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Impact of Increased Ethanol Mandates on Prices at the Pump

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Executive Summary

The Environmental Protection Agency (EPA) proposed in November to reduce 2014 biofuel mandates. One concern expressed by EPA is that it will be difficult, if not impossible, to consume the 2014 target levels of ethanol in the Renewable Fuel Standard (RFS) because of infrastructure issues. Difficulty in meeting ethanol mandates is reflected into increased compliance costs and a measure of compliance cost is the price of the tradable ethanol credit known as a RIN (Renewable Identification Number). The price of RINs represents the gap between the cost of producing another gallon of ethanol and the price of ethanol that is needed to induce consumers to buy another gallon. Compliance with the ethanol mandates falls to owners of oil refineries who must purchase a specified number of RINs per gallon of gasoline produced. We show in previous work that increasing the number of stations that sell E85 decreases the ethanol price discounts needed to induce enough ethanol consumption to meet targets by making the fuel more accessible to consumers. Any reduction in required discounts directly leads to lower RIN prices and hence lower compliance costs. Thus, obligated parties faced with high RIN prices would have a strong incentive to invest in the infrastructure that would facilitate increases in ethanol consumption.

As the cost of complying with RFS falls to owners of oil refineries, it is a natural position for them to oppose any further increase in mandated ethanol volumes. One argument that has often been made by the oil industry against increases in ethanol is that compliance costs will be passed on to consumers. This seems like a reasonable argument because this type of cost increase in any economic model will tend to lead to higher gasoline prices, hence higher consumer prices. Our objective in this study is to provide a transparent economic analysis of the impact on consumer fuel prices from increased ethanol mandates. One feature of our analysis is that it accounts for an increase in the consumption of E85, the most likely compliance path that would be taken in 2014 to meet increases in ethanol mandates.

Each year, EPA establishes a percentage standard for ethanol by dividing the desired quantity of ethanol by the total anticipated domestic sales of unblended gasoline. Each producer of gasoline has an RVO (Renewable Volume Obligation) that is determined by multiplying the percentage standard by total domestic sales of gasoline. The RVO is met by acquiring RINs. If an obligated party's sales of gasoline increases, so too does the RVO. This means that an obligated party can reduce the number of RINs that it needs to comply with the RFS by decreasing the volume of gasoline sales. This direct link between the cost of RINs and gasoline sales implies that increases in the cost of RINs reduces the quantity of gasoline that refiners will provide to consumers at any given gasoline price.

Our model has separate demand curves for E10 and E85. The two demand curves are related because increases in E85 consumption come at the expense of E10. The model calculates the retail price of E85 that is needed to induce consumers to buy enough ethanol so that the number of RINs generated is adequate to meet oil refineries' RVO obligations. The obligations are met through increased E85 consumption and reduced E10 consumption. Increased E85 consumption can only occur with a lower retail price of E85. Given E10 and E85 prices, we can calculate the value at wholesale for gasoline and ethanol. It is the difference between the value of ethanol at wholesale and the cost of producing the required quantity of ethanol that determines the RIN price. The compliance cost to oil refineries per gallon of gasoline is the product of the RIN price and the percentage standard.

We find two direct effects of a binding ethanol mandate. The first is an increase in the wholesale price of gasoline because positive RIN prices increase the cost of producing gasoline. The second is a decrease in the ethanol price paid by blenders net of the RIN value. The net price of ethanol will decrease to induce consumers to consume enough ethanol to meet the mandate. Because most US consumers buy E10, the lower price of ethanol in the blend offsets at least some portion of the increased gasoline price. In addition to these two direct effects on the price of E10, there exists an indirect effect that works to lower E10 prices. To meet mandates beyond E10 requires an increase in E85 consumption, which results in a decrease in E10 consumption because some owners of flex vehicles switch fuels. The effect of substituting E85 for E10 is a net decrease in gasoline demand, which results in some reduction in wholesale gasoline prices. Whether the net effect of these three market forces results in a net increase or decrease in E10 pump prices requires the development of an economic model to sort out.

We developed and calibrated such a model with the purpose of showing how feasible increases in ethanol blending mandates will affect the price of E10 under a range of possible conditions. We find that feasible increases in the ethanol mandate in 2014 will cause a small decline in the price of E10. That is, even though increased mandates increase gasoline prices, the offsetting effects from a decline in ethanol price and movement by motorists to E85 from E10 are enough to result in a net decrease in the price of E10.

