either Baltimore's industrial waterfront or the agriculturally rich county of Somerset.[3] Overall, the Renewable Fuels Association (RFA) details that 26 states have functioning ethanol producing facilities, 9 more states than in 1999, bringing the total number of ethanol plants to 119 and the RFA reports 87 more plants are either under construction, are expanding, or are being planned. The United States produced almost 4.2 billion gallons of ethanol in 2005, slightly more than the world's second leading ethanol producer Brazil

[2] This same article notes that Hereford is called the "Beef Capital of the World" because it contains over 1 million cattle among its 16,000 residents.
[3] In the *Maryland State Agricultural Overview of 2005*, NASS reports that corn was second only to soybeans in acreage planted and harvested among field crops.

(RFA 2006), consuming close to 14 percent of the U.S. corn crop (Baker and Zahniser 2007). The Energy Information Administration (EIA 2006b), the official energy statistics provider of the U.S. Department of Energy, predicts that ethanol production will reach 14.6 billion gallons (8 percent of total gasoline production) by 2030, though 86 percent of the primary energy supply in the U.S. will still be provided by traditional fossil fuels such as oil, coal, and natural gas. The report estimates that of the 14.6 billion gallons of ethanol produced in 2030, 14.4 billion gallons will be used for ethanol blends and 0.2 billion gallons for E-85.[4] Corn based ethanol will account for 13.6 billion gallons, cellulosic ethanol[5] will comprise 0.3 billion gallons, and imported ethanol (mainly sugar based ethanol) will account for 0.8 billion gallons. In addition the report indicates ethanol production will consume approximately 31 percent of the domestic corn supply by 2017.

With the ethanol industry growing and consuming a steadily increasing amount of the total U.S. corn crop, ethanol is changing the agricultural landscape, particularly the corn market. Since net feedstock cost is the highest value import in the production of ethanol (Gallagher and Shapouri 2005) and corn is the leading feedstock used in the production of ethanol in the U.S., ethanol production will have a significant effect on equilibrium price and quantity of U.S. corn. Using reduced-form equations arising from a structural model of the corn market, this study examines the impact of E-85 prices, political intervention (the use of subsidies), and Presidential persuasion (State of the Union addresses) in the ethanol market on the corn market in equilibrium.

[4] E-85 is a motor fuel traditionally comprised of a mixture of 85 percent ethanol and 15 percent gasoline even though a blend of 77 percent ethanol and 23 percent gasoline is also called E-85. The traditional blend of E-85 is the leading alternative fuel produced by corn sold in the U.S. Since the two blends are both known as E-85, the data on E-85 does not distinguish between the blends so for statistical purposes they are treated the same.

[5] Cellulosic ethanol is ethanol fuel produced from cellulose, a naturally occurring complex carbohydrate polymer found in plant walls.

This study is broken into 6 chapters. The current chapter introduces the topic by giving a broad picture of the rising importance of ethanol throughout the country. Chapter two offers a short history of ethanol and presents the historical political influence in the ethanol market while also offering a literature review that presents findings of other researchers who have studied ethanol and its interrelationship with various economic factors. This chapter also offers a brief summary of Presidential speechmaking regarding ethanol and its influence on public opinion and governance. Chapter three outlines the methodology and economic theory used in the analysis. Chapter four presents the results of an empirical analysis on the effects of ethanol and explains the evolution of the statistical methodologies involved. Chapter five tenders concluding remarks and succinctly suggests other avenues future research might find fruitful when analyzing the relationship of the ethanol and corn markets.

CHAPTER II

HISTORY OF ETHANOL AND LITERATURE REVIEW

The production and use of ethanol is not a relatively new phenomenon. Ethanol has been produced and used in the U.S. since the early 19th century. Therefore, this chapter will provide a brief history of the use and production of ethanol to show that ethanol has been used in the past to power internal combustion engines and automobiles. Also, the ethanol market, like many markets, does not operate free from government interference. For this reason, this chapter offers an extensive review of legislation since the mid 1970's and a shorter appraisal of various State of the Union Presidential addresses that were intended to promote the use of ethanol as a motor fuel alternative to petroleum products. The literature review is broken into two sections. The first section highlights different approaches other authors have used in analyzing the ethanol market. The second section succinctly explains the way Presidential speeches influence both public opinion and public policy. The literature review concludes with an explanation of how this analysis adds to the overall discussion of ethanol's impact on the corn market.

A. Production and Use of Ethanol

Ethanol is alcohol distilled from fermented, mashed grain. It is produced into household products and used in such things as distilled vinegar, alcoholic beverages, hand wipes, antibacterial hand sanitizer, and solvents. Ethanol is also used as a biofuel, which is defined as a transportation fuel derived from biological (e.g. agricultural) sources, and this is where the major boom in ethanol production stems. With rising oil prices and a global concern for environmental damage oil may be causing, ethanol's demand as an alternative fuel is growing and should continue to grow in the next few decades.

One bushel of corn can produce 2.7 gallons of ethanol although many of the newer ethanol producing facilities are exceeding this corn-to-ethanol conversion rate (Baker and Zahniser 2007). In Brazil ethanol is commercially produced from sugarcane.[6] In laboratories, renewable resources like wood chips and switch grass are being transformed into cellulosic ethanol. Although this production is not yet viable commercially, the possibility that inexpensive and highly renewable resources like switch grass can be used to produce ethanol indicate that the long run future of ethanol production is likely found in cellulosic ethanol instead of sugar or corn based ethanol. However it is unsure how long it will be until cellulosic ethanol is produced commercially so at least in the short run sugar and corn based ethanol are the only legitimate forms of ethanol available for commercial use.

Corn based ethanol is manufactured in two ways, wet milling and dry milling. The main byproducts of the dry milling process are dried distillers grain soluble and carbon dioxide (CO_2)[7]. The most important byproducts of the wet milling process are corn gluten meal, corn gluten feed, corn oil, and CO_2. Most new ethanol plants are dry milling operations because of the lower investment costs (Eidman 2006).

---

[6] The USDA reported in July 2006 in a report titled *The Economic Feasibility of Ethanol Production from Sugar in the United States* that producing ethanol from U.S. sugarcane is profitable. However, in March of 2007, the *Tampa Tribune* reported U.S. sugarcane growers do not expand into ethanol production like their agricultural counterparts in corn because it is more profitable to sell sugarcane for sugar instead of fuel due to the protective U.S. trade policies that support higher U.S. sugar prices than the worldwide sugar price.

[7] The CO_2 captured during ethanol production is often sold to manufacturers of refrigerated frozen foods containers as well as to the petroleum industry for oilfield recovery.

Regardless of how ethanol is made, it has played a large historic role in the use of the automobile and modern internal combustion engine (EIA 2006a).[8] Ethanol was also the motor fuel of choice in the early use of the automobile (EIA 2006a). Its use as a motor fuel peaked at 60 million gallons during World War I when the war consumed substantial amounts of fuel. When the war ended and gasoline became more readily available, ethanol became uncompetitive with gasoline due to gasoline's relatively lower production costs when compared to ethanol. The 1930's was the last decade of great commercial ethanol demand as a motor fuel. A majority of ethanol sold in the 1930's was sold in the Midwest where corn was plentiful and production costs were lower. Over 2,000 fueling stations in the Midwest sold gasohol, which is gasoline blended with between 6 and 12 percent ethanol (EIA 2006a). For perspective, the 1930's had more fueling stations selling ethanol than are currently selling ethanol today.[9] By the end of World War II, oil prices declined enough to make gasoline the reigning choice of motor fuel. It wasn't until the 1970's, with oil boycotts across the oil producing states in the Middle East, a growing world economy, and mounting environmental concerns, that ethanol was considered again as a commercially viable alternative fuel to petroleum products.

[8] Some milestones involving ethanol, motor vehicles, and engines include Samuel Morey's development of an engine that ran on ethanol and turpentine in 1826, Nicholas Otto's (the inventor of the modern internal combustion engine) use of ethanol in many of his initial engines, Henry Ford's first automobile, the quadricycle, using pure ethanol instead of gasoline in 1896, and in 1908 Henry Ford's Model T being the world's first commercially produced hybrid, able to operate on pure ethanol, gasoline, or some combination of the two.

[9] The National Ethanol Vehicle Coalition (NEVC) reports that as of June 2007 1,230 fueling stations offer E-85. The web site containing the specific breakdown of fueling stations for each state can be found at http://www.e85refueling.com/states.php?PHPSESSID=58ce6d14ac2a7a15ef9206933a8f1f40.

B. Political History of Ethanol

Ethanol also has a rich history of government intervention. As far back as the U.S. Civil War, the federal government regulated ethanol. In the years preceding the Civil War, ethanol was a primary illuminating oil, so much so that the Union Congress put an astronomical $2 per gallon excise tax on ethanol to help fund the war effort (EIA 2006a). The excise tax remained in place even after the war ended in April of 1865 and was extended by proxy to the whole of the U.S. when the states reunited. Eventually in 1906, Congress removed the excise tax on ethanol and it instantly became the competitive alternative to gasoline as a motor fuel.

It was not until 1974 that ethanol became an important enough issue for the federal government to once again intervene in the ethanol market.[10] The Solar Energy Research, Development, and Demonstration Act provided money to research the development of cellulose and other organic materials such as corn and waste products into useful commercially viable energy and fuels. The effort to develop energy sources and motor fuel from renewable resources was furthered by the passage of the Energy Tax Act of 1978 and the National Energy Act of 1978. The National Energy Act required utilities to buy electricity from small power plants using renewable energy resources. The Energy Tax Act officially defined gasohol as a blend of gasoline with at least 10 percent alcohol by volume, excluding alcohol made from petroleum, natural gas, or coal. The Energy Tax Act also provided a subsidy (technically fuel with at least 10 percent ethanol

[10] The federal legislation highlighted in this analysis was accessed through the Library of Congress THOMAS website http://thomas.loc.gov/. This web site offers federal legislative information to the public from the 93rd Congress (1973) to the present Congress. The full text of legislation can be found from the 101st Congress to the present Congress. Information about bills such as summaries, sponsors and co-sponsors, amendments, and links to the full text of the bill from the Government Printing Office web site are available for federal legislation before the 101st Congress back to the 93rd Congress.

was exempted from the 4 cents a gallon federal gasoline excise tax) of 40 cents per gallon for every gallon of ethanol blended with gasoline. In addition, the law provided a 10 percent energy investment credit for biomass-ethanol conversion equipment thus boosting the incentive for businesses to become ecologically friendly. The 1970's emergence of biomass related federal legislation also included the Interior and Related Agencies Appropriation Act of 1979 that allocated $1 billion to biomass related projects.

Much like the 1970's, the decade of the 1980's continued federal legislation in the area of renewable energy. In 1980, the Energy Security Act offered insured loans for small ethanol producers (those producing less than 1 million gallons of ethanol per year), up to $1 million in loan guarantees per project that could cover up to 9 percent of construction costs of an ethanol plant, price guarantees for biomass energy projects, and purchase agreements for biomass energy used by federal agencies. The federal government also placed an import tariff on foreign-produced ethanol effectively eliminating foreign competition of ethanol, most notably from Brazil.[11] The Gasohol Competition Act of the same year banned gasoline marketer practices that discouraged the use of ethanol/gasoline blends and retaliation against ethanol resellers while the Crude Windfall Tax of 1980 extended the ethanol/gasoline blend tax credit.

The Caribbean Basin Economic Recovery Act (CBERA) of 1983 established an exception to the import tariff by establishing the Caribbean Basin Initiative (CBI). The CBI's intent was to facilitate economic trade and increase political and economic relations between the U.S. and countries in Central America and the Caribbean, notably

[11] Despite the tariff, Brazil remains the largest ethanol exporter to the U.S. according to the Renewable Fuels Association (2006).

excluding Cuba, in hopes that these countries would reject communism.[12] Most products from these countries, including ethanol, are given duty-free access to the U.S. market. According to the *Fact Sheet on Ethanol in CAFTA* (2004) from the Office of the United States Trade Representative (USTR), these countries can export ethanol into the U.S. market up to 7 percent of the U.S.'s total ethanol consumption as long as the ethanol is processed within CBI countries. For example in 2006, 5 billion gallons of ethanol were produced domestically so CBI countries could export approximately 350 million gallons of ethanol into the U.S. market, though at least 50 percent of the quota typically goes unused (USTR 2004). The largest exporting countries of ethanol to the U.S. from the CBI are Jamaica, El Salvador, Costa Rica, and Trinidad and Tobago. Jamaica is the second largest exporter of ethanol to the U.S. according to industry statistics provided b the Renewable Fuels Association (2006).

A major loophole exists in regards to ethanol within the CBI. The ethanol that can be sold in the U.S. from CBI countries only has to be processed as opposed to being produced in CBI countries. When the law was passed, sugar based ethanol from Brazil was not produced as efficiently and inexpensively as it is today. Although it was still considered a grave threat at the time, the increased importance of Brazilian sugar based ethanol being processed in CBI countries and then sold into the U.S. market was arduous and expensive enough to ensure the practice was so limited that it wouldn't be worth the painstakingly tortuous route around the ethanol import tariff. However as the years have progressed and technological advances have improved the efficiency of ethanol

[12] The U.S. Caribbean Basin Trade Partnership Act (CBTPA) extended the CBI to include 4 additional countries for a total of 24 countries. CBTPA went into affect on October 1, 2000 and will expire September 3, 2008 or sooner if another trade agreement is reached between the U.S. and the member states of the CBI.

production, the practice of exporting ethanol to CBI countries to be processed and then exported to the U.S. duty free is increasingly becoming more popular and lucrative.

