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Relationship between ethanol and gasoline: AIDS approach

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ABSTRACT

Ethanol production in the United States has increased significantly due to government support, which has begun to dwindle. Ethanol now seems to compete with gasoline for vehicle fuel but because ethanol is mostly sold as a blend, gasoline and ethanol could be complementary fuel sources. The study investigates the true relationship between these fuels since it has policy implications. Results of LA/AIDS estimation show the two fuels were substitutes before the rapid expansion of ethanol production but have become complements overtime due to increasing share of ethanol in fuel consumption.

1. Introduction

The real crude oil price per barrel has more than tripled over the past 20 years, rising from about $27 per barrel in 1993 to $98 per barrel in 2013 (Energy Information Administration, 2014a, 2014b). Initially created under the Energy Policy Act of 2005 and expanded under the Energy Independence and Security Act of 2007, the Renewable Fuel Standard program requires 36 billion gallons of renewable fuel (e.g., ethanol) to be blended into transportation fuel by 2022 (U.S. Environmental Protection Agency (EPA), 2013). This combination of market and policy factors has led to a substantial increase in ethanol production; in 2013, 13.3 billion gallons of ethanol were produced up from 3.9 billion gallons in 2005 (Renewable Fuels Association, 2014). The arguments that ethanol is a renewable energy source, yields environmental benefits, and reduces the United States' dependence on imports of oil[1] would suggest that ethanol and gasoline are substitutes. However, the Volumetric Ethanol Excise Tax Credit of 2004, which initially provided a tax incentive to gasoline blenders in the amount of $0.51 per gallon of pure ethanol blended with gasoline (U.S. Department of Energy, 2011), may have affected these fuels' competitiveness, making them complements.[2] Given the true relationship between ethanol and gasoline influences government policy direction, this study estimates the responsiveness of ethanol use to gasoline prices to determine if they are substitutes, complements, or switched from being substitutes to complements over time.

If ethanol and gasoline are substitutes, then price parity will be influential in consumer preference. For example, relatively high gasoline prices will lead to increased ethanol consumption. Tyner and Taheripour (2007) show that 93% of the variance in monthly gasoline prices is due to crude oil prices. In this case, the government could minimize its role and allow the market to determine ethanol use as crude oil prices increase. In Brazil, where most vehicles can use pure ethanol (E100) and high ethanol blends (E25), the consumption of ethanol is influenced by price parity; 25–30% less than gasoline (Inslee and Hendricks, 2007). Also in Brazil, Bastian-Pinto et al. (2010) found that flex-fuels save 15% on fuel cost over the life of the vehicle. Using simulation, they also found that the lower the correlation between gasoline and ethanol prices, the higher the savings. Conversely, if ethanol and gasoline are complements, then high crude oil price will decrease both

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[1] Various countries generally attempt to reduce gasoline consumption via gasoline taxes, among other things. Parry and Small (2005) used simulations to determine the optimal Pigovian gasoline taxes in the U.S. and U.K. and found that the U.S. gasoline tax was too low—about 50% of their computed second-best optimal rate. Thus, the U.S.'s heavy dependence on fossil fuel could be attributed to its low gasoline tax.

[2] This tax credit expired December 31, 2011.

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Table 1
Vehicle fuel descriptive statistics.

	Ethanol		Gasoline		Diesel	
	1982–2005	2006–2012	1982–2005	2006–2012	1982–2005	2006–2012
Price ($ per gallon)						
Mean	2.870	3.437	1.088	2.351	1.018	2.461
Variance	0.735	0.403	0.144	0.241	0.131	0.345
St. dev.	0.857	0.635	0.379	0.491	0.362	0.587
Maximum	5.359	5.598	2.323	3.266	2.360	4.002
Minimum	1.666	2.358	0.459	1.183	0.458	1.347
Coef. of variation	2.870	3.437	1.088	2.351	1.018	2.461
Quantity (million gal per month)						
Mean	112.6	857.4	9593.3	10,420.9	2529.4	3605.0
Variance	6223.7	62,166.3	899,663.7	247,252.3	351,028.8	42,784.5
St. dev.	78.9	249.3	948.5	497.2	592.5	206.8
Maximum	381.3	1215.1	11,423.8	11,410.5	3727.2	4042.1
Minimum	18.0	338.8	7795.1	9449.8	1517.6	3233.8
Coef. of variation	0.701	0.291	0.099	0.048	0.234	0.057
Shares						
Mean	0.0221	0.0805	0.7864	0.6757	0.1915	0.2439
Variance	0.0001	0.0004	0.0011	0.0006	0.0007	0.0003
St. dev.	0.0089	0.0198	0.0334	0.0250	0.0270	0.0168
Maximum	0.0496	0.1178	0.8498	0.7284	0.2712	0.2827
Minimum	0.0045	0.0380	0.6854	0.6107	0.1428	0.2060
Coef. of variation	0.401	0.246	0.043	0.037	0.141	0.069

Data source: U.S. Energy Information Administration.

gasoline and ethanol consumption, which will call for more government involvement in the ethanol market.