Our results should reassure those in Congress and the Administration who are worried that following the RFS commitment to expanding the use of renewable fuels will result in sharply higher fuel prices for consumers. There may be sound policy reasons that could justify Congress revisiting the RFS. However, concern about higher pump prices for consumers is not one of them.

Impact of Increased Ethanol Mandates on Prices at the Pump

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The Environmental Protection Agency (EPA) proposed in November to reduce 2014 biofuel mandates. One concern expressed by EPA is that it will be difficult, if not impossible, to consume the 2014 target levels of ethanol in the Renewable Fuel Standard (RFS) because of infrastructure issues. In a recent paper, we addressed this issue by showing how the infrastructure issues could be resolved through investments by obligated parties incentivized by the lower compliance costs that such investments would facilitate.[1] A measure of compliance cost is the price of the tradable ethanol credit known as a RIN (Renewable Identification Number). The price of RINs represents the gap between the cost of producing another gallon of ethanol and the price of ethanol that is needed to induce consumers to buy another gallon. To induce consumption of more ethanol than is contained in a 10 percent blend (E10) requires a drop in the price of ethanol. This drop in ethanol price increases the price of RINs because it increases the gap between production costs and consumer value. An increase in the price of RINs increases the cost of complying with ethanol mandates. These costs are borne by owners of oil refineries. Increasing the number of stations that sell E85 and E15 decreases the ethanol price discounts needed to induce enough ethanol consumption to meet targets by making the fuel more accessible to consumers. Any reduction in required discounts directly leads to lower RIN prices and hence lower compliance costs. Thus, obligated parties faced with high RIN prices would have a strong incentive to invest in the infrastructure that would facilitate increases in ethanol consumption.

It is no surprise that owners of oil refineries would balk at being forced to facilitate mandated consumption of a fuel that they do not produce by making investments in gasoline stations that they do not own. Thus, their trade associations have mounted a strong lobbying effort to get Congress and the Administration to repeal or reduce ethanol mandates. The proposed EPA rule that would allow ethanol mandates to be met with E10 represents a significant policy change that reflects the success of the industry at exerting political pressure in Washington.

One argument that the oil industry uses in its campaign against RFS mandates is that high compliance costs would lead to significant increases in pump prices for consumers. For example, Tom O'Malley, chairman of PBF Energy, is quoted in a Reuters article as saying that the price of RINs is a hidden tax on consumers because his company will have to pass the rising costs of RINs on to consumers.[2] Mr. O'Malley is also quoted in a Platts article as saying, "This price increase will be passed along to consumers, raising the pump price..."[3] This argument would seem to have economic merit because it is usually the case that cost-increasing government regulations will eventually result in higher consumer prices. It is clear that high RIN prices are a cost borne by producers of gasoline (the owners of oil refineries). Furthermore, because each barrel of gasoline

[1] See Babcock, B.A., and S. Pouliot. (2014). "Feasibility and Cost of Increasing Ethanol Consumption Beyond E10." 14 PB-17 Center for Agricultural and Rural Development, Iowa State University.
[2] Article available at http://www.reuters.com/article/2013/05/02/pbf-earnings-rins-idUSL2N0DJ23820130502.
[3] Platts. April 20, 2013. "RINs are a disaster for US consumers: PBF Energy chairman." Article available at http://www.platts.com/latest-news/oil/newyork/rins-are-a-disaster-for-us-consumers-pbf-energy-21944290.

produced results in the need to buy more RINs for compliance, it is a variable cost that directly increases the cost of producing gasoline. This type of cost increase in any economic model will tend to lead to higher gasoline prices, hence higher consumer prices.

According to other press reports, the concern about high RIN prices was also expressed by White House officials who weighed in on the review of EPA's proposed rules. Amanda Peterka reported on January 6, 2014 that Office of Management and Budget reviewers wrote "If volumes are too low, no harm no foul. If volumes are too high, then the prices of RINs will be high and we will face a real problem."[4] Peterka's article did not detail exactly what problems high RIN prices were supposed to lead to, but lower profits for oil companies or higher pump prices for consumers seem likely.

The extent to which an increase in the cost of producing gasoline will lead to a change in pump prices depends on many factors. One cannot conclude that pump prices will increase simply because owners of refineries have to comply with a costly regulation. The fuel that most drivers use today contains 10 percent ethanol. Thus, at a minimum, one needs to account for the effects of compliance with ethanol mandates on the price of ethanol. After all, high RIN prices reflect low consumer ethanol prices which will tend to decrease pump prices, not increase them.