The practice has become so lucrative that it has caught the ire of certain U.S. lawmakers from the Corn Belt, including Senator Charles Grassley of Iowa who is the ranking Republican on the Senate Committee of Finance. In July of 2004, Senator Grassley introduced a bill in Congress that would "introduce a fixed cap on the amount of ethanol that can take advantage of the 'pass-through' provision. The amount of the cap is based on the historical volume of ethanol exports from the CBI region over the past 20 years" (Grassley 2004). The bill would "permit the continued duty-free importation of some ethanol that is simply dehydrated in the CBI region, based on historical trade amounts…" but "would put a stop to the unlimited future growth of such duty-free imports." On May 12, 2006 Senators Grassley, Talent, Thune, Brownback, Bond, Voinovich, Coleman, DeWine, and Roberts sent President Bush a letter calling for the ethanol import tariff to remain in place since ethanol from Brazil and other countries can already enter the U.S. duty free as long as the ethanol is "dehydrated"[13] in CBI countries, a practice seen by many lawmakers as a creative way to circumvent the U.S. ethanol import tariff (Grassley 2006). On March 1, 2007 Senator Grassley continued his assault against the CBI loophole in another letter to President Bush by assailing the plans of U.S. backed development of ethanol facilities in CBI countries writing that such a partnership would "lead to the replacement of our dependence on foreign oil with a dependence on foreign biofuels" (Grassley 2007).

[13] Dehydrating ethanol is a processing technique that removes a small amount of water from "wet" ethanol thus making "dry" ethanol.

Since its inception, the ethanol subsidy (technically an exemption from the federal fuel excise tax) has varied in amount and has been extended multiple times. In 1983, the Surface Transportation Assistance Act increased the ethanol subsidy to $0.50 per gallon. In 1984, the Tax Reform Act increased this subsidy to $0.60 per gallon. In 1988, the Omnibus Budget Reconciliation Act decreased the ethanol subsidy to $0.54 per gallon. In 1998, the ethanol subsidy was extended through 2007 with gradual reduction occurring starting January 1, 2002. In 2001, the subsidy was decreased to $0.53 per gallon. In 2005, the subsidy was decreased to $0.51 per gallon. The American Jobs Creation Act of 2004 extended the subsidy to 2010. With the 2007 Farm Bill currently being debated and support for ethanol strong in the political swing states of the Midwest, the subsidy is likely to extend beyond 2010 and many government reports on energy and agriculture assume in their projections that the ethanol subsidy will be extended indefinitely.

Legislation affecting the ethanol subsidy is not the only legislation important to the growth of the domestic ethanol market. Legislation primarily aimed at improving the environment has also had substantial influence. In 1973, federal legislation required that lead, an octane-increasing gasoline additive, be slowly removed from gasoline so by 1986 each gallon of gasoline only contained one-tenth of a gram of lead. The Clean Air Act of 1990 officially ended the still small amount of lead enhanced gasoline sold domestically starting January 1, 1996. The automobile industry had already taken steps to make lead enhanced gasoline obsolete as early as 1975 when most vehicles manufactured and sold in the U.S. were equipped with catalytic converters to help control emissions, the use of which required lead-free fuel. With the outlawing of lead as an octane-increasing gasoline additive, ethanol became a leading alternative as an octane-increasing gasoline additive.

The Clean Air Act of 1990 also mandated the use of oxygenated fuels (with a minimum of 2.7 percent oxygen by volume) in specific regions of the U.S. during the winter months to reduce carbon monoxide.[14] In addition, it established the Reformulated Gasoline Program (RFG). The RFG mandated that cleaner-burning reformulated gasoline (requiring 2 percent oxygen) be sold in the 9 worst ozone non-attainment areas to reduce ground level ozone (smog) and improve other elements of air quality.[15] The two most common methods to increase the oxygen level of gasoline are blending fuel with methyl tertiary-butyl ether (MTBE) or ethanol. According to the EPA (1998) since ethanol has higher oxygen content then MTBE, only about half the volume of ethanol is required to produce the same oxygen level in gasoline as MTBE produces. This allows ethanol, typically more expensive than MTBE because ethanol has to be shipped from the Midwest instead of moved through pipelines, to compete favorably with MTBE for the wintertime oxygenates market. Unfortunately, ethanol's high volatility, measured by Reid vapor pressure (Rvp), limits its use in hot weather where evaporative emissions can contribute to ozone formation (EPA 1998).

Despite ethanol's weakness in hot weather as an oxygenate when compared to MTBE, ethanol received a major boost when in September of 1999 the EPA warned that MTBE may contaminate groundwater. This warning prompted numerous states,

---

[14] In *Massachusetts, et al. v. Environmental Protection Agency, et al 2007*, the Supreme Court ruled the EPA must regulate greenhouse gas under the Clean Air Act despite protests from the Bush Administration. Greenhouse gas include motor vehicle emissions, which previously were not regulated. This ruling may boost the production of alternative motor vehicles using E-85.

[15] The first of these oxygenate requirements was implemented in 1992. The RFG was implemented in 1995.

including California, to ban the use of MTBE as an oxygenate. California slowly phased out MTBE by a 1999 Governor's Executive Order and MTBE was officially eliminated from California fuel on December 31, 2003. California's decision to ban MTBE and make ethanol the only state-approved additive for gasoline is important because California is the largest consumer of ethanol in the U.S. according to a California Energy Commission report released in January of 2004.

Environmental concerns regarding motor fuel extended beyond pollution and included conservation regarding the limited supply of fossil fuels available for consumption. Motor vehicle companies were compelled by federal legislation to manufacture motor vehicles with better gas mileage. The Alternative Motor Fuels Act of 1988 (AMFA) encouraged the growth of ethanol by establishing Corporate Average Fuel Economy (CAFE) credits for alternative fuel vehicle production.[16] These credits are granted against manufacturers' compliance calculation, which is the applicable average fuel economy standard that each manufacturer must meet for passenger cars and light trucks. However, while these credits added more alternative fuel vehicles to the road, manufacturers continued to manufacture vehicles that fell below the federal fuel standards since the CAFE credits can be used to offset the poor fuel performance of other vehicles in their fleet. Fortunately for the ethanol industry, a majority of the alternative fuel vehicles produced are E-85 compliant. Wanting even more alternative fuel vehicles on the road, Congress passed the Energy Policy Act of 1992 (EPACT). This required certain government and "fuel provider" fleets of motor vehicles to acquire alternative fuel

[16] The standard CAFE is the sales weighted average fuel economy, expressed in miles per gallon (mpg), of a manufacturer's fleet of passenger cars or light trucks with a gross vehicle weight rating (GVWR) of 8,500 lbs or less, manufactured for sale in the U.S., for any given model year.

vehicles with new vehicle purchases. The law also extended the ethanol excise tax exemption to ethanol/gasoline blends of 5.7 and 7.7 percent.

The Omnibus Budget Reconciliation Act of 1990 gave a much needed boost to small ethanol producers. This legislation established a small ethanol producer's income tax credit $0.10 a gallon for producers who produced less than 30 million gallons of ethanol a year. This tax credit was applicable for the first 15 million gallons a year and could not exceed $1.5 million per year.

The latest piece of federal[17] legislation directly affecting the ethanol market is the Energy Policy Act of 2005. This law includes three provisions affecting ethanol. First, the small ethanol producer's income tax credit is extended to facilities that produce 60 million gallons or less of ethanol a year, doubling the production ceiling previously established. Second, the law establishes a 30 percent credit for the cost of installing clean-fuel vehicle refueling equipment. Lastly and most vital to the long run future of the ethanol market, the Renewable Fuel Standard (RFS) was launched. The RFS mandates that 4 billion gallons of renewable fuel be produced by 2006. This amount increases to 7.5 billion gallons by 2012. The only negative aspect of the RFS for corn farmers is that refiners are required to use a minimum of 250 million gallons of cellulosic ethanol a year for the blending starting in 2013. If cellulosic ethanol is readily available by 2013, refiners may make the wholesale change of moving away from corn ethanol and into cellulosic ethanol since it can be made with more renewable resources. However, cellulosic ethanol is mostly limited to laboratories and small-scaled production not large

[17] For an abbreviated list of state incentive programs dealing with ethanol see Appendix A. This list is adapted from the California Energy Commission's report *Ethanol Fuel Incentives Applied in the U.S.* released in January 2004.

enough for commercial use. The main reason for its lack of success is the prohibitive cost of constructing a cellulosic ethanol plant. The EIA (2007) estimates that a 50 million gallon corn ethanol plant costs $67 million (2005 dollars) to build while a 50 million gallon cellulosic ethanol plant costs $375 million (2005 dollars) to build.

The ethanol market has also been touched by Presidential persuasion. Presidents often address energy issues in their annual State of the Union address. The energy sections of these speeches usually highlight energy conservation and the need for new alternative fuels that are inexpensive and environmentally friendly. In each of the last three State of the Union addresses, President Bush has singled out ethanol as one of those alternative fuels that will help diversify the nation's energy supply while at the same time harm the environment less than the use of fossil fuels. The President has requested federal tax dollars be made available for continued research of ethanol production.

C. Literature Review of Ethanol

Literature on ethanol is varied across disciplines. In the scientific community, much has been written on the environmental impact of ethanol as an alternative motor fuel. These studies show mixed results with some studies concluding the use of ethanol as a motor fuel to have a positive impact on the environment while other studies conclude that the use of ethanol as a motor fuel is detrimental to the environment (see below). These studies often concentrate on net energy values of ethanol, soil erosion, air quality, and water quality.

The movement from fossil fuels (petroleum, natural gas, and coal) into biofuels will only be beneficial if the following criterion is met. First, the biofuel in question should produce a positive net energy gain over the energy sources used to create it.[18] Second, the biofuel must be produced in sufficient quantities that are renewable so it has a meaningful impact on energy demand. Lastly, the biofuel must be economically competitive with other fuel substitutes. The more economically competitive the biofuel is without government support the more beneficial the biofuel is since legislative protection can encourage rent seeking behavior and subsidies can cause crowding out effects. This last point is particularly crucial since the EIA (2007) estimates that E-10 has 3.3 percent less energy content than regular gasoline and E-85 has 24.7 percent less energy content than regular gasoline meaning that the price of E-85 must be less than gasoline or consumers will probably still prefer gasoline.

The use of ethanol has a positive energy balance even before subtracting the energy allocated to its byproducts. When the energy of ethanol's byproducts is included in the energy balance the energy balance of ethanol increases even more (Shapouri, et al. 2004). Ethanol use, including ethanol byproducts, yields 25 percent more energy than the energy invested in production. The production and combustion of ethanol reduces the use of fossil fuels by as much as 12 percent (Hill, et al. 2006). Corn ethanol even reduces greenhouse gas emissions by up to 13 percent, a figure that can improve as the incentives, whether market or government, to improve ethanol yield and ethanol production increases (Farell, et al. 2006).

Not all scientific studies agree that the production and consumption of ethanol will result in environmental benefits. One study that questions the environmental

---

[18]Calculating the amount of energy used in producing the biofuel and comparing it to the amount of energy the biofuel actually produces and the energy the byproducts of biofuel production produces determine net energy value.

friendliness of ethanol use in motor vehicles found that deaths related to increased ozone would increase by 4 percent in the U.S. if all motor vehicles operated on E-85 as opposed to petroleum products (Jacobson 2007). A second study concluded that ethanol produces a negative energy value, though this study does not take into account the energy value of ethanol byproducts (Patzek and Pimentel 2005). Furthermore, a study arguing solely from the First and Second Law of Thermodynamics[19] and the Law of Mass Conservation[20] finds that the industrial corn ethanol cycle is severely detrimental to the environment of the continental U.S. The study concludes air quality diminishes, surface and subsurface water supplies become more polluted, top soil erodes at a greater rate because of the changed farming cycles which include more corn acreage and less acreage rotation, minerals are being depleted, and fossil fuels, in particular natural gas, are consumed at an even greater rate than before because of the construction and operation of an increasing number of ethanol plants (Patzek 2005). While the debate on the environmental costs and benefits are important, this study is more interested in the literature surrounding the direct economic costs and benefits of ethanol production as opposed to the indirect economic costs produced through an evolving environmental landscape.

A first way to determine the economic costs and benefits of ethanol production is to analyze the impact of the ethanol subsidy in the domestic market, particularly its effects on private investment and government costs. The ethanol subsidy is a subsidy not contingent on market conditions or prices. In a sense it is a "fixed" subsidy that is paid

[19] The First Law of Thermodynamics states that the increase in the internal energy of a thermodynamic system is equal to the amount of heat energy added to the system minus the work done by the system on the surroundings. The Second Law of Thermodynamics states that the entropy of an isolated system not in equilibrium will tend to increase over time, approaching a maximum value at equilibrium.

[20] The Law of Mass Conservation states that matter cannot be created nor destroyed, though it may change form. This implies that for any chemical process in a closed system, the mass of the reactants must equal the mass of the products

regardless of ethanol price or ethanol production costs. With ethanol production increasing yearly, this “fixed” subsidy will continue to cost taxpayers a greater amount of federal tax dollars. It is estimated that roughly $1 in the price of a gallon of ethanol comes from government subsidies, loans, and price supports (Lieberman 2007). However this amount would change if the ethanol subsidy could be transformed into a “variable” subsidy, a subsidy that is contingent on market conditions and prices, for example a subsidy that increases as the price of ethanol falls and decreases when the price of ethanol increases. A “variable” subsidy of this type reduces private sector risk by stabilizing returns and increases the likelihood of private investment while at the same time saving taxpayer money by removing the subsidy during high ethanol prices. A “variable” subsidy would reduce government cost and private sector risk bringing a win-win to the ethanol marketplace (Tyner and Quear 2006).

Reducing private risk is important since the ethanol industry structure has evolved where the ownership of production facilities are controlled by a large number of relatively small firms (Eidman 2005). Eidman reports that in 1990, 13 companies managed the 17 commercially produced ethanol facilities with the largest firm controlling 55 percent of the capacity. By 2005 this market power shifted and was diminished as 71 companies and cooperatives operated 84 facilities with the largest firm controlling less than 30 percent of the capacity. In addition, 49 of these plants are producer (farmer) owned plants where profits are directly linked with community farmers and investors.

While the trend in the last decade has been a movement away from larger firms controlling significant amounts of the market share, the increased interest in ethanol production, because of large accounting and economic profits, has encouraged the building of mega ethanol producing plants to take advantage of economies of scale. For example, Archer Daniels Midland, the leading U.S. ethanol producer, is building a 275 million gallon plant in Nebraska and a 275 million gallon plant in Iowa, which will combine to produce almost the same amount of ethanol as all of Minnesota's current ethanol facilities. Kenkel and Holcomb (2006) report many newer plants will be built in places outside the Corn Belt. The geographic dispersion and size of the new plants may once again shift the ethanol market back into the hands of a relatively small number of firms and away from producer-ownership such as cooperatives. If the trend is again towards larger ownership and this is deemed socially harmful, then the adaptation of a subsidy that supports small ethanol producers but excludes large ethanol producers would be preferable to the current subsidy. This type of subsidy would help level the playing field between small and large ethanol producers by minimizing the importance of economies of scale in production.

