The Impact of Ethanol Production on US and Regional Gasoline Markets: An Update to May 2009

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Abstract

This report updates the findings in Du and Hayes 2009 by extending the data to December 2010 and concludes that over the sample period from January 2000 to December 2010, the growth in ethanol production reduced wholesale gasoline prices by $0.25 per gallon on average. The Midwest region experienced the biggest impact, with a $0.39/gallon reduction, while the East Coast had the smallest impact at $0.16/gallon. Based on the data of 2010 only, the marginal impacts on gasoline prices are found to be substantially higher given the much higher ethanol production and crude oil prices. The average effect increases to $0.89/gallon and the regional impact ranges from $0.58/gallon in the East Coast to $1.37/gallon in the Midwest. In addition, we report on a related analysis that asks what would happen to US gasoline prices if ethanol production came to an immediate halt. Under a very wide range of parameters, the estimated gasoline price increase would be of historic proportions, ranging from 41% to 92%.

Introduction

In a 2009 analysis published in *Energy Policy* (Du and Hayes 2009), we evaluated the impact of US ethanol production on national and regional gasoline prices. This article was based on data that was available prior to 2008. Since then, US ethanol production has increased significantly, and two years of additional historical data has become available. The purpose of this report is to update the earlier analysis. We calculate the average impact of ethanol production both nationally and regionally over the period January 2000–December 2010 and specifically for 2010. Estimation results indicate that, on average, over the whole sample period and all five PADD (Petroleum Administration for Defense District) regions, the growth in ethanol production reduced wholesale gasoline prices by $0.25/gallon. The Midwest region (PADD II) experienced the biggest impact with a $0.39/gallon reduction, while the East Coast (PADD I) had the smallest impact at $0.16/gallon. Based on the data of 2010 only, the marginal impacts on gasoline prices are found to be substantially higher given the much higher ethanol production and crude oil prices. The national average effect increases to $0.89/gallon and the regional impact ranges from $0.58/gallon on the East Coast to $1.37/gallon in the Midwest.

In addition, we now report on a related analysis that asks what would happen to US gasoline prices if ethanol production came to an immediate halt. This analysis is topical because a 2011 drought might force a shutdown of corn-based ethanol production and also because world energy stocks are tight. Moreover, the ethanol industry now provides approximately 10% of the gasoline used in automobiles, an amount that exceeds the spare capacity of US oil refineries. This "missing" fuel would have to be imported in the short run, and the required volume would be large relative to available import supplies. The only way to solve this short-term supply problem would be to use high gasoline prices to ration demand. The size of the required gasoline price increase cannot be calculated with any certainty because key parameters are not known with certainty. However, we can say that under a very wide range of parameters, the gasoline price increase would be of historic proportions, ranging from 41% to 92%.

The impact of ethanol production on wholesale gasoline prices

In this section, we briefly describe the updates and changes to Du and Hayes 2009. In the current study, the sample period is extended to January 2000 through December 2010.

Dependent variables

As in Du and Hayes 2009, two dependent variables are employed:

(a) The crack ratio (π_{CR}), the relative gasoline price to the price of crude oil, is defined as

(1) $\pi_{CR} = P_G * 42 / P_O$

where P_G is the average wholesale gasoline price (\$/gallon), and P_O is the US crude oil composite acquisition cost to refiners (\$/barrel).

(b) The crack spread (π_{CS}) is defined as

(2) $\pi_{CS} = \dfrac{2}{3} P_G * 42 + \dfrac{1}{3} P_H * 42 - P_O$

where P_H is the wholesale price of No. 2 distillate fuel (\$/gallon). The crack spread is then deflated by the Producer Price Index of crude energy material. Monthly data of all related prices are collected from the Energy Information Administration (EIA) website.

Explanatory variables

As in the previous study, besides the monthly US ethanol production, other explanatory variables include monthly dummies (January to November), monthly crude oil ending stocks (excluding the Strategic Petroleum Reserve), total motor gasoline ending stocks, complexity-adjusted refinery capacity, HHI index for regional refinery market concentration, dummy variables for September and October 2005 representing the unexpected supply disruptions induced by Hurricanes Katrina and Rita, and regional gasoline imports. Please see Du and Hayes 2009 for the justifications for included variables.

One change worth noting is that since EIA discontinued the Amsterdam-Rotterdam-Antwerp gasoline price series after September 2008, in the current study, the regional gasoline imports are not instrumented as described in Du and Hayes 2009, and the estimation method is changed accordingly.

Estimation

A fixed-effects panel data model is specified as

(3) $\pi_{it} = \alpha_i + X_{it}'\beta + \varepsilon_{it}$ $i = 1,...,N; t = 1,...T$

where $i = 1,...,N$ denotes the cross-section dimension, the PADD regions, and $t = 1,...T$ denotes the time-series dimension. π_{it} is the crack ratio (crack spread) on the ith region for time period t. X_{it} is the K-dimensional vector of explanatory variables discussed above.

