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An ethanol blend wall shift is prone to increase petroleum gasoline demand

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ABSTRACT

In 2010, the U.S. Environmental Protection Agency announced a waiver allowing an increase in the fuel–ethanol blend limit (the "blend wall") from 10% (*E10*) to 15% (*E15*). Justifications for the waiver are reduced vehicle-fuel prices and less consumption of petroleum gasoline, leading to greater energy security. Empirical investigations of this waiver using Monte Carlo simulations reveal an anomaly where a relaxation of this blend wall elicits a demand response. Under a wide range of elasticities, this demand response can actually increase the consumption of petroleum gasoline and thus lead to greater energy insecurity. The economics supporting this result and associated policy implications are developed and discussed.

1. Introduction

Fostered by an array of policies including consumption and production subsidies, environmental standards, and minimum consumption mandates, ethanol as a transportation fuel in the U.S. has experienced rapid growth over the last decade. Central to the expansion of the ethanol industry in the U.S. is the Energy Independence and Security Act of 2007, which set a Renewable Fuels Standard (RFS) mandate of 36 billion gallons of biofuels blended with gasoline by 2022. The motivations for promoting ethanol as an alternative to petroleum gasoline for motorized vehicles are wide-ranging. Supporters argue that blending ethanol with gasoline displaces gasoline consumption, which reduces dependence on oil, increases national energy independence, reduces greenhouse gas emissions, improves farm and rural incomes, and stabilizes or lowers motor vehicle fuel costs (Halm and Cecot, 2009; Low and Isserman, 2009). However, a growing body of research has emerged raising questions as to whether the proffered benefits of ethanol, and hence the policies supporting the ethanol market, are well founded (de Gorter and Just, 2009; Saitone et al., 2008; Vedenov and Wetzstein, 2008).

In particular, a key underlying ethanol-program assumption has been brought into question. Government promotion of ethanol based on the assumption of increased ethanol consumption yielding reduced petroleum gasoline consumption is questionable. The potential for this assumption not holding, leading to a perverse policy outcome, arises due to the linkages between the ethanol and gasoline sectors. Policies such as an ethanol subsidy that reduce the price of ethanol have both a substitution effect (i.e., the ethanol price decline causes a shift away from gasoline to ethanol) and an expansion effect (i.e., the ethanol price decline increases total fuel consumption). Depending upon the relative magnitudes of the substitution and expansion effects, which are determined by market elasticities, overall consumption of petroleum gasoline may actually increase due to the government induced decline in ethanol prices.

Similar paradoxes have been explored in a number of avenues. Hutchinson et al. (2010) consider the potential for low-carbon fuel subsidies to result in an overall increase in emissions. They derive necessary and sufficient conditions of when this paradox may occur and show via a calibrated model that ethanol subsidies in the U.S. are likely to result in a net increase in carbon emissions. Vedenov and Wetzstein (2008)

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account for income and substitution effects in their derivation and estimation of an optimal U.S. ethanol fuel subsidy. Zhang et al. (2010b) show theoretically that an increase in the blending limit for ethanol can result in an overall increase in petroleum gasoline consumption. Holland et al. (2009) demonstrate that low carbon fuel standards aimed at reducing greenhouse gas emissions may result in an overall increase in emissions due to increased fuel consumption spurred by lower prices. De Gorter and Just (2009) theoretically determine that tax credit and mandate policies subsidize fuel consumption instead of biofuels. They then conclude that such policies can increase petroleum gasoline consumption and hinder energy security.

The objective is to build upon this previous literature with an empirical analysis of the potential market effects resulting from a shift in gasoline–ethanol blending regulations. Under the U.S. Clean Air Act, the maximum percentage of ethanol permitted for use in U.S. conventional non-flex-fueled vehicles is 10%. This cap, which is popularly termed the “blend wall,” has recently come under fire for stymieing the expansion of ethanol and failing to fully realize potential reductions in U.S. petroleum gasoline consumption. Proponents of shifting the blend wall from 10% to 15% have argued that raising the ethanol cap is necessary for the U.S. to achieve its renewable fuel goals set by the RFS (EPA, 2013). The American Coalition for Ethanol contends that unless the blend wall is increased, demand for U.S. biofuels will come to a standstill in the short run and will place the future of cellulosic biofuels in jeopardy (American Coalition for Ethanol, 2009). Growth Energy, a U.S. advocacy group supporting ethanol use, filed in 2010 a Green Jobs waiver with the Environmental Protection Agency, which resulted in a partial increase in the blend wall. The waiver requested a blend wall shift from 10% to 15% arguing that it would help accelerate U.S. renewable fuel consumption and increase energy security by substituting conventional gasoline with ethanol.

Although relaxing the blend wall will, as proponents have argued, help foster growth for the ethanol industry and help the U.S. meet RFS mandates, the impact on petroleum gasoline consumption is not apparent. Building upon the theoretical analysis of Zhang et al. (2010b), the impact of a blend wall shift on overall petroleum gasoline consumption is empirically assessed. The direction and magnitude of total petroleum gasoline consumption from a positive shift in the blend wall is estimated by employing published elasticities and parameter values. Employing Monte Carlo simulations, the standard deviations of comparative statics results are estimated and the probabilities of increased total petroleum gasoline consumption for blended fuels containing 10% to 90% ethanol are determined.