A second way to compare the costs and benefits of ethanol production is to analyze the industry's processing margins. As ethanol production increases processing margins fall to zero due to increased competition. This increased competition is a reality because if all the ethanol plants that were planned and constructed as of 2005 enter the marketplace, 26 billion gallons of ethanol will be produced by August 2009, approximately 5 times the amount of ethanol produced in 2006 (Tierney 2006). At this level, processing margins would be in a steady decline thus dampening the entrance of other firms into the ethanol market and capping the number of firms corn farmers have to sell their crop. At some point a saturation point is reached and the payback for a firm's initial investment to enter the market elongates. In the initial stages of the current ethanol boom (late 1990's), the payback period for ethanol plant investment was less than 2 years (Gallagher and Otto 2001). Thus the size of the processing margins becomes an important signal for new and future investors as to whether or not it is economically sensible to enter and compete in the ethanol market.

A third way to analyze the costs and benefits of ethanol production is to compare the newer ethanol plants built in the 2000's to "older" ethanol plants built in the 1990's and consider what changes occurred over time. The newer ethanol plants are being constructed for half the cost of the older plants and operate at twice the efficiency thanks to the use of information technology. Information technology has decreased the costs of planning, constructing, and operating ethanol plants as better access to information and financing have offset the cost savings traditionally connected with vertical integration found mainly in processing industries, which ethanol production is. From the initial planning to the first drop of ethanol produced, information technology has allowed newer ethanol plants to open as much as 6 to 12 months earlier than older ethanol plants could. Information technology has also allowed mid-sized and small-sized ethanol production facilities to remain competitive with larger firms even if these newer plants are smaller than the older plants (Crooks and Dunn 2006).

A fourth way to explore the costs and benefits of ethanol production is to determine how ethanol production affects local economies. Many ethanol plants are still built in small communities often located in rural agricultural America where population is declining, but commodities are still plentiful so the effects of ethanol production on these communities weigh heavily in the decision making process of whether or not a community should invest in the production of an ethanol plant. Any gain can greatly enrich a small community in a way never before seen, and since ethanol plants employ over 3,500 workers nationwide, pay over $132 million in annual salaries, and generate $110 million in local taxes yearly, areas with small and declining populations have great incentive to invest in ethanol plants and to specialize in corn production (Parcell and Westhoff 2006). Besides the number of new jobs added to a community, ethanol plants can give a local economy a much need cash flow. A cost-benefit analysis of the oxygen requirement in motor fuels (as required by the U.S. EPA) suggests that gains for consumers, producers, and local economies in terms of cash flow would more than offset any possible lost federal tax revenues in those communities that decide to build an ethanol plant (Dikeman, et al. 2000). However, as more ethanol production facilities are built, particularly in corn areas, the chance of an over saturated market increases.[21] Still, the new market for feed grains and in particular corn is welcomed news in many farming communities since advances in feed grain production technology has often times allowed supply to outstrip demand and depress agricultural prices thus damaging farming communities across the country (Houck and Ryan 1972).

A fifth way to analyze the costs and benefits of ethanol production is to see the effects trade distorting policies in the U.S. (tariffs, subsidies, loan guarantees, etc.) have on the world ethanol market, in particular Brazil. Brazil and the U.S. are the world's largest producers of ethanol. Since the production costs of ethanol using sugarcane are lower than that of corn, Brazil's ethanol is more competitively priced on the world

---

[21] The possibility of an over saturated market has not dampened the spirits of the residents of Heron Lake, Minnesota where the *Star Tribune* reports the building of a $110 million ethanol plant has revitalized the area and given it a much needed shot in the arm. The *Tribune* reports that local farmers and residents invested a minimum of $20,000 each to buy stock in the plant and Mayor John Hay plans to use the increased city's tax base (which is expected to triple) to upgrade area roads as well as fix the roof of the city-owned nursing home. This ethanol facility will join the 16 other ethanol production facilities in the state.

market. The protection granted the U.S. domestic ethanol industry by Congress has made Brazil's ethanol uncompetitive with U.S. ethanol in the U.S. market.[22] However, the removal of the U.S. trade barriers would decrease the worldwide price of ethanol by 13.6 percent resulting in a 7.2 percent decline in U.S. production and a 3.6 percent increase in consumption. The U.S. net ethanol imports would increase by 199 percent and Brazil would increase its ethanol production by 9.1 percent (Elobeid and Tokgoz 2006a). An ethanol market devoid of tariffs and quotas is important to the U.S. if it is serious in obtaining energy independence. If the entire Midwestern corn crop was produced into ethanol it would only supply the Midwest region with two-thirds of the region's gas demand (Gallagher 2006). The EIA (2006b) estimates that in order to produce 12-16 billion gallons of ethanol 33-38 percent of the U.S. corn crop would need to be used. Therefore for the country to become completely energy independent without eliminating the trade distorting policies that keep foreign ethanol uncompetitive in the domestic market, a substantial increase in corn acreage, corn yields, and ethanol efficiency is needed. This decision would dramatically affect other agricultural crops negatively since an increase in corn acreage would result in less acreage for other crops as well as the use of idle and less efficient land. Such a change has the possibility of causing catastrophic environmental and ecological damage to the U.S. and in particular the Midwest region as soil becomes depleted of much needed minerals, more fertilizer is used causing groundwater contamination, and petroleum is used in farm machinery to care for the additional crop.

[22] In his trip to Central and South American countries in March 2007, President Bush informed Brazil's president, Luiz Inacio Lula da Silva that the ethanol tariff will remain in place until 2009 (Van Susteren 2007).

A sixth way to analyze the costs and benefits of ethanol production is to determine how price changes in the gasoline market affect the corn market. Since ethanol is a substitute of gasoline and ethanol is produced primarily from corn, a shock in the gasoline market will shock the ethanol market, which in turn will reverberate in the corn market. The positive correlation between gasoline and ethanol prices in the U.S. is due mainly to the political intervention in the ethanol and corn market with the Renewable Fuel Standard and the banning or replacing of MTBE with ethanol. Elobeid and Tokgoz (2006b) estimate the effect a price shock in the gasoline market on corn prices. They determined that a 20 percent increase in gasoline price would cause a 1.4 percent decrease in ethanol consumption, a 0.7 percent decrease in ethanol production and a 0.6 percent increase in corn price. This result may seem counterintuitive since it is assumed that ethanol is a substitute for gasoline and thus as a substitute good. Therefore an increase in the price of gasoline would increase the consumption of ethanol, increase the production of ethanol, and increase the price of corn. However, the authors noted that ethanol acts as both a substitute and a complement to gasoline for three reasons. First, the majority of ethanol produced is used in the blending of E-10 (a motor fuel comprised of 10 percent ethanol and 90 percent gasoline) instead of E-85. Since the late 1970's almost all commercial vehicles in the U.S. are equipped to run on pure gasoline or E-10 so many consumers may unknowingly be filling their vehicles with a gasoline/ethanol blend. Second, the NEVC reports that as of 2006 approximately 6 million vehicles in the U.S. are flex-fuel vehicles. Flex-fuel vehicles are vehicles that can run on either E-85 or regular gasoline. Lastly, the availability of fueling stations that offer E-85 is limited. Combined with the limited availability of E-85 and the limited number of flex-fuel vehicles available for public purchase, ethanol is not a true economic substitute for gasoline. These caveats make it understandable why Tokgoz and Elobeid (2006b) concluded that the composition of a country's vehicle fleet determines the direction of the response ethanol consumption has on changes in gasoline and feedstock prices (either as a substitute or complement).

This same study also analyzed the impact a price shock in corn prices would have on the ethanol market. Using reduced form equations for U.S. crop exports that capture the responses of international crop markets to changes in U.S. crop prices and solving for corn prices endogenously through an equilibrium mechanism that equates excess supply to excess demand, Tokgoz and Elobeid concluded a 20 percent increase in the market price of corn would lead to a 3.7 percent decrease in domestic ethanol production and a 2.3 percent increase in ethanol price. This increase in corn price should decrease profitability of ethanol producers since corn comprises 57 percent of total ethanol production costs (USDA 2005). A lower domestic profit margin would have international market spillover. If the domestic production of ethanol were adversely affected by a price shock in the corn market resulting in lower production coupled with increased corn-ethanol prices, the domestic market would become more suitable for the importation of foreign ethanol even if the trade distorting policies remained intact.

A final way to analyze the costs and benefits of ethanol production is to estimate when ethanol production would cease to expand because the ethanol market and all related markets (corn, wheat, soybeans, poultry, etc.) reach equilibrium. Using a multi-commodity, multi-country system of integrated commodity models, it is estimated that ethanol expansion will cease when the price of corn per bushel reaches $4.05 (Elobeid, et al. 2006). At this price the authors estimate that corn ethanol production will reach 31.5 billion gallons per year and require 95.6 million acres of corn to be planted. This analysis assumes corn yield trends will grow at the same rate as in previous years and does not compensate for any increase in corn yield. The authors note that an increase in corn yield would enlarge the ethanol industry and have a less severe impact on feedstock markets. In addition the author's analysis did not address weather uncertainties, in particular drought. The authors acknowledged the impacts on related markets due to drought would be greater than the results they presented since the lower supply of corn would be competed for by an increasing number of buyers. The acknowledgement of common shocks in the agricultural markets is important and cautions researchers against the use of all contemporary prices in statistical models of agriculture since the common shocks affect all the markets and thus all the prices, a violation of ordinary least-squares (OLS) in regards to endogeneity.

D. Literature Review of Presidential Speeches

A review of how political speeches affect the behavior of lawmakers and the public is also needed since speeches made by the President are an important component of the analysis presented here. Presidents have the unique opportunity of using their "bully pulpit" to advance their agenda. When the President calls a news conference, all the major media outlets in print, television, radio, Internet, etc. cover it. When the President gives his State of the Union address, he has the advantage of a captive audience because he is uninterrupted in his speech except for the applause. When the media reports the President's proposals, actions, and speeches, support for the President's policy positions increases (Page and Shapiro 1985). If real world conditions are worsening and the President turns his attention to these issues in a major public address, the public concern for these issues increases and affords the President the opportunity to alert the public in a way that is most politically beneficial for him (Behr and Iyengar 1985). His speechmaking also alters his approval ratings among certain partisan, income, and regional groups, which is useful if the President is reaching out to a particular segment of society (Ragsdale 1987). Since the occurrence of a Presidential speech has a significant, positive effect relative to other variables such as military activity (Ragsdale 1984), the President can effectively use his speeches to advance his own policies, his own popularity which in turn builds political capital that can be used for future policies, and his own reputation among a particular group that he may need to reach for a particular issue. This behavior is clearly seen in State of the Union addresses where Presidents typically speak on the same basic issues (the economy, energy, and national security) every year but with different caveats aimed at particular groups. For example, from 1978 to 2007 the topic of energy independence has been inserted into these speeches. Specifically in the last three State of the Union addresses ethanol has been used by name. President Bush is clearly trying to take advantage of the national public opinion on environmental concern while also improving the Republican Party's appeal in the Midwest, where much of the country's corn is grown, many of the country's ethanol plants are located, and numerous swing states (Minnesota, Iowa, Indiana, and Illinois) are found and whose electoral college votes are crucial for future Republican Party Presidential victories. It also does not hurt that reaching out to rural America holds a certain romantic appeal in the hearts of many Americans even if they do not or have never lived in a small farming community.

Therefore reaching out to rural agricultural America has many positive benefits with very little social and political costs in the eyes of politicians.

Presidential persuasion and federal intervention through the use of subsidies in the ethanol market is important for the corn market because ethanol produced in the U.S. is produced almost exclusively from corn.[23] The demand for corn is derived, at least in part, from the demand for ethanol. Therefore the demand for corn is partially determined by the price of ethanol and of any factors that affect the demand for ethanol, such as political persuasion and subsidies, plus any factors that affect the productivity of corn in the production of ethanol. The corn and ethanol markets cannot be separated and movements in one market affect the other market. This is where this study differs from previous studies. This study not only analyzes the impact ethanol has on the corn market but also how factors that influence the ethanol market impact the corn market.

In summary, the literature on ethanol is diverse. Some research focuses on its environmental factors with a disagreement existing on whether ethanol use is a positive or a negative for the environment. The economic literature focuses on the costs and benefits of different aspects of ethanol. Ethanol production is a benefit for local rural agricultural communities where corn and ethanol are abundant. Changes in the ethanol industry have increased productivity in ethanol plants and allow them to be more competitive with foreign ethanol plants. Changes in information technology are allowing smaller domestic ethanol producers to compete with larger domestic ethanol producers.

[23] It is appropriate here to define the type of corn being used in this study. When farmers plant their corn, they have the option of harvesting it early (before the kernel is dry and fully mature) and having sweet corn or harvesting when the kernel is dry and fully mature thus having field (grain corn). A majority of corn grown in the U.S. is field corn (NASS Database 2006). The corn used in ethanol production is field corn. For the rest of the analysis field corn will simply be referred to as corn.

Price increases in the gasoline market would adversely affect the ethanol market but would increase corn prices. Under some conditions, rapid increases in corn prices would destabilize the ethanol industry and could possibly cause a reduction in the number of ethanol plants being constructed or even operating which would mean that fewer ethanol plants would be bidding for corn thus causing a subsequent drop in corn prices. The interdependence of the agricultural sector means that any model analyzing ethanol has to include prices from the different markets closely related and that these prices cannot be contemporary prices or endogeneity may be a problem for the model.

Ethanol also has a rich history of political intervention. Politicians have passed much federal legislation that has encouraged the growth of the ethanol industry, which indirectly helps the corn industry since more corn is needed to fuel the ethanol boom. The use of subsidies and tariffs has had a mixed effect on the domestic ethanol market. While the ethanol tariff and subsidies have protected the domestic ethanol industry from foreign competition and thus providing a stable market for U.S. corn farmers to sell, these exact market barriers could stunt future production, as the domestic market will reach a saturation point. Presidents have also used their ability to speak to broad audiences to promote their own policy agenda, which in regards to energy independence has included the promotion of ethanol in the last few years. These results suggest that subsidies and Presidential speeches play a significant role in the ethanol and thus the corn market because of derived demand and should be accounted for in any model analyzing the connection between ethanol and corn.

