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Supply and demand elasticities in the U.S. ethanol fuel market

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ABSTRACT

The market for ethanol has grown from approximately 1.2 billion gallons in 1997 to almost 5 billion gallons in 2006. With the huge increase in ethanol demand in recent years, the growth in derived demand for corn has driven up many food prices. This paper uses monthly data from 1997–2006 to estimate the market supply and demand for ethanol at the national level. The simultaneous determination of the supply and demand curves using two-stage least squares allows for the calculation of supply and demand-side elasticities, which are important results in light of the tremendous growth in this market and recent legislation concerning ethanol.

1. Introduction

As oil resources are depleted and the outcry against global warming becomes more intense, the need for a viable alternative fuel to replace gasoline is becoming increasingly dire. As a potential domestic alternative to foreign oil, ethanol fuel has become a hot topic in the economic, political, environmental, and scientific arenas. President Bush has proposed an ambitious goal of replacing 15% of US gasoline use with biofuels, including ethanol and biodiesel, within the next ten years (*Los Angeles Times*, May 17 2007). Though Congress' 2005 mandate that oil refiners use 7.5 billion gallons of renewable fuels such as ethanol was initially well-received, opposition has increased as the effects of increased ethanol production become clearer and more strongly felt (*The Economist*, October 11, 2007). Many now feel that ethanol may not be the energy fix that everyone was hoping for, and even some environmentalists now oppose it due to ethanol's need for huge amounts of new corn production that cause erosion and degrade habitats. The ethanol controversy has only been heightened by the Energy Information and Security Act of 2007 that calls for 36 million gallons of yearly renewable fuel production by 2022 (*The Economist*, October 11, 2007; *Chicago Tribune*, December 14, 2007). The Renewable Fuels Standard (RFS) portion of the act requires 11.1 billion gallons of renewable fuels production in 2009 and an increase in ethanol production up to a 15 billion gallon annual cap in 2015 (Energy Independence and Security Act of 2007, 110th US Congress). The act also provides credits for cellulosic ethanol, funding for cellulosic ethanol research, and funding for construction of biorefineries and ethanol infrastructure to help meet the RFS.

Ethanol is currently used as an octane booster (or oxygenate) in conventional gasoline, as well as a clean-air additive in reformulated gasoline (RFG) (DiPardo, 2002). Ethanol serves as a non-toxic, renewable fuel alternative that can be used to power many vehicles. Ethanol also has the ability to function as a complete substitute to gasoline, or more commonly, as a major fuel component in E85 (85% ethanol). As a liquid biofuel, ethanol is created by fermentation of biomass, which is green plant material usually from corn, soybeans, or sugarcane (Pimentel and Patzek, 2007).

In 2007, ethanol only accounted for 3.5% of U.S. fuel consumption, and though any car can use 10% ethanol fuel, only 6 million of this country's 237 million vehicles are compatible with E85 (*The Economist*, June 2 2007). However, ethanol is becoming increasingly popular as a fuel additive, evidenced by the doubling of U.S. ethanol production between 2000 and 2004 (Fig. 1). Ethanol production rose from 3.9 billion gallons in 2005 to 4.85 billion gallons in 2006 (EIA, 2007a,b,c,d). According to the Renewable Fuels Association (2007), though there are already 120 ethanol plants in operation in the U.S., another 76 are being built or expanding. Based on all of the ethanol plant construction throughout the corn belt, production capacity is expected to increase to at least 11 billion gallons by 2011 (Baker and Zahniser, 2007).

The increasing demand for ethanol requires the use of a large amount of corn, soybeans, sugarcane, or other crops to feed the large fermentation vats necessary for mass production of ethanol fuel. The need for corn to produce much larger quantities of ethanol has inflated prices from the generally stable price of $2/bushel to more than $4 by

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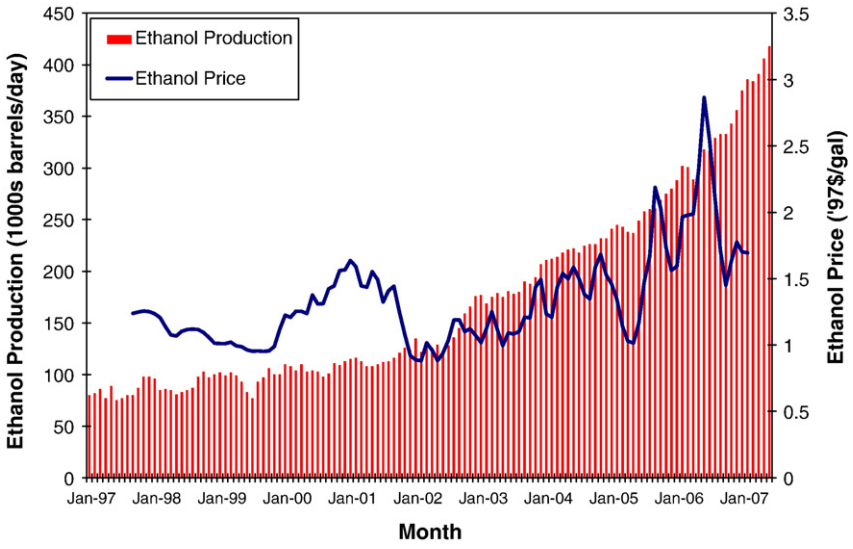