The parameter estimates for the crack ratio and crack spread are presented in Table 1. All explanatory variables have the expected signs and are largely consistent with our previous study.

Evaluating at the sample mean, the wholesale gasoline price is lowered by $0.25/gallon because of ethanol production, which is about 16% of the sample average. We use the crack ratio to quantify the gasoline price impact. Specifically, the change in the wholesale gasoline price, -0.25/gallon, is calculated as

$$
\begin{aligned}
\text{Price change} &= \text{estimated coefficient} \times \text{Average ethanol production} \times \text{Average crude oil price (\$/gallon)} \\
&= \text{-0.000031} \times 10916.95 \times \frac{53.67 \ (\$/\text{barrel})}{42} \\
&= \text{-0.2525 (\$/gallon)}
\end{aligned}
$$

where the average ethanol production and crude oil price are averaged over the whole sample period.

Regional analysis

We use wholesale gasoline prices for this portion of the analysis. The crack ratio is employed as the dependent variable. The ordinary least squares estimation results are reported in Table 2. The results indicate that ethanol production has a significant and negative effect on wholesale gasoline prices in all regions. The Midwest has the largest impact at $0.39/gallon. The East Coast experiences the smallest negative ethanol impacts, with gasoline prices lowered by $0.16/gallon. The Gulf Coast has a $0.20/gallon reduction in retail gasoline prices. The downward gasoline price changes in the West Coast and the Rocky Mountains are about $0.17/gallon and $0.38/gallon, respectively. The change in gasoline price in a regional market, for example, $0.39/gallon in the Midwest region (PADD II), is calculated as

Price change $=$ estimated coefficient $\times$ Average ethanol production $\times$ Average crude oil price ($/gallon)

$$= \text{-0.0000276} \times 10916.95 \times \frac{53.67 \text{ (\$/barrel)}}{42}$$

$$= \text{-0.3850 (\$/gallon)}$$

Based only on the 2010 data, we calculate the marginal impact of increasing ethanol production on wholesale gasoline prices. We find that the average national effect increases to $0.89/gallon and the regional impact ranges from $0.58/gallon in the East Coast to $1.37/gallon in the Midwest. The average and marginal effects of ethanol production on the US and regional markets are summarized in Table 3.

The impact of eliminating ethanol production on wholesale gasoline prices

Here we attempt to predict what would happen to domestic wholesale gasoline prices if ethanol production was totally eliminated. We treat ethanol as a perfect substitute for gasoline and then quantify the impact of reduced ethanol supply on domestic gasoline prices in a partial equilibrium model. The domestic gasoline demand, domestic supply including ethanol, and imports are modeled in a simultaneous equation system as

(4)
$$\begin{cases} D_1 = D(p_1) \\ S_1^d = S_1^d(p_1) \\ S_1^i = S_1^i(p_1) \end{cases}$$

where D, the domestic gasoline demand, is defined as a function of domestic gasoline price p. S_d and S_i denote domestic gasoline supply including ethanol and gasoline imports, respectively. The demand and supply equations are assumed to be linear with slopes given by short-run price

elasticities. Specifically, given demand elasticity $\varepsilon_d \left(\equiv \dfrac{D_1 - D_0}{p_1 - p_0} \times \dfrac{p_0}{D_0} \right)$, the demand price relation

is derived as $D_1 = \varepsilon_d D_0 (p_1 - p_0) / p_0 + D_0$. We use the market data of 2010 as starting points

(D_0 and p_0) in the system. The domestic supply and import equations can be similarly defined as functions of gasoline prices.

The short-run demand elasticity is obtained from the literature as -0.06 with a range of -0.034 to -0.077 (Hughes, Knittel, and Sperling 2008). The short-run elasticity of domestic supply is

estimated to be 0.06 with a range of 0.03–0.07.[1] Following Lee and Sumner (2010), the import elasticity is approximated as[2]

(5) $\varepsilon_i = (Q_{tu} / Q_i)\varepsilon_d - [(Q_{tu} / Q_i) - 1]\varepsilon_s$

where Q_{tu} / Q_i is the inverse of the import share in the domestic gasoline market, which is approximately 5% in our case. ε_s and ε_i denote domestic supply and import elasticities, respectively.

In the scenario in which ethanol is totally eliminated from domestic supply, the system specified in (4) is used to simulate the gasoline price responses after taking into account (i) the gasoline stocks at the level of 2010, and (ii) the full utilization of the spare capacity of US oil refineries in 2010. Three sets of simulation results are generated under different levels of elasticities (high, medium, and low). The results summarized in Table 4 indicate that if the ethanol supply were eliminated from the domestic gasoline market, wholesale gasoline prices may change by 41%–92% in the short run depending on the sensitivity of producers and consumers to prices.