CHAPTER III

METHODOLOGY AND THEORY

The analysis presented in this study is concerned with the impact E-85 prices have on the equilibrium corn market. Since corn is the primary feedstock used in ethanol production in the U.S. and the political intervention in the search for alternative fuels has thus far favored corn ethanol production, ethanol, politics, and the corn market are interwoven and should be studied together. In general, if the demand for alternative fuel sources is growing and the current political structure encourages ethanol production, there is a greater demand for corn. Specifically, if demand for ethanol is increasing, thus driving up the price and quantity of E-85, then the demand for corn is increasing.

Since the demand for corn is partially determined by the demand for ethanol, an analysis of the corn market is an analysis of derived demand. The demand for corn is determined by the price of ethanol and any factors that affect the demand for ethanol, such as political persuasion and subsidies, plus any factors that affect the productivity of corn in the production of ethanol, and any other factors that affect the demand for corn independent of ethanol. If more corn is being demanded for ethanol production then farmers are faced with four choices: farmers could increase the number of acres devoted to corn by using previously idle land, they could increase the number of acres devoted to corn by substituting away from other crops such as soybeans, wheat, and sorghum, they could devote the acres they had planned to use for sweet corn and allow the corn to stay in the ground longer so as to harvest it as field corn, or they could simply devote more time, energy, and money into their existing corn crop and increase corn yield at the expense of the other crops planted.

Whatever choice the farmer makes will have consequences on more than just the corn and ethanol markets. A greater demand for ethanol drives up the demand for corn and thus provides a higher price for farmers. Farmers will adjust to these higher prices by increasing the supply of corn they bring to market. This increased competition between ethanol producers and more traditional corn buyers such as food processing companies will drive corn prices even higher as the competition for the limited supply of corn intensifies. This higher price for corn will increase food prices if food-processing companies cannot find suitable substitutes for their products, whether it is other products (for example the use of cane sugar instead of corn syrup in soda) or foreign sources of corn.

The increased competition for domestic corn will affect both the supply and demand side of the corn market. E-85 acts as a substitute good to other consumers of corn, whether they are food processors or poultry farmers. It does not matter to the farmer what the end result of the corn he grows is, only that the increased competition among buyers is beneficial to him by driving up the market price of corn and encouraging him to grow more. The demand and supply sides of the corn market are changing simultaneously as a growing ethanol market is demanding more corn and higher prices are encouraging farmers to grow more corn. The question is whether the demand for corn is outstripping the supply of corn or vice versa. If the demand for corn is growing faster than the supply of corn, then the price of corn will rise as the demand for ethanol rises. If the supply of corn is growing faster than the demand for corn, then the price of corn will fall even as the demand for ethanol increases because of an excess supply of corn.

The fact that farmers cannot adjust instantaneously should also be included in the analysis. Farmers cannot plant corn continuously on the same acreage or yields will fall due to falling soil nutrients. Farmers also must wait an extended period of time before harvesting their corn. Corn reaches maturity between 85 and 140 days after planting depending on where the corn is grown. These two restrictions mean that adjustment time for farmers is longer than for other markets, say, manufacturing, that do not have to wait for nature to take its course. Farmers make the decision of how much acreage to devote to corn based on the most current information. In this analysis, a high E-85 price signaling a strong demand for ethanol encourages the farmer to plant more corn than he otherwise may have because he is anticipating a higher future corn price. It may also be the case that a farmer has to decide whether to harvest the corn as sweet corn or allow it to fully mature into grain corn. If the price of E-85 is high at the time when the farmer would harvest the corn as sweet corn, then the farmer may decide to allow the corn to mature and sell it as field corn instead of sweet corn in hopes of obtaining a higher price. Either planting more corn or harvesting the corn as field corn instead of sweet corn has the same effect, an increase in the supply of corn heightening the possibility of supply outstripping demand of corn at harvest. The greater supply could dampen corn prices and thus discourage the farmer from planting the same amount or even more corn the next year, or harvesting his corn crop as sweet corn instead of field corn. If the farmer plants less corn this year because of the depressed corn price he received last year, the demand for field corn may outstrip the supply of field corn at the next harvest and drive market prices in an upwards direction. A continuation of this pattern results in a cobweb effect as the supply of corn fluctuates up and down continuously or until the market reaches stabilization.

As mentioned earlier, markets have both a demand and supply side for a good. The demand function for good X can be expressed as a function of the price of X (p_x), the price of all other related commodities (p_y), the tastes of the buyers (t), the expectations of the buyers (e), and the money income (m). The demand function for good X is expressed as:

$$X = f(p_x, p_y, t, e, m) \quad (1)$$

The supply function for good X can be expressed as a function of the price of X (p_x), the prices of inputs needed to produce the good (w), the price of joint commodities (p_j), the price of rival commodities (p_r), the technology needed to produce the good (a), and the expectations of the producers (e). The supply function for good X is expressed as:

$$X = f(p_x, w, p_r, p_j, a, e) \quad (2)$$

Since the demand and supply sides of a market simultaneously determine market price and quantity exchanged, simultaneous equations are used for estimation. Based on the supply and demand systems posited above, the structural (market) equations used to determine E-85 and political intervention's effects on the corn market are:

$$\text{Quantity Demand (Corn)} = a_0 + a_1 \text{(Price of corn)} + a_2 \text{(Income)} + a_3 \text{(Price of broilers)} + a_4 \text{(Price of E-85)} + a_5 \text{(Speeches)} + a_6 \text{(Subsidies)} + a_7 \text{(Time)} + \mu_1 \quad (3)$$

$$\text{Quantity Supply (Corn)} = b_0 + b_1 \text{(Price of corn)} + b_2 \text{(Price of wheat)} + b_3 \text{(Price of soybeans)} + b_4 \text{(Winter)} + b_5 \text{(Spring)} + b_6 \text{(Summer)} + b_7 \text{(Time)} + b_8 \text{(Speeches)} + \mu_2 \quad (4)$$

$$\text{Quantity Demand (Corn)} = \text{Quantity Supply (Corn)} \qquad (5)$$

The data for all variables are monthly, starting with October 1997 and ending December 2006. All prices are nominal. It is assumed that markets clear where supply meets demand so that the observed quantity is taken to be the equilibrium quantity and the observed price is taken to be the equilibrium price.

The price of corn is represented by a_1 in the demand side and b_1 in the supply side of the analysis. This variable is the average equilibrium price of a bushel of corn received by farmers as reported by the online database of the National Agricultural Statistical Service (NASS) of the USDA. Assuming corn is not a Giffen good, the Law of Demand states that when the price of corn increases the quantity demanded for corn will decrease. Therefore a_1 should be negative. The Law of Supply states that when the price of corn increases, the quantity supplied of corn will increase. Therefore b_1 should be positive.

The income variable is represented by a_2. This variable is the total private average weekly earnings of U.S. workers as reported by the Bureau of Labor Statistics (BLS) scaled to monthly data.[24] Income is in the demand equation because as income increases an individual is able to demand more goods for consumption. Therefore the coefficient sign for a_2 is expected to be positive.

The price of broilers[25] is represented by a_3. This variable is the average equilibrium price per pound of a broiler received by farmers as reported by the online database of NASS. Farmers who raise broilers use corn as a main feed and are therefore

[24] The adjustment process used two steps. First, each week's earnings were multiplied by 13/3 to represent the average number of weeks per month to scale the weekly earnings into monthly earnings. Second, the BLS inflation calculator was used to update the 1982 dollars to 2006 dollars.
[25] Broilers are chickens raised primarily for meat instead of eggs.

consumers of corn.[26] These poultry farmers are direct competitors with ethanol producers for the consumption of corn. If the price of broilers increases then the demand for corn should increase and the signs of a_3 should be positive.

The price of E-85 is represented by a_4. This variable is the monthly price of E-85 from the state of Minnesota and is acting as a proxy variable for national E-85 prices.[27] The demand for corn is derived, at least in part from the demand for ethanol. Since ethanol production requires corn as an input, the price of E-85 and other factors affecting the productivity of corn in the production of ethanol summarize the effects of the ethanol market on the demand for corn. Ethanol producers are direct competitors with poultry farmers for the consumption of corn, since corn is an input in the production of broilers and ethanol. If the price of E-85 increases then the demand for corn increases and a_4 should be positive.

The variable Speeches is represented by a_5 and is a dummy variable for the State of the Union addresses. If the President mentions ethanol by name in the State of the Union address, the months of that year receive a 1. If the President does not mention ethanol by name in the State of the Union address, the months of that year receive a 0. This variable is included in the demand equation because it shapes the demand for ethanol, which in a derived demand scenario affects the demand for corn. Since energy policy is often mentioned in the State of the Union addresses and these addresses allow Congress and the public to see the President's agenda for the year, these speeches have

[26] F tests were conducted to see whether or not the price of beef and the price of hogs should be included in the model in place of or in conjunction with the price of broilers. The results of the F tests indicated that the price of broilers was the only variable that had any statistical significance in the model.

[27] The reason this variable was chosen as a proxy variable is that historical data on national average of E-85 prices does not exist on a monthly basis. The state of Minnesota has 25.8 percent of all fueling stations that sell E-85 according to the NEVC and thus has kept the longest historical tracking of E-85 prices in the U.S.

the ability to make a large impact on the ethanol market. If ethanol is influenced positively by these speeches and its demand increases, then the demand for corn increases since ethanol is part of the derived demand for corn. It is expected that a_5 will be positive since the mentioning of ethanol by name in an important national address will be beneficial for the ethanol market and in turn beneficial for the corn market.

The variable Subsidies is represented by a_6. This variable is the amount of federal subsidy a blender of ethanol receives for each gallon of ethanol blended with gasoline. The current subsidy is $0.51 for every gallon of ethanol blended. Just like the Speeches variable, this variable is in the demand equation because it affects the demand for ethanol, which affects the demand for corn. Increasing the ethanol subsidy over time increases the demand for corn as more firms enter the ethanol market to obtain the increasing ethanol subsidy. A decreasing subsidy over time decreases the demand for corn as the incentive to enter the ethanol market is lower and may actually cause firms to leave the ethanol market. It is expected that a_6 will be positive since the subsidy is expected to remain in place at least for the foreseeable future thus encouraging firms to enter the market for ethanol and therefore increasing the demand for corn.

The last variable in the market demand equation is Time and is represented by a_7. Following the derived demand argument, this variable is modeling technological changes in the ethanol market. Since such advances in technology are expected to increase the marginal productivity of corn in the production of ethanol, they would in turn increase the demand for corn and hence imply a positive coefficient for a_7.

The price of wheat is represented by b_2. This variable is the average equilibrium price of a bushel of wheat received by farmers as reported by the online database of

NASS. It is in the supply equation because it is a rival good of corn in production. Many farmers have the option of planting wheat instead of corn. Therefore b_2 is expected to be negative since an increase in the price of wheat will encourage farmers to move production away from corn and towards wheat for the higher market price.

The price of soybeans is represented by b_3 and is the average equilibrium price of a bushel of soybeans received by farmers as reported by the online database of NASS. It is in the supply equation because it is a rival good of corn in production. Many farmers have the choice of either planting soybeans or corn or have the option of adjusting their crop cycles to either include more or less corn and soybeans. Therefore b_3 is expected to be negative since an increase in the price of wheat will encourage farmers to move production away from corn and towards soybeans where a higher market price is obtainable.

The variables Winter, Spring, and Summer are represented by b_4, b_5, and b_6 respectively. These variables are seasonal dummy variables designed to allow for the possibility that different seasons differentially effect the production of agricultural goods. Almost all agricultural products are seasonal in nature because of the different growing seasons. The winter months are December, January, and February. The spring months are March, April, and May. The summer months are June, July, and August. The months of September, October, and November are considered fall months and a fall variable was excluded to avoid the dummy variable trap. A month in winter receives a 1 for Winter and a 0 for Spring and Summer. A month in spring receives a 1 for Spring and a 0 for Winter and Summer. A month in summer receives a 1 for Summer and a 0 in Winter and Spring.

The variable Time is included in the market supply equation and is represented by b_7. This variable is modeling changing technologies in the corn market over time. Since such advances in technology are expected to increase the marginal productivity of corn a positive coefficient sign for b_7 is expected.

The last variable in the market supply equation is Speeches and is represented by b_8. Speeches is included in the supply equation because farmers as well as consumers watch the State of the Union addresses. Therefore the supply of ethanol is affected as well as the demand for ethanol. It is expected that b_8 is positive.