The purpose of this study is to estimate the impact of RIN prices on the pump price of fuel. Estimates are made for a wide range of price sensitivities of supply and demand, RIN prices, and ethanol mandates. Rather than attempt to sort out the effects of RIN prices on pump prices using historical data, we instead build a standard economic model that takes into account the cost of producing ethanol, the consumer demand for transportation fuel, and the cost of producing gasoline. We assume that ethanol producers, fuel blenders, and gasoline producers are perfectly competitive, which simply means that they do not attempt to manipulate prices in their favor. The next section describes this model in some detail.

Our objective in writing this paper is to provide a transparent economic analysis of the impact on consumer fuel prices from mandates that increase the consumption of ethanol. We hope that the findings of this paper will contribute to the ongoing RFS debate by allowing involved parties to focus on whether the policy objectives of expanding use of renewable fuels are being met with the RFS in a cost-effective manner. As we demonstrate here, one of the costs that does not need to be considered is an increase in the pump price of fuel, because we show that the most likely outcome from increasing ethanol mandates is a drop in pump prices, not an increase.

The Model

To simulate the impact of RIN prices on fuel costs requires a model of how fuel prices are determined. The first step is to determine which fuels will be modeled. The focus of this study is on ethanol. In its proposed rule the EPA would mandate that nearly every gallon of gasoline should contain 10 percent ethanol. Thus, one of the fuels we model is E10. Two fuels—E85 and E15—could be used for compliance if EPA were to mandate ethanol consumption beyond levels that can be consumed with E10. We assume that E85 would be used for compliance so that we can build on our earlier work on the consumer

[4] Peterka, A. Jan. 6, 2014. "White House urged EPA restraint on 2014 RFS targets." Available at http://www.eenews.net/stories/1059992426.

demand for E85.[5] The model accounts for fuel substitution because consumers that use E85 to fuel their cars do not use E10.

We simplify how RFS obligations are established by focusing solely on ethanol. We assume that EPA establishes a percentage standard for ethanol by dividing the desired quantity of ethanol by the total anticipated domestic sales of unblended gasoline. Therefore, if EPA has a target of 13.5 billion gallons of ethanol and anticipates that domestic sales of gasoline will be 121 billion gallons then the percentage standard will be 11.16 percent. Each producer of gasoline has an RVO (Renewable Volume Obligation) that is determined by multiplying the percentage standard by total domestic sales of gasoline. The RVO is met by acquiring RINs. If an obligated party's sales of gasoline increases, so too does the RVO. This means that an obligated party can reduce the number of RINs that it needs to comply with the RFS by decreasing the volume of gasoline sales. This direct link between the cost of RINs and gasoline sales implies that increases in the cost of RINs reduces the quantity of gasoline that refiners will provide to consumers at any given gasoline price. Figure 1 shows the impact of the obligation on a hypothetical gasoline supply curve. Each additional gallon of gasoline sold domestically increase refinery costs by the product of the RIN price and the percentage standard. With a percentage standard of 11.16 percent and a RIN price of $1.00, the gasoline supply curve shifts up by 11.16 cents per gallon. That is, the supply of gasoline shifts up an amount equal to the product of the percentage standard and the RIN price.