Overall, results indicate a shift in the blend wall from 10% to 15% will result in an increase in total petroleum gasoline consumption. In fact, only if the blend wall is increased to a level greater than 70% ethanol in gasoline blends, will petroleum gasoline consumption not likely increase. These results indicate that increases in the blend wall will increase ethanol consumption in the U.S., but fail to achieve the environmental and energy security benefits associated with reductions in petroleum consumption.

The remainder of this paper is outlined as follows. In the following section, the theoretical model that serves as the foundation for the empirical analysis is presented. This is followed by a description of the data and parameters used to calibrate the model. The fourth section presents estimates of the impact of the blend wall shift on petroleum and ethanol markets by employing benchmark parameter values. This is followed by the Monte Carlo analysis considering the entire range of parameter values identified in the literature. Finally, before discussing the implications of the empirical analysis, a sensitivity analysis of individual parameter values on comparative statics estimates is presented.

2. Theoretical development

2.1. Theoretical model

As a theoretical framework, two blended fuels are considered: *E85*, containing 85% ethanol and 15% petroleum gasoline, and $E\gamma$, where γ is the proportion of ethanol used in the intermediate blended ethanol fuel. The current blend wall at $\gamma = 10$ (*E10*), containing 10% ethanol and 90% petroleum gasoline, is employed as the benchmark fuel blend. A comparative statics analysis is then based on the currently existing fuel blends, *E10* and *E85*, with *E10* as the benchmark.

A decade ago over 95% of the U.S. gasoline market was composed of unblended ethanol-free gasoline. In contrast, currently the availability of unblended gasoline is severely limited with no major brand gas stations supplying it, so only blended fuels are considered in the analysis. Although the market is relatively small for *E85*, which can only be used in flex-fuel capable vehicles, it is critical to incorporate this market in the empirical analysis in order to fully capture the impacts of a blend wall shift. A blend wall shift not only affects ethanol and petroleum gasoline consumption via the $E\gamma$ market, but it also has a spillover effect on *E85* prices as well. This has a small, but non-negligible effect on total ethanol and petroleum gasoline consumption and a number of policy implications for the future of flex-fuel vehicles.

For this framework, the theoretical model developed in Zhang et al. (2010b) that casts the ethanol market as a two sector industry: an ethanol refining sector and a blending sector is employed. This construction is consistent with prior efforts toward investigating the economic effects of bioenergy policies (Böhringer et al., 2009; Kangas et al., 2011; Kretschmer et al., 2009; Kretschmer and Peterson, 2010; Lankoski and Ollikainen, 2011; Strand, 2011; Timilsina et al., 2011).

Ethanol market supply, Q_e^S, is specified as

$$Q_e^s = Q_e^s(p_e|\bar{r}), \tag{1}$$

where p_e is the competitive price of ethanol, with $\partial Q_e^s/\partial p_e > 0$ and $\bar{r}$ a vector of input prices. Inverse demands of *E85* and $E\gamma$ are captured respectively as

$$p_{85} = p_{85}\left(E_{85}^D|\bar{x}\right) \text{ and} \tag{2a}$$

$$p_\gamma = p_\gamma\left(E_\gamma^D|\bar{x}\right), \tag{2b}$$

where p_{85} and p_γ are the prices of *E85* and $E\gamma$ respectively, and E_{85}^D and E_γ^D are the quantities demanded with $\bar{x}$ as the corresponding vector of demand shifters.

A representative blender aims to maximize the total profit of blending *E85* and $E\gamma$. The associated equilibrium F.O.C.s yield a blender's demand for ethanol, e, as a function of *E85* and $E\,\gamma$ prices p_{85} and p_γ, respectively, and petroleum gasoline price p_g, $e = e(p_\gamma, p_{85}, p_e, p_g)$. Assuming that the price of petroleum gasoline is exogenous and summing all the representative blenders' demand functions for ethanol, the market demand function for ethanol could be characterized as $Q_e^D(p_\gamma, p_{85}, p_e|p_g)$, where Q_e^D is a function of *E85*, $E\,\gamma$, and ethanol prices based on a given price of petroleum gasoline.[1] Market equilibrium exists where ethanol supply equals to demand

$$Q_e^D\left(p_\gamma, p_{85}, p_e|p_g\right) = Q_e^s(p_e|\bar{r}). \tag{3}$$

[1] The assumption of an exogenous petroleum gasoline price assumes that the petroleum fuel sector does not impact the price of ethanol. Empirical results by Zhang et al. (2010a) support this assumption with their findings that in the short-run petroleum gasoline prices do not Granger cause ethanol price movements. In the long-run, empirical results indicate petroleum gasoline and ethanol are complements and tend to move in tandem with the oil market, which drives economic activity (McPhail, 2011; McPhail et al., 2012; Qiu et al., 2012; Zhang et al., 2010a).