Since the price of corn affects both the demand and the supply side of the market, the process of substitution is applied. The quantity demand and quantity supplied equations are transformed to produce an equilibrium price equation for corn. This price equation is the reduced form equation. The reduced form coefficients include both the direct and indirect effects of the change in the market (Ford and Jackson 1998). The price equation is estimated to determine the effect the price of E-85 and political intervention has on the equilibrium price of corn. Substituting equations (3) and (4) into (5):

$$a_0 + a_1 \text{ (Price of corn)} + a_2 \text{ (Income)} + a_3 \text{ (Price of broilers)} + a_4 \text{ (Price of E-85)} + a_5 \text{ (Speeches)} + a_6 \text{ (Subsidies)} + a_7 \text{ (Time)} + \mu_1 = b_0 + b_1 \text{ (Price of corn)} + b_2 \text{ (Price of wheat)} + b_3 \text{ (Price of soybeans)} + b_4 \text{ (Winter)} + b_5 \text{ (Spring)} + b_6 \text{ (Summer)} + b_7 \text{ (Time)} + b_8 \text{ (Speeches)} + \mu_2 \qquad (6)$$

Solving for the Price of Corn:

$$a_1 - b_1 \text{ (Price of Corn)} = - a_0 - a_2 \text{ (Income)} - a_3 \text{ (Price of broilers)} - a_4 \text{ (Price of E-85)} - a_5 \text{ (Speeches)} - a_6 \text{ (Subsidies)} - a_7 \text{ (Time)} + b_0 + b_2 \text{ (Price of wheat)} + b_3 \text{ (Price of soybeans)} + b_4 \text{ (Winter)} + b_5 \text{ (Spring)} + b_6 \text{ (Summer)} + b_7 \text{ (Time)} + b_8 \text{ (Speeches)} + (\mu_2 - \mu_1) \qquad (7)$$

So that:

Price of corn = $(b_0 – a_0 / a_1 – b_1)$ – $(a_2 / a_1 – b_1)$ Income – $(a_3 / a_1 – b_1)$ Price of broilers – $(a_4 / a_1 – b_1)$ Price of E-85 – $(a_6 / a_1 – b_1)$ Subsidies + $(b_2 / a_1 – b_1)$ Price of wheat + $(b_3 / a_1 – b_1)$ Price of soybeans + $(b_4 / a_1 – b_1)$ Winter + $(b_5 / a_1 – b_1)$ Spring + $(b_6 / a_1 – b_1)$ Summer + $(b_7 – a_7 / a_1 – b_1)$ Time + $(b_8 – a_5 / a_1 – b_1)$ Speeches + $(\mu_2 - \mu_1 / a_1 – b_1)$

(8)

This equation is substituted into the quantity demand structural equation:

Quantity Exchanged of Corn = a_0 + $(a_1b_0 – a_1b_0 / a_1 – b_1)$ – $(a_1a_2 / a_1 – b_1)$ Income – $(a_1a_3 / a_1 – b_1)$ Price of broilers – $(a_1a_4 / a_1 – b_1)$ Price of E-85 – $(a_1a_6 / a_1 – b_1)$ Subsidies + $(a_1b_2 / a_1 – b_1)$ Price of wheat + $(a_1b_3 / a_1 – b_1)$ Price of soybeans + $(a_1b_4 / a_1 – b_1)$ Winter + $(a_1b_5 / a_1 – b_1)$ Spring + $(a_1b_6 / a_1 – b_1)$ Summer + $(a_1b_7 - a_1a_7 / a_1 – b_1)$ Time + $(a_1b_8 – a_1a_5 / a_1 – b_1)$ Speeches + a_2 Income + a_3 Price of broilers + a_4 Price of E-85 + a_5 Speeches + a_6 Subsidies + μ_1 (9)

When this equation is simplified it becomes the reduced form quantity exchanged equation and is:

Quantity Exchanged of Corn = $(a_0a_1 – a_0b_1 / a_1 – b_1)$ – $(a_2b_1 / a_1 – b_1)$ Income – $(a_3b_1 / a_1 – b_1)$ Price of broilers - $(a_4b_1 / a_1 – b_1)$ Price of E-85 – $(a_6b_1 / a_1 – b_1)$ Subsidies + $(a_1b_2 / a_1 – b_1)$ Price of wheat + $(a_1b_3 / a_1 – b_1)$ Price of soybeans + $(a_1b_4 / a_1 – b_1)$ Winter + $(a_1b_5 / a_1 – b_1)$ Spring + $(a_1b_6 / a_1 – b_1)$ Summer + $(a_1b_7 - a_1a_7 / a_1 – b_1)$ Time + $(a_1b_8 – a_1a_5 / a_1 – b_1)$ Speeches + $(a_1\mu_2 - \mu_1b_1 / a_1 – b_1)$ (10)

The reduced form price of corn equation can be written as:

$$\text{Price of Corn} = \Pi_0 + \Pi_1 \text{ (Income)} + \Pi_2 \text{ (Price of broilers)} + \Pi_3 \text{ (Price of E-85)} + \Pi_4 \text{ (Speeches)} + \Pi_5 \text{ (Subsidies)} + \Pi_6 \text{ (Price of wheat)} + \Pi_7 \text{ (Price of soybeans)} + \Pi_8 \text{ (Winter)} + \Pi_9 \text{ (Spring)} + \Pi_{10} \text{ (Summer)} + \Pi_{11} \text{ (Time)} + \Lambda_1 \qquad (11)$$

The reduced form quantity exchanged of corn can be written as:

$$\text{Quantity Exchanged of Corn} = \Pi_{12} + \Pi_{13} \text{ (Income)} + \Pi_{14} \text{ (Price of broilers)} + \Pi_{15} \text{ (Price of E-85)} + \Pi_{16} \text{ (Speeches)} + \Pi_{17} \text{ (Subsidies)} + \Pi_{18} \text{ (Price of wheat)} + \Pi_{19} \text{ (Price of soybeans)} + \Pi_{20} \text{ (Winter)} + \Pi_{21} \text{ (Spring)} + \Pi_{22} \text{ (Summer)} + \Pi_{23} \text{ (Time)} + \Lambda_2 \qquad (12)$$

With the reduced form equations specified, what are the signs of the variables in these equations? The denominator ($a_1 - b_1$) is always negative because the Law of Demand states that a_1 is negative and the Law of Supply states that b_1 is positive so subtracting b_1 from a_1 results in a negative sign. The sign hypotheses of the reduced form price equation are found in Table One and the sign hypotheses of the reduced form quantity exchanged equation are found in Table Two.

The dependent variables of the reduced form equations are the price of corn in the reduced form price equation and the quantity of corn in the reduced form quantity exchanged equation. The price of corn is the average equilibrium price of a bushel of corn received by farmers as reported by the online database of NASS. The quantity exchanged of corn is the estimated number of bushels produced per year (scaled)[28] as reported by the online database of NASS. As an example, the quantity number of bushels for 1997 is the number of bushels produced and harvested at the end of the year in 1996 and the same pattern for each subsequent year.

[28] If the number in a year was 9 billion bushels of corn then it was entered as 9.0.

With the variables described, the structural and reduced form equations identified, and the expected signs of the parameter estimates defined, the results are presented in the next chapter. The results chapter presents regression results from the evolving statistical methodologies involved in the empirical analysis to show why lag prices are preferable to contemporaneous prices and why using standard OLS regression estimation is not the best approach when studying agricultural products.

Table One: Sign Hypotheses for the Reduced Form Price Equation

Π's	Description	Expected signs of Π's from the reduced form equations
Π_1 (Income)	$-(a_2 / a_1 - b_1)$	Positive
Π_2 (Price of broilers)	$-(a_3 / a_1 - b_1)$	Positive
Π_3 (Price of E-85)	$-(a_4 / a_1 - b_1)$	Positive
Π_4 (Speeches)	$(b_8 - a_5 / a_1 - b_1)$	Unsure
Π_5 (Subsidies)	$-(a_6 / a_1 - b_1)$	Positive
Π_6 (Price of wheat)	$(b_2 / a_1 - b_1)$	Positive
Π_7 (Price of soybeans)	$(b_3 / a_1 - b_1)$	Positive
Π_8 (Winter)	$(b_4 / a_1 - b_1)$	Unsure
Π_9 (Spring)	$(b_5 / a_1 - b_1)$	Unsure
Π_{10} (Summer)	$(b_6 / a_1 - b_1)$	Unsure
Π_{11} (Time)	$(b_7 - a_7 / a_1 - b_1)$	Unsure

Table Two: Sign Hypotheses for the Reduced Form Quantity Exchanged Equation

Π's	Description	Expected signs of Π's from the reduced form equations
Π_{13} (Income)	$-(a_2b_1 / a_1 - b_1)$	Positive
Π_{14} (Price of broilers)	$-(a_3b_1 / a_1 - b_1)$	Positive
Π_{15} (Price of E-85)	$-(a_4b_1 / a_1 - b_1)$	Positive
Π_{16} (Speeches)	$(a_1b_8 - a_1a_5 / a_1 - b_1)$	Unsure
Π_{17} (Subsidies)	$-(a_6b_1 / a_1 - b_1)$	Positive
Π_{18} (Price of wheat)	$(a_1b_2 / a_1 - b_1)$	Negative
Π_{19} (Price of soybeans)	$(a_1b_3 / a_1 - b_1)$	Negative
Π_{20} (Winter)	$(a_1b_4 / a_1 - b_1)$	Unsure
Π_{21} (Spring)	$(a_1b_5 / a_1 - b_1)$	Unsure
Π_{22} (Summer)	$(a_1b_6 / a_1 - b_1)$	Unsure
Π_{13} (Time)	$(a_1b_7 - a_1a_7 / a_1 - b_1)$	Unsure

Table Three: Descriptive Statistics of the Independent Variables (before lags)

Variable	Mean	Standard Deviation	Minimum	Maximum	Cases
E-85	1.45	0.35	0.94	2.55	111
Wheat	3.096	0.575	2.12	4.68	111
Soybeans	5.518	1.16	1.63	9.8	111
Broilers	0.379	0.526	0.27	0.52	111
Income	2489.91	126.372	1198.43	2564.22	111
Subsidies	0.529	0.011	0.51	0.54	111
Speeches	0.216	0.413	0	1	111
Time	56	32.186	1	111	111
Winter	0.261	0.441	0	1	111
Spring	0.243	0.431	0	1	111
Summer	0.243	0.431	0	1	111

Descriptive Statistics of the Dependent Variables

Variable	Mean	Standard Deviation	Minimum	Maximum	Cases
Price of Corn	2.11	0.296	1.52	3.01	111
Quantity of Corn Exchanged	9.956	0.873	8.97	11.81	111

CHAPTER IV

RESULTS

The purpose of this study is to analyze the changes movements in the price of E-85 have on the equilibrium price and quantity of the corn market through the estimation of reduced form equations using information on variables during the time period of October 1997 to December 2006. This chapter presents the results of the evolving statistical methodologies used to determine E-85's impact on the corn market.

The first statistical model utilized in estimating the reduced form equations is standard OLS regression estimation using contemporaneous prices and quantity. Using reduced form equations eliminates the simultaneity bias that would occur when estimating the market supply and demand equations. Simultaneity bias prevents OLS from being used. With the simultaneity bias removed, estimating the reduced form equation with OLS is acceptable. Table Four reports the parameter estimates for the reduced form price equation estimated using OLS regression estimation and contemporaneous prices. Table Five reports the parameter estimates for the reduced form quantity exchanged equation again using OLS regression estimation and contemporaneous prices and quantity. A single asterisk on the t-statistic indicates a variable is statistically significant at the 10 percent level. A double asterisk labels a variable as statistically significant at the 5 percent level and a triple asterisk designates that a variable is statistically significant at the 1 percent level. This analysis will focus on the variables of interest: E-85, Speeches, and Subsidies.

The results of the reduced form price equation show that the coefficient for E-85 is negative and statistically significant at the 1 percent level, different than expected. Table One indicates the coefficient sign should be positive since increasing demand in the ethanol market will increase demand for corn and thus raise the price of corn, part of the derived demand argument used in this analysis. A negative coefficient indicates that as demand for ethanol increases the price of corn decreases. If the price of E-85 is increasing, this is occurring for one of two reasons. First, the price of E-85 could be increasing because of a shrinking supply of corn. A shrinking supply of corn drives up corn prices as ethanol producers bid against each other for the corn. As corn becomes more expensive, ethanol production costs increase. Second, the price of E-85 could be increasing because of an increased demand for ethanol. Which of these two scenarios is happening in reality? According to the online database of NASS (2006), the supply of corn has generally been increasing over the time period analyzed. Over this same time period the Renewable Fuel Association (2006) reports that ethanol production has exploded from 1.3 billion gallons of ethanol produced in 1997 to close to 5 billion gallons in 2006. These two facts indicate that the growth in the ethanol industry is due to an increase in the demand for ethanol, not a decrease in the supply of corn. If this is the case then it does not make economic sense that an increase in the price of E-85 due to an increase in demand for the product would cause a decrease in the price of corn. An explosion in the demand for ethanol requires a larger supply of corn dedicated to ethanol production since the majority of ethanol produced in the U.S. comes from corn. The sign coefficient of E-85 should therefore be positive, not negative.

The reduced form quantity exchanged equation of corn behaves as expected except for the variable Subsidies. Table Two indicates that the coefficient sign should be positive but the OLS regression result shows the coefficient sign is negative. This indicates that in increase in the ethanol subsidy will actually decrease the quantity exchanged of corn. However, since Subsidies is included in the regression because it affects the ethanol market and the coefficient sign on E-85 is negative, there is consistency. If an increase in the price of E-85 decreases the price of corn, then any factor increasing the demand for ethanol, such as the subsidy, will decrease the price of corn as well as part of derived demand for corn.

While the use of OLS is appropriate for reduced form equations, a major problem exists with using standard OLS regression estimation for this analysis. Since the prices are mainly agricultural prices, using contemporary prices with no lag period allows for endogeneity to appear in the data due to common agricultural shocks, a violation of OLS. If a drought occurs, whether regional or national, all agricultural products are affected. In addition, the fact that E-85 and corn are closely intertwined lends itself to the same problem that occurs with the agricultural products. A shock in the corn market will heavily affect the ethanol market and E-85 prices and vice versa. This endogeneity problem nullifies the results of the OLS regression estimation. It is clear that at the very least lags in the price variables are needed to address these issues.

In an attempt to solve the problem of endogeneity in the data, particularly among the agricultural prices and the price of E-85, all price variables on the right hand side of the regression model are lagged 4 periods. The economic reasoning behind why 4 lag periods was chosen is that it takes corn between 3 and 5 months to fully mature, from when it is planted to when it is harvested. Therefore a 4 month lag seems to be an appropriate time lag. These lagged variables are no longer endogenous but are now considered predetermined. These predetermined variables are stochastically independent of the disturbances of the system when regressed against the contemporaneous price and quantity of corn in the different reduced form equations. Table Six shows the results of the reduced form price equation and Table Seven shows the results of the reduced form quantity exchanged equation.

The results from the reduced form price equation report the expected positive coefficient sign for the variable E-85 and it is statistically significant at the 5 percent level. The positive coefficient sign indicates that an increase in the price or E-85, which is due to an increase in the demand of ethanol, increases the quantity exchanged of corn, exactly what is expected in a derived demand relationship. The results also show a positive coefficient sign for the variable Subsidies at the 10 percent level, which is expected. An increase in the ethanol subsidy will encourage more firms to enter the ethanol market, creating greater competition for the consumption of corn, and thus driving up prices.