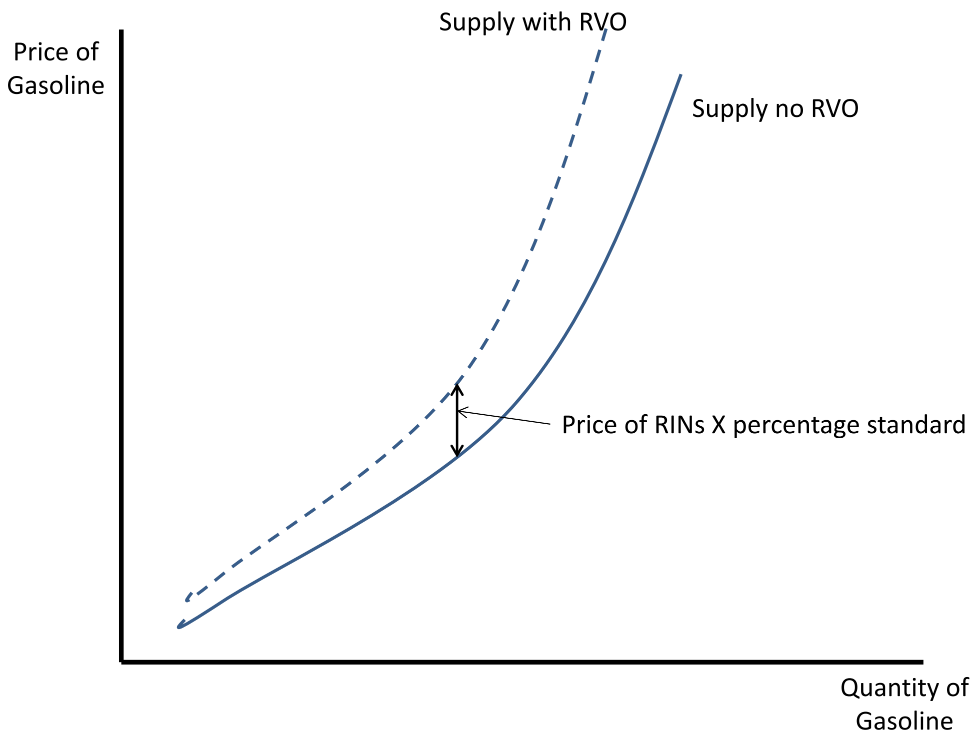

Figure 1. Impact of RFS obligation on supply curve of gasoline

[5] See Babcock, B.A., and S. Pouliot. (2013). "Price It and They Will Buy: How E85 Can Break the Blend Wall." 13-PB 11. Center for Agricultural and Rural Development, Iowa State University.

Figure 2 shows the impact of this shift on the wholesale price of gasoline by adding a downward sloping gasoline demand curve. The shift up in the supply curve of gasoline increases the market-clearing price of gasoline from P1 to P2 and decreases the quantity sold from Q1 to Q2. This result means that faced with the added cost from RINs, oil refineries will reduce the quantity of gasoline sold, which will also reduce the number of RINs that they need to turn into EPA. Note that the magnitude of the price increase is less than the cost increase. This means that some of the cost increase is borne by buyers of wholesale gasoline and some by gasoline producers. This is a standard result in economic analyses that try to estimate the impact of a tax on production. Producers bear more of the impact when their quantity supplied is less sensitive to a price increase than the quantity demanded by consumers.

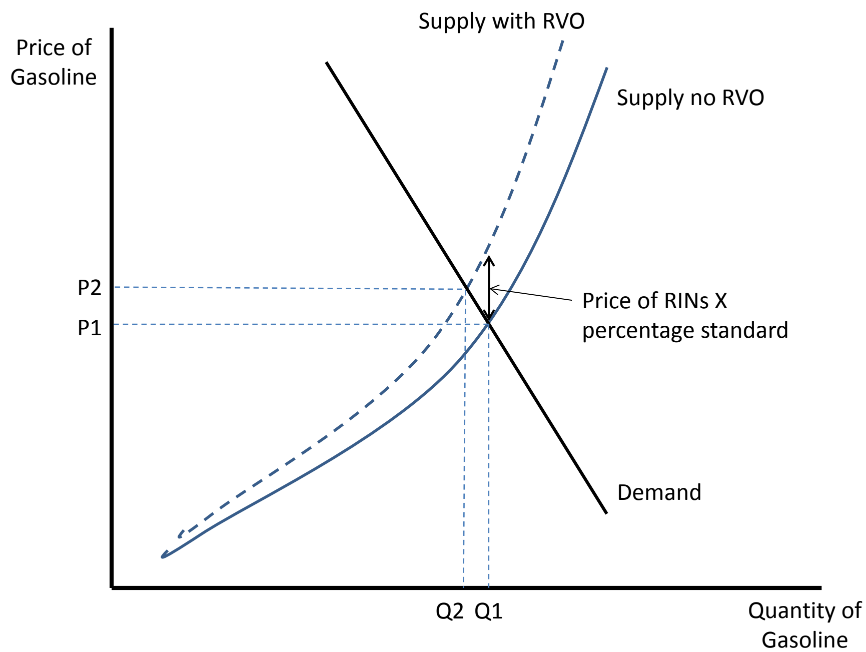

Figure 2. Impact of RFS obligation on wholesale price of gasoline

However, consumers do not consume pure gasoline—our model assumes that they consume either E10 or E85. Therefore, we need to account for the change in equilibrium ethanol prices as well as equilibrium gasoline prices. It is not really possible to show in simple supply and demand diagrams how the model finds market-clearing prices because of interdependencies between the demand for E10 and E85. Nor is it possible to derive an-easy-to-understand algebraic formula to characterize how E10 price changes as mandates and RIN prices increase. However, a description of the economic factors that determine how E10 prices are impacted will be useful.