Fig. 1. U.S. ethanol production and price, 1997–2007.

early 2007 (*The Washington Post*, June 15 2007; USDA, 2007). As feed grains such as corn become more expensive, meat and other livestock prices become more expensive to produce. The rising price of corn, which has recently become known as "agflation," has at least partly caused agricultural prices to increase in the United States in recent years (*The Economist*, June 23 2007; International Food Policy Research Institute, May 7 2008; *OECD-FAO Agricultural Outlook, 2007–2016*). Since corn is used in the production of goods ranging from high-fructose sweeteners to cattle feed, corn prices have a considerable effect on a large portion of food industries. The portion of corn used to produce ethanol is expected to rise from 12% to 23% by 2015 (Runge and Senauer, 2007). Additionally, the rising demand for corn has diverted land from soybean production, leading to price pressure on increasingly popular trans-fat-free cooking oils (*The Washington Post*, June 15 2007). Beyond the direct impacts, ranchers are having a more difficult time finding grazing lands in the face of steep competition from corn farmers expanding their fields (*USA Today*, July 25 2007). The great demand for corn derived from ethanol demand is clearly having an effect on the U.S. economy, and many fear that widespread "agflation" will only worsen in the coming years.

The recent surge in the demand for fuel ethanol, coupled with the above mentioned legislative mandates and proposals for the use of ethanol, has already begun to have an impact on the U.S. gasoline and agricultural markets. The present situation accentuates the need for an updated and expanded econometric analysis of the ethanol fuel market in order to better understand the likely impact of these mandates and proposed legislation. This paper will study the ethanol fuel market from the perspective of supply and demand. What are the largest determinants of ethanol prices and quantities? A simultaneous system of equations will be estimated in order to derive the demand and supply curves for ethanol. These supply and demand models will utilize monthly ethanol production and real price data from September 1997 through December 2006, while analyzing the effects of gasoline prices, income, corn factor prices, transportation costs, technological innovations, co-product prices, changes in federal subsidy levels, changes in regulatory structure, such as methyl tert-butyl ether (MTBE) restrictions, and MTBE prices. Based on the updated supply and demand models, price elasticities can be calculated to assess the predicted responses of ethanol production to ethanol, gasoline, MTBE, and corn price changes. This analysis will then be used to speculate about future ethanol prices and the feasibility of expanding the use of ethanol as an alternative fuel. By understanding the economic model, discussion about the environmental and political outcomes of increased ethanol production will become more informed. Given current government policy decisions regarding alternative fuels, this model will enhance our ability to understand how ethanol production and demand may change in the coming years.

2. Literature review

Though the ethanol fuel market has been studied extensively from environmental and business perspectives, a more current analysis of the market supply and demand is lacking at present. Previous work by Kevin Rask (1998) provides the framework for an econometric model for ethanol fuel supply and demand. Rask's analysis is based on data from 1984–1993, and a more current analysis that utilizes data from the past 10 years would greatly enhance the model's ability to understand the present and future of ethanol use. Rask's empirical demand and supply models contain a handful of variables, including transportation cost, technology level, and regulatory variables, that warrant updating. Rask calculates ethanol price elasticities based on both the supply (0.75) and demand (−0.37) equations. Rask concludes that the own price response (ethanol price elasticity) is relatively inelastic, so demand shocks (which cause movement along the supply curve) have a larger effect on prices than on production quantity. This means that a decrease in the federal ethanol subsidy would be expected to have a smaller effect on ethanol industry revenues than if the supply was price elastic. Because the ethanol price elasticity in the demand curve is even more inelastic, Rask also believes that supply shocks (such as changes in corn prices) are transferred more to price changes with less impact on production. Thus, increasing corn factor prices are thought to increase revenues, which makes sense given the large profits being made by farmers and ethanol refiners even though corn prices have been on the rise. With this in mind, Rask believes, based on the very low own price elasticity in the demand equation (−0.37), that ethanol is being over-subsidized. Rask further concludes based on the relative ethanol price elasticities in the supply and demand curves that the ethanol retailers are receiving a larger portion of the government subsidy than the consumers.

Rask (1998) also calculates price elasticities for corn inputs (−3.03) and gasoline (−2.13) based on monthly data from January 1988 to May 1993. These results demonstrate corn's vital importance in affecting ethanol production over the period being