The only coefficient sign that is not what is expected is the sign of Broilers. Table Two indicates that this sign should be positive and yet the OLS results show the sign to be negative, thus saying that an increase in the price of Broilers will decrease the demand for corn. Since poultry farmers are large consumers of corn, the relationship should be that an increase in the demand for broilers will encourage more farmers to raise broilers and demand more corn to feed them. However, if the price of broilers is increasing because of an increase in corn prices, thus making production costs of broilers higher and driving farmers away from raising broilers, then it is possible that a higher price of broilers will actually depress corn prices because there are fewer farmers raising broilers and thus a lower demand for corn.

The reduced form quantity exchanged equation with 4 lags behaves as expected among the variables that are statistically significant. The coefficient sign of Wheat is negative and statistically significant at the 5 percent level, indicating that an increase of the price of wheat will decrease the quantity exchanged of corn, which makes economic sense as farmers substitute away from corn and into wheat because of wheat’s higher price. Both the variables Speeches and Subsidies have positive coefficient signs and are statistically significant at the 1 percent level. These positive coefficient signs indicate that as these factors increase demand for ethanol that the quantity of corn exchanged will increase in order to fuel the ethanol growth. Even the variable Broilers, which had a different coefficient sign than what was expected in the price equation, has the hypothesized positive sign in the quantity exchanged equation and is statistically significant at the 1 percent level.

Even with the good results of the reduced form equations when 4 lags are included, the problem of model specification appears. In order to test for general model specification, the RAMSEY Reset test is used. The reduced form price equation passes the RAMSEY Reset test signaling correct specification, or at least, the absence of any statistically significant specification errors. However, the reduced form quantity exchanged equation does not pass the RAMSEY reset test. This failure indicates statistically significant model specification problems.[29]

The success of using 4 lags as opposed to contemporaneous prices in the estimation means that the model specification problem likely isn't an endogeneity issue but instead something else. The problem may be that there is a clustering of large and small disturbances suggesting a form of heteroskedasticity in which the variance of the forecast error depends on the size of the preceding disturbance, similar to what occurs in an Autoregressive Conditionally Heteroskedastic (ARCH) model. ARCH models are often used in analysis of financial data. It is very plausible that this type of behavior is also found in agricultural prices over time. Therefore a multiplicative heteroskedasticity regression estimation approach is used to estimate the reduced form equations' maximum likelihood estimates.[30] The variance function estimated will include the time trend variable as well as the winter and summer dummy variables. Table Eight shows the maximum likelihood estimates of the reduced form price equation as well as the variance function for the reduced form price equation and Table Nine reports the maximum

[29] A question may be asked how subsidies and other government incentive programs in the corn market affect the dependent variables price of corn and quantity exchanged of corn. While it is certain that these government incentives impact the price and quantity of corn, the passing of the RAMSEY Reset test indicates that there is no statistically significant model specification problems so the regression estimates are not biased by the possible problems of how the dependent variables are measured.

[30] The multiplicative heteroskedasticity approach gives parameter estimates that are maximum-likelihood estimates. To achieve these estimates, a regression and variance function is estimated. The logarithm of the variance is assumed to be a function of a different set of explanatory variables, some of which may appear in the regression function but it is not a requirement. The estimation procedure is best explained as using repeating steps. The regression function is estimated by ordinary least-squares (OLS) and the residuals are saved. These residuals are squared and then logged. These adjusted residuals become the dependent variable for the variance function and then estimated by OLS. The predicted values from this variance function are then used as weights in a generalized least-squares (GLS) estimation of the regression function. The residuals are then kept, squared, logged, and act again as the dependent variable for a new estimation of the variance function. Iteration between estimates of the regression function and variance function continue until the coefficients of the two models stabilize and converge. When this stabilization and convergence occurs, the parameter estimates are the maximum-likelihood estimates presented.

likelihood estimates of the reduced form quantity exchanged equation as well as the variance function for the reduced form quantity exchanged equation. Using this multiplicative heteroskedasticity regression estimation approach, both the reduced form price equation and the reduced form quantity exchanged equation pass the RAMSEY Reset test signaling correct model specification, or at least, the absence of any statistically significant errors.

The maximum likelihood estimates of the reduced form price equation show that the coefficient sign for the variable E-85 is both positive and statistically significant at the 5 percent level. It can be concluded then that a rise in the price of E-85, indicating an increase in ethanol demand, does increase the demand of corn and thus the price of corn. Positive coefficient signs also are present for Wheat and Soybeans, which are statistically significant at the 1 percent level, exactly what is expected. The seasonal variables, Winter, Spring, and Summer all have a positive impact on the price of corn, the first time all of them have been statistically significant (at the 1 percent level) in the reduced form price equation. However, the maximum likelihood estimates do show that the variables Speeches and Subsidies do not have a statistically significant influence on the equilibrium price of corn. This is the first time Subsidies was shown not to have a statistically significant impact in the reduced form price equation.

The variance regression presents a different result. As mentioned, the seasonal dummy variables have a statistically significant effect on the equilibrium price of corn. However, the variance equation shows that the seasonal variables do not have a statistically significant effect on the changing variance over time. The time trend variable does have a statistically significant impact (at the 1 percent level) on the variance of the regression over time but does not have a statistically significant impact on the price of corn.

A variable can have a statistically significant effect but be economically insignificant, such as in areas of public policy or science (McCloskey and Ziliak 1996). Since this analysis is highlighting political intervention, if a variable is statistically significant but not economically significant than it is less important for policy implications and thus less important in this analysis. The only variable of interest that is statistically significant in the reduced form price equation is E-85 so what is the economic significance of the regression results?

In order to determine the economic significance of E-85, the mean price of a bushel of corn, which is $2.10, will be used. A one-unit (dollar) increase in the price of E-85 increases the price of corn by approximately $0.28. This translates into a 13 percent increase in the price of corn. A 13 percent price increase in any good is a significant economic change. Therefore corn is an elastic good.

The maximum likelihood estimates of the reduced form quantity exchanged equation show that E-85 has no statistical significance on the quantity exchanged of corn. It could very well be that there is a capacity constraint issue occurring in the ethanol market. There are only so many ethanol facilities operating and they may not have the current capacity to handle any more production and thus any more corn. However it is expected that when all the ethanol plants being planned are built, E-85 will have a statistically significant impact on the quantity of corn exchanged.

The variable Wheat (statistically significant at the 1 percent level) has the expected negative coefficient sign and Broilers (statistically significant at the 1 percent level) has the expected positive coefficient sign. The only variable that is statistically significant (at the 1 percent level) and has an unexpected sign is Subsidies. The expected sign is positive while the regression results show a negative sign. It is possible that simultaneity bias is occurring within the model and that this bias is causing the negative sign for Subsidies. However, the reduced form quantity exchanged of corn equation passes the RAMSEY Reset test so there is no statistically significant evidence that model specification error exists that would cause the coefficient estimates to be biased.

The variance regression for the reduced form quantity exchanged equation shows that the seasonal dummy variable Winter and the variable Time have a statistically significant effect (Winter at the 5 percent level and Time at the 1 percent level) on the variance of the equation. This is a different result than the regression function where none of the seasonal variables or the time variable had any statistically significant impact on the quantity exchanged of corn.

How does the statistically significant variable of interest, Speeches, translate into economic significance? In order to determine the economic significance of E-85 the average yearly yield per acre of corn, the mean quantity of corn exchanged in the study, and total U.S. corn acreage used for field corn is used. It is assumed that the yearly yield per acre of corn is 139.9 bushels, the average yearly yield per acre of corn over the last 10 years. The mean quantity of corn exchanged in the study is 9,983,000,000 bushels. The total U.S. corn acreage harvested (field corn) over the last 10 years is 71,662,500.

When the President mentions ethanol by name in his State of the Union address, the quantity exchanged of corn increases by 1.24 billion bushels. This is an increase of 12.4 percent, a significant increase. In order to produce this increased amount of bushels, approximately 886,343 more acres will be need to be planted with corn, a 12.3 percent increase in total corn acreage.

The evolving statistical methods employed in this chapter show that modeling the corn market with contemporaneous prices is inadequate. Even when the prices are lagged an appropriate amount, using standard OLS regression estimation fails to compensate for changing variances over time and thus results in model misspecification. Only when the prices are lagged and changing variances over time are accounted for using a modified ARCH model, or more specifically a multiplicative heteroskedasticity approach, does the regression estimates pass model specification and avoid endogeneity. When the model is correctly specified and variance is accounted for, the results show that an increase in the price of E-85 does increase the price of corn, exactly what was expected.

Table Four: OLS Regression Estimation of the Reduced Form Price Equation (Contemporaneous Prices and Quantities)

Variable	Coefficient	Standard Error	T-Statistic
Constant	-5.065	2.944	-1.721*
E-85	-0.198	0.075	-2.660***
Wheat	0.515	0.041	12.432***
Soybeans	0.08	0.016	4.953***
Broilers	0.715	0.317	2.252**
Income	0.00005	0.00009	0.460
Subsidies	9.52	5.415	1.759*
Speeches	0.047	0.091	0.512
Winter	0.035	0.035	1.017
Spring	0.166	0.035	4.731***
Summer	.0141	0.036	3.958***
Time	-0.002	0.001	-1.452

R-squared: 0.84

Adjusted R-squared: 0.82

F-statistic: 48.61

N: 111

Mean Price of Corn: $2.12

Std. Deviation of Price of Corn: 0.296

Table Five: OLS Regression Estimation of Reduced Form Quantity Exchanged Equation (Contemporaneous Prices and Quantities)

Variable	Coefficient	Standard Error	T-Statistic
Constant	21.955	7.217	3.042***
E-85	0.159	0.183	0.867
Wheat	-0.186	0.102	-1.833*
Soybeans	-0.071	0.039	-1.775*
Broilers	3.872	0.778	4.977***
Income	-0.0003	0.0002	-1.164
Subsidies	-23.396	13.276	-1.762*
Speeches	1.174	0.224	5.240***
Winter	0.130	0.085	1.531
Spring	0.098	0.086	1.130
Summer	-0.019	0.087	-0.214
Time	0.001	0.003	0.342

R-squared: 0.89

Adjusted R-squared: 0.88

F-statistic: 74.55

N: 111

Mean Quantity Exchanged of Corn: 9.956

Std. Deviation of Quantity Exchanged of Corn: 0.873

Table Six: OLS Regression Estimation of the Reduced Form Price Equation (Prices Lagged 4 Periods)

Variable	Coefficient	Standard Error	T-Statistic
Constant	-7.239	4.210	-1.720*
Lag E-85	0.334	0.146	2.287**
Lag Wheat	0.288	0.066	4.402***
Lag Soybeans	0.046	0.023	1.994**
Lag Broilers	-0.856	0.427	-2.003**
Income	-0.000009	0.0002	-0.060
Subsidies	14.869	7.601	1.956*
Speeches	-0.092	0.113	-0.817
Winter	0.127	0.052	2.423**
Spring	0.178	0.053	3.378***
Summer	0.115	0.047	2.461***
Time	0.002	0.001	1.768*

R-squared: 0.60

Adjusted R-squared: 0.55

F-statistic: 13.04

N: 107

Mean Price of Corn: $2.10

Std. Deviation of Price of Corn: 0.289

Table Seven: OLS Regression Estimation of the Reduced Form Quantity Exchanged Equation (Prices Lagged 4 Periods)

Variable	Coefficient	Standard Error	T-Statistic
Constant	28.466	6.705	4.245***
Lag E-85	-0.289	0.199	-1.450
Lag Wheat	-0.245	0.106	-2.298**
Lag Soybeans	0.0180	0.037	0.485
Lag Broilers	3.963	0.712	5.567***
Income	-0.0001	0.0003	-0.431
Subsidies	-35.710	12.217	-2.923***
Speeches	1.202	0.197	6.096***
Winter	-0.063	0.077	-0.816
Spring	0.059	0.78	0.750
Summer	0.039	0.080	0.484
Time	-0.0003	0.002	-0.127

R-squared: 0.90

Adjusted R-squared: 0.89

F-statistic: 82.73

N: 107

Mean Quantity Exchanged of Corn: 9.983

Std. Deviation of Quantity Exchanged of Corn: 0.876

Table Eight: Multiplicative Heteroskedastic Regression Estimation of the Reduced Form Price Equation (Prices Lagged Four Periods)

Maximum Likelihood Estimates

Variable	Coefficient	Standard Error	T-Statistic
Constant	-5.379	4.124	-1.304
Lag E-85	0.279	0.129	2.171**
Lag Wheat	0.308	0.064	4.795***
Lag Soybeans	0.054	0.022	2.405***
Lag Broilers	-0.575	0.417	-1.381
Income	-0.000008	0.0002	-0.045
Subsidies	11.21	7.463	1.502
Speeches	-0.093	0.121	-0.771
Winter	0.154	0.044	3.466***
Spring	0.211	0.047	4.462***
Summer	0.115	0.045	2.572***
Time	0.001	0.001	0.731

Variance Function

Variable	Coefficient	Standard Error	T-Statistic
Sigma	0.104	0.016	6.585***
Time	0.02	0.004	4.606***
Winter	-0.269	0.338	-0.796
Summer	-0.182	0.333	-0.546

Table Nine: Multiplicative Heteroskedastic Regression Estimation of the Reduced Form Quantity Exchanged Equation (Prices Lagged Four Periods)

Maximum Likelihood Estimates

Variable	Coefficient	Standard Error	T-Statistic
Constant	24.237	6.303	3.845***
Lag E-85	-0.137	0.195	-0.704
Lag Wheat	-0.271	0.097	-2.809***
Lag Soybeans	-0.018	0.033	-0.560
Lag Broilers	4.184	0.638	6.561***
Income	-0.00009	0.0002	-0.397
Subsidies	-28.073	11.461	-2.449***
Speeches	1.250	0.181	6.907***
Winter	-0.098	0.080	-1.230
Spring	0.099	0.068	1.450
Summer	0.101	0.063	1.607
Time	0.0009	0.002	0.417

Variance Function

Variable	Coefficient	Standard Error	T-Statistic
Sigma	0.160	0.024	6.585***
Time	0.015	0.004	3.481***
Winter	0.676	0.338	2.001**
Summer	-0.191	0.333	-0.572

CHAPTER V

CONCLUSION

There has been much publicity about the effects ethanol and political intervention in the ethanol market has had and will have on the energy and agriculture markets in the next few decades as the search for alternative motor fuels intensifies due to economic, social, and environmental pressures. If technological progress is slow in the development of other sources of ethanol besides corn and U.S. government policy continues to restrict the amount and type of foreign ethanol allowed entry into the U.S. market, the ethanol market will continue to put increased pressure on the domestic and worldwide corn markets. As the demand for ethanol continues to increase, the price of corn will increase.