Our model has separate demand curves for E10 and E85. The two demand curves are related because increases in E85 consumption come at the expense of E10. The model calculates the retail price of E85 that is needed to induce consumers to buy enough ethanol so that the number of RINs generated is adequate to meet oil refineries' RVO obligations. The obligations are met through increased E85 consumption and reduced E10 consumption. Increased E85 consumption can only occur with a lower retail price of E85. Given our assumption of a fixed markup between wholesale and retail prices, we can calculate what wholesale price of E85 corresponds to the required retail price. Given a wholesale gasoline price, we can then calculate the required wholesale ethanol price because we assume that E85 contains no more than 75 percent ethanol. The difference between the required wholesale price of ethanol and the cost of producing the required quantity of ethanol equals our model's RIN price. Because we treat ethanol as a commodity product, we only have one wholesale price of ethanol. This wholesale price of ethanol equals the plant price (including ethanol transportation costs) minus the RIN price.

The quantity of ethanol that is needed to meet the aggregate obligations of gasoline producers is split between E85 and E10. The obligation to meet blending mandates and the position of the E85 demand curve are the primary factors that determine how much E85 is consumed, how much E10 is consumed, and the wholesale price of ethanol. Starting from an equilibrium situation, an increase in the percentage standard will increase E85 consumption and reduce E10 consumption. Each gallon of reduced E10 consumption reduces gasoline consumption by 0.9 gallons. Each gallon of increased E85 consumption increases gasoline consumption by 0.25 gallons. Even after accounting for the reduced energy content of E85 there will be a net decrease in the domestic demand for gasoline from a move to E85. With reference to Figure 2, this reduction in gasoline demand would result in a leftward shift in the demand for gasoline and will result in a lower equilibrium gasoline price than P2. Our model's E10 price equals 90 percent of the gasoline price plus 10 percent of the ethanol price and a fixed margin to retailers. Thus, the likely net increase in the gasoline price will tend to increase E10 prices.

An increase in blending requirement necessarily reduces the wholesale ethanol price. This means that at least some portion of the increased E10 price from higher wholesale gasoline prices will be offset by lower ethanol prices. It is possible that the wholesale ethanol price will decline enough to actually reduce E10 prices. The purpose of our model is to show how feasible increases in blending mandates will affect the price of E10 under a range of possible conditions. Results from model simulations are presented next.

Simply put, we can summarize the impact of an increase in the ethanol mandate on the price of E10 by three forces: (*a*) a decrease in the price of E10 because of a decrease in the wholesale price of ethanol; (*b*) a decrease in the price of E10 because of substitution by motorists of from E10 to cheaper E85; and (*c*) an increase in the price of E10 because of an increase in the wholesale price of gasoline. At equilibrium, the relative magnitude of these three forces will determine the impact of the mandate on the price of E10. In the next section, we calibrate and solve our model to gauge whether an increase in the ethanol mandate has a positive or negative impact on the price of E10.

Model outcomes

Table 1 shows the calibration that anchors our model. The calibration of the model is based on the price of E10, the quantity of E10, and the wholesale price of gasoline obtained from the latest Energy Information Agency (EIA) Short-Term Energy Outlook for 2014.[6] The model accounts for ethanol plants selling ethanol to blenders who buy refinery-produced gasoline. Blenders blend gasoline and ethanol in fixed proportions to produce E10 and E85. We fix the proportion of ethanol in E85 at 75 percent.[7] The

[6] See EIA Short-Term Energy Outlook at http://www.eia.gov/forecasts/steo/.
[7] In its predictions, the US Energy Information Administration assumes that E85 contains 74 percent ethanol (see footnote 8 in http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2013&subject=0-

wholesale price of blended fuel equals the share-weighted wholesale prices of gasoline and ethanol. The retail price of blended fuel equals the wholesale cost plus a fixed markup of 75 cents per gallon.[8] The demand curve for E10 is calibrated to demand elasticities that range from -0.1 to -0.4, a retail price of $3.46 per gallon, and a quantity of 134.9 billion gallons. The supply curve of gasoline is calibrated to supply elasticities that range from 0.15 to 0.5, a wholesale price of $2.78 per gallon, and a quantity of 121 billion gallons. The demand curve for E85 is taken directly from our previous studies and is calibrated to result in 130 million gallons of consumption at an E85 price of $3.45 per gallon.