References

Du, X., and D.J. Hayes. 2009. The Impact of Ethanol Production on US and Regional Gasoline Markets. *Energy Policy* 37: 3227-3234.

Lee, H., and D.A. Sumner. 2010. International Trade Patterns and Policy for Ethanol in the United States. Ch. 19 in *Handbook of Bioenergy Economics and Policy*, ed. M. Khanna, J. Scheffran, and D. Zilberman, 327-345. New York: Springer.

Hughes, J.E., C.R. Knittel, and D. Sperling. 2008. Evidence of a Shift in the Short-Run Elasticity of Gasoline Demand. *Energy Journal* 29: 113-134.

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[1] The results are available upon request.
[2] The equation is found on page 333 of Lee and Sumner 2010.

Table 1. Estimation results for a fixed effects model on the crack ratio and crack spread

Variable	Crack Ratio		Crack Spread	
	Estimate	Std. Err.	Estimate	Std. Err.
Oil stock	3.42e-06***	6.46e-07	7.2e-5***	1.2e-5
Gasoline stock	-3.62e-07	1.7e-06	-6.0e-5*	3.1e-5
Equivalent Refinery capacity	1.18e-06	2.47e-6	0.00013***	4.6e-5
Ethanol production	-.000018***	8.12e-07	-.00019***	1.5e-5
Supply disruption	.09**	.04	.18	.69
Gasoline import	-6.6e-6**	2.80e-06	-9.2e-5*	5.1e-5
HHI	5.1e-6	3.7e-5	.0023***	.001
January	0.004	.02	-.12	.39
February	0.01	.02	.44	.39
March	.08***	.02	1.45***	.39
April	.13***	.02	2.64***	.40
May	.16***	.02	3.20***	.39
June	.11***	.02	2.46***	.39
July	.06***	.02	1.76***	.39
August	.06***	.02	2.17***	.40
September	.07***	.02	2.70***	.40
October	.03	.02	2.01***	.35
November	.007	.02	.59	.39

Note: Single (*), double (*), and triple (***) asterisks denote significance at the 0.10, 0.05, and 0.01 levels, respectively.

Table 2. Regression results on the crack ratio with individual PADD regional data

Variable	PADD I	PADD II	PADD III	PADD IV	PADD V
Oil stock	5.1e-6	7.7e-6***	2.3e-6***	.000022	3.8e-6
Gasoline stock	-6.8e-6***	-5.8e-6	-9.7e-8**	-.000022	-2.4e-6
Refinery capacity	-1.8e-5**	.00001	1.7e-6	.0002	-.000065***
Ethanol production	-.0000116***	-0.000028***	-.000015**	-.000027***	-.0000124**
Supply disruption	.19***	0.06	.17**	.11	.08
Gasoline import	-3.8e-6	.0005**	-1.3e-5	.003	.0001***
HHI	-.00011**	-.0003*	-.0002	.0004**	.00006
January	.04	.06	.01	-.02	-.01
February	.002	.05	.003	-.00002	.02
March	.04	.06	.04	.05	.09
April	.11***	0.09**	.09**	.10*	.16**
May	.15***	.17***	.11***	.17***	.12*
June	.09**	.13***	.06	.13**	.10
July	.042	.07	.02	.09*	.05
August	.0006	.09**	.01	.10**	.01
September	-.01	.09**	.01	.12**	.07
October	-.05	.03	-.01	.06	.04
November	-.03	-.002	-.03	.03	.02
Constant	2.3***	1.31***	1.11***	.29	3.31***
R^2	.65	.69	.60	.64	.61

Note: Single (*), double (*), and triple (***) asterisks denote significance at the 0.10, 0.05, and 0.01 levels, respectively.

Table 3. The negative impact of ethanol production on wholesale gasoline prices (in $/gallon)

	Average across regions	PADD I	PADD II	PADD III	PADD IV	PADD V
Average effect (based on whole sample period)	0.25	0.16	0.39	0.20	0.38	0.17
Marginal effect (based only on 2010 data)	0.90	0.58	1.37	0.72	1.35	0.62

Table 4. Simulation results of the impact of eliminating ethanol production

	Equilibrium gasoline price ($/gallon)	Domestic gasoline demand (million gallons)	Domestic gasoline supply (million gallons)	Gasoline import (million gallons)
2010 baseline	2.16	138496	131571	6925
Low elasticities $\varepsilon_d = -0.034;$ $\varepsilon_s = 0.03;$ $\varepsilon_i = 0.11.$	4.15	134168	126544	7625
Medium elasticities $\varepsilon_d = -0.06;$ $\varepsilon_s = 0.06;$ $\varepsilon_i = 0.06.$	3.29	134168	127027	7141
High elasticities $\varepsilon_d = -0.077;$ $\varepsilon_s = 0.07;$ $\varepsilon_i = 0.21.$	3.04	134168	126653	7515