One drawback to this analysis is the short time period analyzed and the use of Minnesota's monthly price data of E-85 as a proxy variable for the national monthly price of E-85. As noted, the time period analyzed was limited to the availability of monthly price data of E-85 from Minnesota because it was the most comprehensive monthly E-85 price data available. No national monthly price data for E-85 is presently available. As time progresses and more fueling stations sell ethanol, national data for E-85 may be recorded and researchers may find different results than what is reported in this analysis. A longer time horizon would also benefit the political intervention variables because the subsidy in the time frame of this analysis was always falling, not oscillating like it has since its inception. The State of the Union addresses may move away from mentioning ethanol by name as more alternative fuel sources become available for public use. It is possible that the Speeches variable in this analysis was picking up trends other than those found in the State of the Union addresses. It is also possible that the Speeches variable should include more than the State of the Union addresses. Perhaps the variable should include all nationally televised speeches and press conferences given by the President or should include major policy addresses given by other influential politicians such as Congressman and Senators. Using more speeches would give a more accurate portrayal of political persuasion towards the ethanol market.

A second drawback to the analysis presented in this study is the way the dependent variable quantity exchanged of corn is defined. This analysis took a simplistic viewpoint of how much corn was available for domestic ethanol producers to purchase. It was assumed that the only corn ethanol producers could buy was domestic corn because protective U.S. trade policy limits the amount of corn entering the U.S. In reality, a more complicated way to estimate the quantity exchanged of corn would have to include import and export numbers.

A third drawback to the analysis is the way the Subsidies variable is measured. Future researchers may want to use a dummy variable for Subsidies. Each time the subsidy changes the months of that year receives a 1 and if the subsidy stays the same from one year to the next the months of that year receives a 0. This adjustment may remove any simultaneity bias that may exist in the model. However, since the reduced form quantity exchanged of corn equation using the multiplicative heteroskedasticity adjustment passed the RAMSEY Reset test and indicated that there was no statistically significant model misspecification, this analysis did not make the Subsidies variable a dummy variable.

Whatever the weaknesses of the study, certain inferences can be drawn from the empirical results of rising equilibrium corn prices due to increasing E-85 prices. An increase in equilibrium corn prices due in large part to the growing ethanol demand, which is consuming a greater and greater percentage of domestic corn will have other effects on numerous related markets. For example, since corn is the main feed in the poultry industry, the cost of raising poultry increases. The higher production costs decreases profit margins. The lower profit margins may decrease the number of farmers in the poultry sector and possibly cause a lower supply of poultry available for consumers. The only silver lining is that a by-product of ethanol production is high protein feed that could counterbalance the rising price of corn feed by becoming a low-cost alternative in the feed market, thus preventing a greater loss of poultry owners than otherwise would occur due to increasing production costs and declining profit margins.

A second consequence of higher domestic equilibrium corn prices is an increase in the price of sweet corn as well as food made from corn. Farmers are faced with the choice of planting acreage for sweet or field corn or harvesting it as sweet or field corn. The higher price for field corn, because of increased ethanol demand, will encourage farmers to devote more acreage to field corn and also encourage farmers to allow their corn crop to fully mature and become feed corn. Both would lower the amount of feed corn sold. The less sweet corn available for sale will increase its price.

Corn is also an ingredient in a countless numbers of foods, from cornstarch to corn syrup used in soda. Higher corn costs raise production costs and lowers profit margins for food producers and suppliers. Falling profit margins means that food producers or suppliers will either absorb this loss of profit or pass the increased production costs to consumers in the form of higher food prices. Higher food prices could become a hardship on families with fixed or lower incomes. Higher food prices will increase political pressure to stop or reduce the ethanol subsidies in order to alleviate the economic strain of poor families. Political pressures in agricultural areas of the country will counterbalance this movement, particularly where corn is the main crop grown. It will be difficult to satisfy both constituent groups and most likely one group will gain at the expense of the other group. Such a scenario would certainly pit political representatives from urban areas against political representatives from rural areas.

A third consequence of higher domestic equilibrium corn prices is an increase in the world market price of corn. An increase in the world market price of corn has the possibility of devastating results for residents in poorer countries. A common staple food in much of Latin American is corn tortillas (Roig-Franzia 2007). A higher price of corn will increase the price of corn tortillas, which could heighten hunger pressures if the price rises too far. This could cause social and political unrest for these poorer countries, which in turn could cause political and economic relationships with the U.S. and these countries to be strained. In fact, Cuban dictator Fidel Castro blasted the U.S. ethanol policy in a March 2007 newspaper editorial. He wrote that the U.S. ethanol policy impoverishes the world's poor and helps aggravate world hunger. Even if the claim is factually incorrect, the perception that the U.S. is an enemy of poor countries and the economically downtrodden in general will not help the U.S. make and keep much needed allies within their own hemisphere. This possible hostility only increases possible political and economic headaches for the U.S. in a region historically predisposed to distrusting the U.S.

When all these factors are considered, political intervention in the ethanol market may not be the wisest policy course for the federal government. If the price of E-85 rises due to market forces and the equilibrium corn prices rises as a result, then the phenomenon of rising prices is simply a case of supply and demand. However, if the federal government continues to stimulate the ethanol and corn markets through the use of legislative policy, then the danger exists of over stimulating these markets towards an unstable equilibrium as well as damaging related markets, such as poultry and hogs, along the way as well as infuriating the governments of countries where poverty is a major issue. Federal government interventionist action into the ethanol market in hopes of achieving vague national energy goals has the possibility of creating a bubble like atmosphere that could burst (over stimulating corn supply to the point that equilibrium corn prices become depressed) and leave the federal government partially responsible for the negative repercussions that could occur, like corporate bailouts of ethanol companies and increased federal farm aid to distressed farmers, who may have been better off in the long run planting other crops instead of a corn but were deceived by artificially created market signals.

State governments have plenty of incentive to intervene within the ethanol market, particularly if these states are major corn producers. State government can help diversify their motor fuel market, assist corn farmers, and avoid the political headaches associated with dealing with foreign powers in their legislative actions aimed at the citizens and companies located within their borders. The federal government cannot avoid the political and economic spillover effects with other countries and should consider carefully whether political intervention in the ethanol and corn markets is worth the economic and social risk. Whatever course of future action the federal government decides to take, this analysis shows that an increase in the price of E-85 increases the equilibrium price of corn. The analysis also shows that political intervention in the form of subsidies and public policy speeches favoring the ethanol market affects the equilibrium quantity exchanged of corn. This analysis shows that the ethanol, political, and corn markets are highly dependent on each other and need to be studied in tandem for a more complete analysis of real world conditions.

REFERENCES

Baker, Allen, and Zahniser, Steven. "Ethanol Reshapes the Corn Market." *Amber Waves,* a publication of the United States Department of Agriculture (USDA), Economic Research Service (ERS), 2006, *4.2*.

Behr, Roy and Iyengar, Shanto. "Television, Real World Cues, and Changes in the Public Agenda." *Public Opinion Quarterly,* 1985, *49*, pp. 38-57.

Bureau of Labor Statistics (BLS). "Wages, Earnings, and Benefits." Available online at: http://www.bls.gov/. (Accessed April 2007).

California Energy Commission. *Ethanol Fuel Incentives Applied in the U.S*. January 2004. Available online at: www.ethanol-gec.org/information/briefing/22.pdf. (Accessed March 2007).

C-Span. *State of the Union*. Available online at: http://www.c-cpan.org/executive/stateoftheunion.asp. (Accessed May 2007).

Crooks, Anthony and Dunn, John. "An Outlook for the Biofuels Industry in the Southern United States." *Journal of Agricultural and Applied Economics*, 2006, *38*, pp.355-367.

Dikeman, Mark, Gallagher, Paul, and Otto, Daniel. "Effects of an Oxygen Requirement for Fuel in Midwest Ethanol Markets and Local Economies." *Review of Agricultural Economics*, 2000, *22.2*, pp. 292-311.

Duffield, James and Collins, Keith. "Evolution of Renewable Energy Policy." *Choices: A Publication of the Agricultural Economics Association*, 2006, *21.1*, pp. 9-14.

Eidman, Vernon." Agriculture's Role in Energy Production: Current Levels and Future Prospects," Paper submitted for a conference in St. Louis, Missouri, December 14-15, 2005.

_____________. "Renewable Liquid Fuels." *Choices: A Publication of the American Agricultural Economics Association,* 2006, *21.1*, pp.15-19.

Elobeid, Amani, Babcock, Bruce, Hart, Chad, Hayes, Dermont, and Tokgoz, Simla.

"The Long-run Impact of Corn-Based Ethanol on the Grain, Oilseed, and Livestock Sectors: A Preliminary Assessment," (*CARD Working Paper 06-BP 49*, Center for Agricultural and Rural Development, Iowa State University, 2006).

_____________and Tokgoz, Simla. "Removal of U.S. Ethanol Domestic and Trade Distortions: Impact on U.S. and Brazilian Ethanol Markets," (*CARD Working Paper 06-WP 427*, Center for Agricultural and Rural Development, Iowa State University, 2006).

_____________ and Tokgoz, Simla. "An Analysis of the Link Between Ethanol, Energy, and Crop Markets." (*CARD Working Paper 06-WP 435*, Center for Agricultural And Rural Development, Iowa State University, 2006).

Energy Information Agency (EIA). "Energy Kids Page." 2006. Available online at: http://www.eia.doe.gov/kids/history/timelines/ethanol.html. (Accessed March 2007).

_____________. "Annual Energy Outlook 2006 with Projections to 2030." Report # DOE/EIA-0383, 2006. Available online at: http://www.eia.doe.gov/oiaf/aeo/. (Accessed May 2007).

_____________. "Annual Energy Outlook 2007 with Projections to 2030." Report # DOE/EIA-0383, 2007. Available online at: http://www.eia.doe.gov/oiaf/aeo/indes.html. (Accessed June 2007).

Etter, Lauren. "Ethanol Tariff Loophole Sparks a Boom in Caribbean." *Associative Press.* March 9, 2007.

Farrell, Alexander, Plevin, Richard, Turner, Brian, Jones, Andrew, O'Hare, Michael, and Kammen, Daniel. "Ethanol Can Contribute to Energy and Environmental Goals." *Science*, 2006, *311,* pp. 506-509.

Ford, George and Jackson, John. "On the Interpretation of Policy Effects From Estimates of Simultaneous Systems of Equations." *Applied Economics,* 1998, *30*, pp. 995-999.

Gallagher, Paul. "Energy Production with Biomass: What are the Prospects?" *Choices: A Publication of the American Agricultural Economics Association*, 2006, *21.1,* pp. 21-25.

Gallagher, Paul and Otto, Daniel. "The Effects of Expanding Ethanol Markets on Ethanol Production, Feed Markets, and the Iowa Economy." (A Report Submitted to the Iowa Department of Agriculture and Land Stewardship, 2001).

Grassley, Charles. "Grassley Introduces Bill to Freeze Duty-Free Imports of Brazilian

Ethanol." July 22, 2004. Press release available online at: http://www.senate.gov/~grassley/index.cfm?FuseAction=PressReleases.Detail&PressRelease=id=&Month=7&Year=2004.

_____________. "Grassley Asks President to Back off Ethanol Tariff Proposal." May 12, 2006. Press release available online at: http:www.senate.gov/~grassley/index.cfm?FuseAction=PressReleases.Detail&PressRelease_id=5060&Mouth=5&Year=2006. (Accessed June 2007).

_____________. "Grassley Expresses Concern Over Possible U.S.-Brazil Partnership on Ethanol." March 1, 2007. Press release available online at: http://grassley.senate.gov/index.cfm?FuseAction=PressReleases.vie&PressRelease_id=5288. (Accessed June 2007).

Hill, Jason, Nelson, Erik, Tilman, David, Polasky, Stephen, and Tiffany, Douglas. "Environmental, Economic, and Energetic Costs and Benefits of Biodiesel and Ethanol Biofuels." *Proceedings of the National Academy of Science of the United States of America,* 2006, *103,* pp. 11206-11210.

Houck, J.P. and Ryan, M.E. "Supply Analysis for Corn in the United States: The Impact of Changing Government Programs." *American Journal of Agricultural Economics,* 1972, pp.184-191.

Jacobson, Mark. "Effects of Converting to Ethanol (E85) Vehicles on Air Pollution and Climate." *Environmental Science and Technology,* 2007, *41.* Available online at http://pubs.acs.org/journals/esthos. (Accessed April 2007).

Kenkel, Phil and Holcomb, Rodney. "Challenges to Producer Ownership of Ethanol and Biodiesel Production Facilities." *Journal of Agricultural and Applied Economics,* 2006, *38.2,* pp. 369-375.

Lavelle, Marianne and Schulte, Brett. "Is Ethanol the Answer?" *U.S. News and World Report* 12 February 2007, pp. 29-39.

Library of Congress. THOMAS. 2007. Available online at: http://thomas.loc.gov/. (Accessed June 2007).

Lieberman, Ben. "The Ethanol Mandate Should Not be Expanded." *Heritage Foundation Reports*. The Heritage Foundation, 28 March 2007.

McCloskey, Deirdre and Ziliak, Stephen. "The Standard Error of Regression." *Journal of Economic Literature*, 1996, *34.*1, pp. 97-114.

National Ethanol Vehicle Coalition (NEVC). http://www.e85fuel.com. (Accessed May 2007).

Office of the United States Trade Representative (USTR). "Fact Sheet on Ethanol in CAFTA." 2004. Available online at: http://www.ustr.gov/document_library/fact_sheets/2004/fact_sheet_on_ethanol_in_CAFTA.html. (Accessed May 2007).

On the Record. With Greta Van Susteren. Fox News, 12 March 2007.