Our model is calibrated such that when all fuel sold contains at least 10 percent ethanol and a small amount of E85 is sold, then the ethanol mandate is not binding and the RIN price will be zero. We extrapolate from Minnesota data on consumption of E85 for 2013,[9] and make the mandate not binding at a consumption of about 130 million gallons of E85 for the entire United States in 2014. From our previous estimate of US demand for E85, we find a market-clearing price of $3.45 per gallon for E85. The model assumes constant elasticity functional forms for the demand for E10 and for the supply of gasoline. The elasticity of demand -0.25 for E10 gasoline is from Lin and Prince (2013) [10] and the elasticity of supply of 0.29 for gasoline is from Coyle, DeBacker, and Prisinzano (2012).[11] We calculate from our model of demand for E85 that the cross-price elasticity of demand for E10 by owners of FFVs with respect to the price of E85 is 0.31. The ultimate impact of a change in the price of E85 on the demand for E10 requires that this cross-price elasticity be multiplied by the ratio of FFVs to total vehicles. Given that there are about 16 million FFVs out of a US vehicle fleet of about 244 million, it results in a cross-price elasticity of demand for E10 with respect to the price of E85 of 0.02. The demand for E85 and its sensitivity with respect to the price of E10 is from our earlier work.[12] The supply curve for corn ethanol used in this study was taken from an earlier paper by Babcock.[13] At an ethanol price of $2.00 per gallon, the quantity produced is 13 billion gallons.

AEO2013&table=2-AEO2013&region=1-0&cases=ref2013-d102312a). We use 75 percent in our model to be consistent with our prior work. The impact of the one percent difference in the results is negligible.

[8] This markup was estimated from a simple linear regression of average US retail wholesale gasoline prices on average wholesale gasoline prices. The intercept from this regression was approximately 0.75 and the slope was approximately 1.0. The results of this regression suggest that the proportional taxes that are assessed on blended transportation fuel are dominated by the fixed taxes and markup formulas.

[9] See the Minnesota E85 + mid-blends station report at http://mn.gov/commerce/energy/images/E-85-Fuel-Use-Data.pdf

[10] Lin, C.-Y. and Lea Prince. (2013). "Gasoline Price Volatility and the Elasticity of Demand for Gasoline." *Energy Economics* 38: 111-117.

[11] Coyle, D., J. Debacker, and R. Prisinzano. (2012). "Estimating the supply and demand of gasoline using tax data." *Energy Economics* 34: 195-200.

[12] See Babcock, B.A., and S. Pouliot. (2013). "Price It and They Will Buy: How E85 Can Break the Blend Wall." 13-PB 11. Center for Agricultural and Rural Development, Iowa State University.

[13] See Babcock, B.A. (2013). "RFS Compliance Costs and Incentives to Invest in Ethanol Infrastructure." 13-PB 13 Center for Agricultural and Rural Development, September, 2013.

Table 1. Model Calibration

Price of E10	$3.46/gal	EIA
Price of E85	$3.45/gal	Author calculation
Quantity of E10	134.9B gal	EIA
Quantity of E85	130M gal	Author calculation
Wholesale Price of gasoline	$2.78/gal	EIA
Elasticity of demand for E10	-0.25	Lin and Prince (2013)
Cross-price elasticity of E10 for E85 price	0.02	Author calculation
Elasticity of supply of gasoline	0.29	Coyle, DeBacker and Prisinzano (2012)
Price of RIN	$0.00/gal	Author calculation

The model is derived assuming that all motor gasoline contains 10 percent ethanol. In practice, however, evidence shows that about four billion gallons of regular gasoline does not contain any ethanol. To account for this, we adjusted the volumes of ethanol by subtracting ten percent of 4 billion gallons. The mandated volumes that we consider are net of any banked RINs applied to 2014 mandated volumes.

Table 2 shows outcomes of the model for mandated ethanol volumes between 13 and 13.8 billion gallons. For volumes of 13 and 13.1 billion gallons the mandate does not bind and the price of RINs equal zero. At those volumes, the model yields results that are very close to the values used for the calibration. Prices for E10 and E85 equal the values selected for the calibration, but the quantity of E10 is slightly below the 134.9 billion gallons used for the calibration and the quantity of E85 is slightly above the volumes used for the calibration.