Currently in the United States, E10, a blend of gasoline and up to 10% by volume of ethanol, is the most popular blend of gasoline and ethanol and makes up about 90% of the gasoline market (U.S. Environmental Protection Agency, 2012). E85 is also available; however, its adoption has been limited because it can only be used in flexible-fuel vehicles and requires specialized pumps at the retail level. Only about 1.8% of gasoline stations are capable of dispensing ethanol blends higher than E10 although research suggests that most vehicles can use E15 without any harm to the vehicle and the EPA allows newer cars and light trucks to use it (U.S. Environmental Protection Agency, 2012; Wald, 2013). Moreover, the United States has reached its ethanol consumption capacity, popularly referred to as the ethanol blend wall, suggesting that further increases in ethanol consumption will occur only if other policy changes occur.

2. Previous literature

Past studies on ethanol have examined its energy efficiency (Hill et al., 2006; Schmer et al., 2008), impact on the environment (Farrell et al., 2006; Hill et al., 2009; Piñeiro et al., 2009), and impact on rural communities (McNew and Griffith, 2005; Swenson, 2008) rather than on its demand. However, there are many gasoline demand studies that are applicable to ethanol. Most of them were done after the 1973 energy crisis. Dahl (1982) estimated gasoline demand as a function of gasoline price, GDP, and per-capita stock of vehicles to determine whether gasoline demand elasticities are constant. He found that estimated elasticities did not vary over time. Berkowitz et al. (1990) estimated gasoline demand to determine factors influencing household gasoline consumption in Canada. They used a disaggregate approach where household demand for gasoline depended on the number and type of vehicles, as well as, vehicle usage. Their results indicate that while vehicle usage is not sensitive to fuel efficiency improvements, fuel consumption appears to be sensitive to government mandated standards. Li et al. (2009) found that a 10% increase in the price of gasoline price increases automobile fleet fuel economy by 0.22% and 2.04% in the short and long run, respectively. Also, a study by Beresteanu and Li (2011) show that increased gasoline prices between 1999 and 2006 led to a 37% increase in the demand for hybrid vehicles, while federal income tax credit for hybrid vehicles led to a 20% increase. The above studies show the relationship between gasoline price, gasoline consumption, and fuel efficient vehicles, and indicate that consumers alter their consumption behavior to minimize gasoline use. However, none provide information on the ethanol–gasoline relationship.

Relatively few studies exist that attempt to study the ethanol–gasoline relationship. Rask (1998) used two stage least squares and monthly data from 1984 to 1993 to estimate the cross-price elasticity of ethanol demand with respect to gasoline. The calculated elasticity coefficients range from 5.05 to −2.13 suggesting that ethanol and gasoline could be complements or substitutes. Luchansky and Monks (2009) updated Rask's (1998) study by using data from 1997 to 2006. Their cross-price elasticity of ethanol demand was estimated to be in the range of −3.06 to −2.08, which implies ethanol and gasoline are complements.

Using comparative statics, Zhang et al. (2010) showed that an increase in ethanol blend (EB) within an intermediate range (E10 ≤ EB ≤ E20) would have the following impact. First, increasing the ethanol blend wall, between E10 and E20, will increase ethanol price and E85 price, and subsequently increase the quantity supplied of ethanol and quantity of ethanol used in the intermediate range. However, the increase of ethanol in the intermediate range would decrease the quantity of ethanol for E85, hence a decrease in gasoline quantity as well. The overall relationship between ethanol and gasoline is therefore ambiguous since relaxing the blend wall has a positive and a negative effect on ethanol and gasoline. Extending the research by Zhang et al. (2010), Qiu et al. (2014) provided the magnitude of price and quantity responsiveness of the above impacts of relaxing the ethanol blend wall. They found that the quantity of ethanol blend responsiveness to price changes decreases as the blend wall is relaxed.

The cross-price elasticities above (Luchansky and Monks, 2009 and Rask, 1998) indicate changes in sign and declining responsiveness. It is therefore imperative to use more current data and the same model to examine the ethanol–gasoline relationship in the two periods studied by Rask (1998) and Luchansky and Monks (2009) since the relationship could be dynamic. Also, because the ethanol mandate was triggered by rising crude oil prices (among others), it is appropriate that the relationship is analyzed from a gasoline price impact on ethanol use perspective instead of the reverse perspective used by Qiu et al. (2014) and Zhang et al. (2010). Finally, the model used by Rask (1998) and Luchansky