Orndorff, Mary. "New Cash Crop Tries to Take Root." *The Birmingham News (Alabama).* (April 10, 2007, A1).

Parcell, Joe and Westhoff, Patrick. "Economic Effects of Biofuel Production on States and Rural Communities." *Journal of Agricultural and Applied Economics,* 2006, *38.2,* pp. 377-387.

Page, Benjamin and Shapiro, Robert. "Presidential Leadership Through Public Opinion." In G. Edwards et al., eds., *The Presidency and Public Policy Making.* Pittsburgh: Univeristy of Pittsburgh Press, 1985.

Patzek, Tad. "Thermodynamics of Production of Corn Ethanol Biofuel." *Critical Review Plant Science,* 2005, *23.6,* pp. 519-567.

_____________ and Pimentel, David. "Thermodynamics of Energy Production from Biomass." *Critical Review Plant Science,* 2005, *24.5,* pp. 327-364.

Pelton, Tom. "Ethanol Push Spurs Plans for Md. Plants: Three Sites in Running for State's First Factory to Convert Corn to Auto Fuel." *The Baltimore Sun (Maryland).* (November 28, 2006, A1).

Ragsdale, Lyn. "The Politics of Presidential Speechmaking." *The American Political Science Review,* 1984, *78.4,* pp. 971-984.

_____________. "Presidential Speechmaking and the Public Audience: Individual Presidents and Group Attitudes." *The Journal of Politics,* 1987, *49.3,* pp. 704-736.

Ray, Russel. "Sweet Promise Has Bitter Reality." *The Tampa Tribune (Florida).* (March 21, 2007, A1).

Renewable Fuels Association (RFA). *Annual Industry Outlook*, various issues, 2006. Available online at: http://www.ethanolrfa.org/industry/outlook/. (Accessed March 2007).

Roig-Franzia, Manuel. "A Culinary and Cultural Staple in Crisis." *The Washington Post (Washington, D.C.).* (January 27, 2007, A1).

Salassi, Michael, Shapouri, Hossein. United States Department of Agriculture (USDA). “The Economic Feasibility of Ethanol Production From Sugar in the United States.” July 2006. Available online at: http://www.usda.gov.dce/ethanolsugarfeasibilityreport3.pdf. (Accessed May 2007).

Savage, David. “Greenhouse Gasses Subject to Regulation, Court Rules.” *The Morning Call (Allentown, Pennsylvania).* (April 3, 2007, A6).

Shapouri, Hossein, Duffield, James, and Mcaloon, Andrew. United States Department of Agriculture (USDA). “The 2001 Net Energy Balance of Corn-Ethanol.” 20 May 2004.

_____________and Gallagher, Paul. United States Department of Agriculture (USDA). “USDA’s 2002 Ethanol Cost of Production Survey.” July 2005. Available online at: http://www.ncga.corn/ethanol/pdfs/031506USDAcostofproduction.pdf. (Accessed June 2007).

_____________, Salassi, Michael, and Fairbanks, Nelson. United States Department of Agriculture (USDA). “The Economic Feasibility of Ethanol Production From Sugar in the United States.” July 2006. Available online at: http://www.usda.gov/oce/EthanolSugarFeasibilityReport3.pdf. (Accessed June 2007).

Stuertz, Mark. “Corndoggle: Dallas is Banking on Ethanol But is it the Fuel of the Future or a Barrel of Pork.” *Dallas Observer (Texas)*. (October 26, 2006, A1).

Taylor, Kevin. “Ethanol Plant Bound for Dadeville.” *The Dadeville Record (Alexander City, Alabama).* (February 07, 2007).

Taylor, Jerry and Van Doren, Peter. “The Ethanol Boondoggle.” *The Milken Institute Review*, 2007, *Q1*, pp. 16-27.

“The Great Corn Rush.” *Star Tribune (Minneapolis, Minnesota)*. (September 24, 2006, A1).

Tierney, W.I. “Ethanol Plant Construction, How Much Ethanol and Related Products Should We Expect? Some Alternative Scenarios.” (Paper Presented at American Farm Bureau Federation Biofuels Conference, Des Moines, IA, September 12-14, 2006).

Tyner, Wallace, and Quear, Justin. “Comparison of a Fixed and Variable Corn Ethanol Subsidy.” *Choices: A Publication of the American Agricultural Economics Association*, 2006, *21.3*, pp. 1999-203.

United States Department of Agriculture, National Agricultural Statistics Service (USDA NASS). Online database. Available online at: http://www.nass.usda.gov/. (Accessed April 2007).

______________. *2002 Census of Agriculture*. Available online at: http://www.nass.usda.gov/Census_of_Agriculture/index.asp. (Accessed June 2007).

______________. *Maryland State Agriculture Overview 2005.* Available online at: http://www.nass.usda.gov/statistics_by_state/Ag_Overview/AgOverview_MD.pdf (Accessed June 2007).

United States Environmental Protection Agency (EPA). "Use and Distribution of MTBE and Ethanol." *MTBE Fact Sheet #3*. Available online at: http://www.epa.gov/OUST/mtbe/mtbefs3.pdf. (Accessed June 2007).

______________. "MTBE in Drinking Water." Available online at: http://www.epa.gov/safewater/contaminants/unregulated/mtbe.html. (Accessed June 2007).

Von Lampe, Martin. "Agricultural Market Impacts of Future Growth in the Production of Biofuels." Working Paper on Agricultural Policies and Markets, OECD, 2006.

APPENDIX A

STATE INCENTIVES FOR THE CONSUMPTION AND PRODUCTION OF ETHANOL (AS OF 2003)

State	Incentive Programs
Alaska	• The gasoline tax is reduced by $0.06 for E-10 • There is no gasoline tax on E-10 for the first five years of production when it is produced from certain wood or waste sources
Arkansas	• A state rebate is available for additional costs associated with alternative fuel vehicles • A state income tax credit is available for investments in production of “advanced biofuels”
Colorado	• A state tax credits is available for alternative fuel vehicles and fueling facilities
Connecticut	• The state gasoline tax of $0.25 per gallon is reduced by $0.01 a gallon for E-10
Hawaii	• Any gasoline/ethanol blend of E-10 or higher is exempted from the 4 percent state excise tax • A state income tax credit is available for investment in new ethanol plants
Idaho	• The state gasoline tax of $0.25 per gallon is reduced by $0.025 cents a gallon for E-10
Illinois	• Any gasoline/ethanol blend of E-70 or higher is exempted from state sales tax • Any gasoline/ethanol blend between E-10 and E-70 receives a 20 percent

	state sales tax reduction • State grants (up to $15 million) are available for new and expanded renewable fuel production facilities • State tax credits are available for the purchase of vehicles that are ethanol friendly and also for the installation of ethanol fueling stations
Indiana	• State funds are available for the purchasing of alternative fuel vehicles for state and local fleets • A state income tax credit of $0.125 a gallon is available for new and expanded ethanol production plants
Iowa	• A state tax exemption exists for gasoline/ethanol blends • A state tax credit is available for retail stations dispensing gasoline/ethanol blends • The availability of loans for renewable fuel production projects
Kansas	• A state income tax credit for alternative fuel vehicles and fueling facilities • Producer incentive payments of $0.05 to $0.075 a gallon for alternative fuels
Kentucky	• State grants are available for E-85 fueling stations and ethanol production plants • State rebates are available for alternative fuel vehicles
Louisiana	• State income tax credits are available for alternative fuel vehicles and alternative fueling stations
Maine	• A state tax credit is available for alternative fueling facilities • Loan programs are available for alternative fuel vehicle and infrastructure purchases
Maryland	• State tax credits and exemptions are available for alternative fueling infrastructure and the purchase of

	alternative fuel vehicles • A $0.01 per gallon reduction in the state fuel tax for E-85
Michigan	• State grants are available for biofuel projects • A state property tax exemption is available for certain alternative fuel production and consumption
Minnesota	• Most gasoline sold in the state is E-10 • A producer incentive payment of $0.20 per gallon up to 15 million gallons per year per facility is available
Mississippi	• A state producer payment of $0.20 per gallon for up to 30 million gallons per year for the first 10 years of production is available
Montana	• A state income tax credit is available for the costs of converting a vehicle to use alternative fuels • A state property tax exemption for ethanol production facilities during construction and the first 10 years of production
Nebraska	• A loan program for the production of alternative fueling facilities is available • A tax credit of $0.18 per gallon for new ethanol plants up to 15.625 million gallons a year for the first 8 years of production is available
New York	• Tax credits and exemptions are available for the purchase of alternative fuel vehicles and alternative fueling infrastructure
North Carolina	• A 25 percent tax credit for renewable energy production facilities and equipment is available
North Dakota	• Producer incentive payments are available for alternative fuels
Ohio	• Some vehicle inspection and maintenance exemptions exist for alternative fuel vehicles

	• Corporate and personal tax credits (maximum of $5,000) for the investment in qualified ethanol production plants are available
Oklahoma	• Producer tax credits for ethanol production facilities are available
Oregon	• State loans for small ethanol plants are available • A 50 percent property tax exemption is available for ethanol plants for the first 5 years of production
Pennsylvania	• Grant programs are available for the cost-sharing of up to 20 percent of investment in alternative fuel vehicles and alternative fueling facilities
Rhode Island	• State tax credits are available for alternative fuel vehicles and alternative fueling stations • A corporate tax deduction is available for the sales of alternative fuel vehicles
South Dakota	• The state motor fuel tax of $0.22 per gallon is reduced by $0.02 per gallon for E-10 and by $0.12 for E-85 • Producer incentive payments of up to $1 million per year up to the first 10 years of production is available
Texas	• State grants are available for alternative fuel infrastructure
Utah	• Grants and loans are available for the purchase of alternative fuel vehicles and the production of alternative fueling facilities
Virginia	• Grants and loans are available for the purchase of alternative fuel vehicles and the production of alternative fueling facilities
Washington	• State reductions and exemptions for ethanol plant investment and production is available
West Virginia	• An income tax credit for the purchase of alternative fuel vehicles

	is available
Wisconsin	• A producer incentive payment of $0.20 per gallon for up to 15 million gallons per year is available
Wyoming	• An ethanol production tax credit for up to $4 million a year is available

APPENDIX B

STATE OF THE UNION ADDRESSES AND ENERGY

The State of the Union address is the primary platform for the President of the U.S. to introduce new ideas for legislation to both Congress and the American public in an unadulterated and uninterrupted form. From 1978 to 2007, the topic of energy independence has been inserted 18 times into these speeches. President Carter focused on the national security threat dependence on foreign oil causes. President Reagan touted the benefits of energy deregulation and how this could help the U.S. energy needs. President George H.W. Bush called for a national energy program to solve the nation's burgeoning energy problem. President Clinton dwelled on the environmental reasons for the increased use of biofuels and President George. Bush has advocated energy independence from foreign oil by touting alternative fuels. In particular, President George W. Bush has used ethanol by name in his last three addresses. The following table offers selected quotations from these 18 speeches in regards to the U.S.'s energy needs.

President and Year	Selected Quotation
Carter (1978)	"Every day we spend more than $120 million for foreign oil. This slows our economic growth, it lowers the value of the dollar overseas, and it aggravates unemployment and inflation here at home…Almost 5 years after the oil embargo dramatized the problem for us all, we still do not have a national energy program. Not much longer can we tolerate this stalemate. It undermines our national

	interest both at home and abroad."
Carter (1980)	"The crises in Iran and Afghanistan have dramatized a very important lesson: Our excessive dependence on foreign oil is a clear and present danger to our Nation's security."
Reagan (1981)	"We will continue support of research leading to development of new technologies and more independence from foreign oil..."
Reagan (1982)	"By deregulating oil we've come closer to achieving energy independence…"
Reagan (1985)	"We seek to fully deregulate natural gas to bring on new supplies and bring us closer to energy independence."
H.W. Bush (1991)	"…a comprehensive national energy strategy that calls for energy conservation and efficiency, increased development, and greater use of alternative fuels…"
H.W. Bush (1992)	"…Step eight, Congress should enact the bold reform proposals that are still awaiting congressional action…my national energy strategy."
Clinton (1993)	"Our plan includes a broad-based tax on energy…promotes energy efficiency, promotes the independence, economically, of this country…"
Clinton (1998)	"…I propose $6 billion in tax cuts and research and development to encourage innovation, renewable energy, fuel-efficient cars…"
Clinton (1999)	"Tonight I propose a new clean air fund to help communities reduce greenhouse and other pollution, and tax incentives and investments to spur clean energy technology."
Clinton (2000)	"The greatest environmental challenge of the new century is global warming…If we fail to reduce the emission of greenhouse gases, deadly heat waves and droughts will become more frequent, coastal areas will flood, and economies will be disrupted. That is going to happen, unless we act…efficient production of bio-fuels will give us the equivalent of hundreds of miles from a gallon of gasoline…I think we

	should give a major tax incentive to business for the production of clean energy and to families for buying…the next generation of super efficient cars…”
G.W. Bush (2001)	“We have a serious energy problem that demands a national energy policy.”
G.W. Bush (2002)	“Good jobs also depend on reliable and affordable energy. This Congress must act to encourage conservation, promote technology, build infrastructure, and it must act to increase energy production at home so America is less dependent on foreign oil.”
G.W. Bush (2003)	“Our third goal is to promote energy independence for our country, while dramatically improving the environment.”
G.W. Bush (2004)	“Consumers and businesses need reliable supplies of energy to make our economy run—so I urge you to pass legislation to…make American less dependent of foreign sources of energy.”
G.W. Bush (2005)	“To keep our economy growing, we also need reliable supplies of affordable, environmentally responsible energy…And my budget provides strong funding for leading-edge technology…to renewable sources such as ethanol…I urge Congress to pass legislation that makes America more secure and less dependent on foreign energy.”
G.W. Bush (2006)	“So tonight, I announce the Advanced Energy Initiative—a 22 percent increase in clean-energy research…We’ll also fund additional research in cutting-edge methods of producing ethanol, not just from corn, but from wood chips and stalks, or switch grass.”
G.W. Bush (2007)	“It's in our vital interest to diversify America's energy supply -- the way forward is through technology. We must continue investing in new methods of producing ethanol, using everything from wood chips to grasses, to agricultural wastes.”