Table 2. Impact of Fuel Prices and Quantities from Different Mandate Levels

Mandate (billion gal)	Quantity of ethanol (billion gal)	Price of E10 ($/gal)	Price of E85 ($/gal)	Quantity of E10 (billion gal)	Quantity of E85 (billion gal)	Price of RIN ($/gal)
13.0	13.188	3.46	3.45	134.8	0.141	0.00
13.1	13.188	3.46	3.45	134.8	0.143	0.00
13.2	13.194	3.46	3.43	134.8	0.155	0.13
13.3	13.285	3.45	3.25	134.7	0.287	0.23
13.4	13.376	3.45	3.09	134.5	0.425	0.42
13.5	13.469	3.45	2.97	134.5	0.563	0.56
13.6	13.561	3.44	2.85	134.4	0.700	0.70
13.7	13.649	3.44	2.70	134.2	0.838	0.89
13.8	13.731	3.43	2.49	134.0	0.975	1.12

The ethanol mandate begins to bind at 13.2 billion gallons as reflected by RIN prices that increase with respect to mandated volumes. A large RIN price reflects a low consumer value for the ethanol that enters into the production of E10 and E85. Greater ethanol mandates are met by a decline in the price of E85 which causes increased consumption of E85. Greater volumes of E85 decrease the demand for E10 causing a small decline in the consumption of E10. This downward shift in the demand for E10 and lower wholesale prices for ethanol are sufficient to offset the increase in the price of gasoline caused by RIN prices as illustrated in Figure 2. Thus, the price of E10 declines from $3.46 per gallon at a mandate of 13.2 billion gallons to $3.43 per gallon at a mandate of 13.8 billion gallons.

Observe that ethanol consumption in equilibrium never quite equals the mandated volumes when the mandate is binding. This is expected because the RVO is specified as a percentage of gasoline sales. As increased consumption of ethanol in E85 displaces volumes of gasoline from consumption of gasoline in E10, the total volumes of gasoline are below the volumes for which the percentage standard is calculated from.

Table 3 shows model results for alternative values of the elasticity of demand for E10 and the elasticity of supply for gasoline. We do not show results for non-binding volumes of ethanol because the outcomes of the model are near its calibration and thus are essentially the same results as those in table 2. We report results when the mandate on ethanol is binding for 13.4 and 13.8 billion gallons of ethanol. Overall, the results are not sensitive to these ranges of elasticities. In particular, our finding that increases in ethanol mandates decrease the price of E10 holds over this range of elasticities.

Table 3. Sensitivity of Results to Alternative Values of Elasticities

Mandate (billion gal)	Quantity of ethanol (billion gal)	Price of E10 ($/gal)	Price of E85 ($/gal)	Quantity of E10 (billion gal)	Quantity of E85 (billion gal)	Price of RIN ($/gal)
Elasticity of E10 demand = -0.10; Elasticity of gasoline supply = 0.29						
13.4	13.371	3.45	3.09	134.5	0.424	0.41
13.8	13.714	3.42	2.48	133.8	0.973	1.13
Elasticity of E10 demand = -0.40; Elasticity of gasoline supply = 0.29						
13.4	13.380	3.45	3.10	134.6	0.426	0.32
13.8	13.741	3.44	2.49	134.1	0.975	1.13
Elasticity of E10 demand = -0.25; Elasticity of gasoline supply = 0.10						
13.4	13.387	3.44	3.09	134.7	0.425	0.42
13.8	13.761	3.41	2.46	134.3	0.977	1.15
Elasticity of E10 demand = -0.25; Elasticity of gasoline supply = 0.50						
13.4	13.372	3.45	3.10	134.5	0.425	0.34
13.8	13.717	3.44	2.50	133.9	0.974	1.12

Results in Tables 2 and 3 are derived assuming a price of corn consistent with current corn futures prices. These prices reflect what the market believes corn prices will be for 2014 given prevailing market conditions and under the expectation that corn yields will be near trend yields. However, if 2014 corn yields fall much below expected levels then the impact of ethanol mandates on E10 prices will be different from those presented above.

Recall that there are three main forces affecting E10 prices when considering changes in ethanol mandates. Changes in corn yields do not affect the value of ethanol to blenders and do not affect the ability of drivers to switch between E10 and E85, so these two factors remain constant. A decline in corn yields would increase corn prices, which would increase the cost of producing ethanol. This increase in production costs would increase RIN prices, which would then cause a larger shift in the gasoline supply curve. Gasoline producers would reduce gasoline production by a greater amount and the equilibrium price of gasoline would increase by a greater amount than we assume in our results. Under these conditions, it is possible that the cost to gasoline producers of complying with the ethanol mandates is large enough to result in enough of a contraction in gasoline supply to result in a net increase in the price of E10.

In contrast, if the 2014 corn crop is a bumper crop, then corn prices, ethanol production costs, and RIN prices would all be lower than assumed in our results. Lower RIN prices would result in a smaller cost increase to gasoline producers. Gasoline prices would therefore increase by a smaller amount than assumed in our results. The net effect would be a larger drop in E10 prices than estimated here.

Implications and Interpretation

Our assessment that the pump price of E10 would actually fall if EPA increases 2014 mandates under current market conditions seems to belie common sense. After all, how can a regulation that increases the cost of producing gasoline result in lower fuel prices? The reason for this counterintuitive result is that gasoline producers do not produce the fuel that consumers buy. Gasoline producers sell their product to blenders who also buy ethanol to produce E10 and E85, which is then purchased by consumers. An increase in the ethanol mandate can only be met through expanded consumption of E85. To induce owners of FFVs to use E85 requires a lower ethanol price. Because ethanol is a commodity, this lower price is also reflected in the cost of producing E10, which in our model with perfectly competitive markets, tends to reduce E10 prices. The same market forces that would cause gasoline prices to increase in response to increased costs of complying with biofuel mandates would decrease ethanol prices. Therefore, even though increased mandates increase gasoline prices, the offsetting effects from a decline in ethanol price and substitution by motorists to E85 are enough to result in a net decrease in the price of E10. Hence, under our maintained assumption that markets are perfectly competitive, the pump price of E10 will drop because of increase ethanol mandates.

A number of academic studies have pointed out that mandating ethanol use can decrease fuel prices.[14] Thus, our result that increasing mandates lowering E10 prices should not be too surprising. However, the academic literature is not typically referenced in the political arena where ethanol policy is debated. The oil industry continues to rely on their own commissioned study (NERA 2012)[15] that predicts gasoline producers will have no choice but to cut domestic sales of gasoline to reduce their obligations under the RFS. The NERA finding is consistent with our results in that the RVO increases the cost of producing gasoline. However, the NERA study does not account for the ability to generate enough RINs through expansion of the demand for E85 to meet expanded mandates. The study's conclusions—that expansion of ethanol mandates would cause severe damage to the economy—are simply not credible unless EPA were to ignore set mandates at such a high level that they literally could not be met regardless of the level of investment in new fueling infrastructure.

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[14] See, for example, Cui, J., H. Lapan, G. Moschini, and J. Cooper. (2010). "Welfare impacts of Alternative Biofuel and Energy Policies." *American Journal of Agricultural Economics* 93(5): 1235-1256

[15] NERA Economic Consulting. (2012). "Economic Impacts Resulting from Implementation of RFS2 Program."

The results of this paper should reassure those in Congress and the Administration who are worried that following the RFS commitment to expanding the use of renewable fuels will result in sharply higher fuel prices for consumers. Under normal corn yields, instead of increasing prices, expanding use of renewable fuels will result in a modest decrease in pump prices. Of course this decrease must be paid for by somebody. With the RFS in place, this price decrease is paid for by owners of oil refineries. This transfer from the oil industry to fuel consumers is the reason why the oil industry has lobbied hard to stop ethanol mandates from expanding further.[16]

There may be sound policy reasons that could justify Congress revisiting the RFS. However, concern about higher pump prices for consumers is not one of them. Other arguments often put forth by biofuel opponents concerning significant impacts of expanded biofuel production on consumer food prices and the lack of ability to consume quantities of ethanol beyond E10 similarly lack a solid economic foundation. The reason the oil industry and much of the livestock industry have joined forces against biofuels is one of simple industry economics: their industries would benefit from cheap corn and reduced competition from ethanol. Rather than taking sides with different industry groups in this policy debate, Congress and the Administration should focus on whether the benefits of increasing renewable fuels by reducing fossil fuels are worth the costs. If they are then support for renewable fuels should not be abandoned. If they are not, then the sooner that resources are allocated to other, higher value uses, the better.

[16] The size of the transfer can be approximated from the results in Table 2. With the 13.8 billion gallon mandate and a RIN price of $1.12, the total value of RINs equals $15.44 billion. The benefit of higher gasoline prices to oil refineries offsets $10.5 billion of this amount. The benefit to fuel consumers is $2.2 billion. The benefit to ethanol producers is $670 million.