Comment: U.S. Environmental Protection Agency's Proposed RFS Small Refinery Exemption Decision

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February 7, 2022

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Disclaimer

The Louisiana State University Center for Energy Studies (LSU-CES) was created by the Louisiana Legislature in 1982 with the stated mission of conducting, encouraging and facilitating research and analysis to address energy-related problems or issues affecting Louisiana's economy, environment and citizenry. The Center's goal is to provide a balanced, objective and timely treatment of issues with potentially important consequences for Louisiana.

LSU-CES was commissioned by Perkins Coie Law Firm LLP to provide an assessment of the plausibility of two specific questions raised in EPA (2021b) including: (1) *Are renewable fuel standards (RFS) compliance costs plausibly the same for all refineries?*, and (2) *Is it plausible that small refineries recover their compliance costs through the market price they receive when they sell their fuel to the market?*

It is important to note that there are many points made and specific data analyzed in EPA (2021b). Given the inherent quick timeline associated with the comment period, we focus on providing a broad assessment of these two major claims as opposed to analyzing particular details or ancillary points. Additional assessment and analysis of other particular details or ancillary points would of course be possible with additional time. The omission of a discussion on any specific claim made by EPA should not be interpreted as either agreeing or disagreeing. Similarly, the citation of a specific analysis or peer reviewed publication should not be interpreted as an endorsement.

Perkins Coie LLP, 20 small refineries with diverse geographic dispersion, and three anonymous academic reviewers were given the opportunity to review and provide feedback on this report. The analysis and opinions expressed, however, are those of the authors alone.

No recommendations will be made on how EPA should act. The purpose of this document is to provide an objective perspective on these two pertinent questions that might influence EPA's decision.

Executive Summary

The EPA is currently accepting comments on a proposed change to its statutory interpretation of the Clean Air Act (CAA) small refineries provisions. According to EPA, this change in interpretation would result in the denial of 65 pending petitions for small refineries to seek small refinery exemptions (SREs) from the Renewable Fuel Standard (RFS) program.

In this report, we will assess two claims made in EPA (2021b). These claims will be motivated by economic theory and then corroborated with a review of empirical research. Public data will be relied upon where appropriate. Importantly, we focus on whether these claims are plausible broadly. No assertions regarding whether the particular conditions and assumptions required for the claims to be valid hold for any one refinery in particular, or any specific refinery at all within the industry are made.

Claim 1: EPA's first claim is that the RFS compliance costs are the same for all obligated parties, and thus no party bears RFS compliance costs that are disproportionate relative to others' costs. We conclude that this claim is implausible. One economic rationale behind a tradable permit program, such as RFS, is to achieve the lowest possible compliance cost market-wide. Economic theory suggests that this least-cost outcome will occur at the point at which the *marginal*[1] compliance cost of each firm is equal to the tradable credit price (i.e. Renewable Identification Numbers, or RIN price in this context). However, equalizing marginal compliance costs across firms does not imply that the *average* compliance costs per unit of output is the same for all individual firms.

There are currently 124 refineries operating in the United States, each with idiosyncratic operating conditions and production functions. For example, refineries are located in different geographic regions across the country. Refineries in different regions serve different markets but may also have varying access to different feedstocks—both crude oil and bio-feedstocks. Even cold weather events can impact an individual refinery's ability to blend certain biofuels. Some refineries are connected to large refined-products

[1] This is, the incremental change associated with one additional unit.

pipeline systems with access to many buyers that are unavailable to other refiners. Further, the feasibility of sales into international markets, which are not subject to the RFS, varies across refineries.

In terms of production, refinery configurations are not uniform, allowing each to produce varying amounts of outputs like gasoline, diesel, or jet fuel. Gasoline and diesel are subject to RFS, while jet fuel is not. In addition, some refineries are part of integrated chemical value chains that can lead to greater operating efficiencies, and allows for greater substitutions in the share of outputs produced.

In contrast to these differences, RINs are traded nationally. Given the variation in refinery characteristics, the net effect of the RFS and changes in RIN prices on individual refineries is almost certainly different. In theory, some refineries may actually receive an overall net benefit from the RFS, while others are, on balance, negatively impacted. Again, we make no claims regarding the size of these differences for an individual firm or whether a specific refinery meets the statutory definition of disproportionate economic hardship (DEH).

Claim 2: EPA's second claim is that obligated parties, including small refineries, recover their compliance costs through the market price they receive when they sell their fuel products, and thus do not bear a hardship created by compliance with the RFS program. We conclude that this claim is partially supported, but not entirely. First, economic theory suggests that the incidence of this policy would be shared by both consumers and producers of gasoline and diesel. Because demand for fuels is relatively unresponsive to prices (i.e., inelastic), especially in the short-run, economic theory suggests that more of the RFS compliance burden will fall on consumers; however, the incidence of compliance costs is ultimately an empirical question.[2]

A number of empirical studies have tested for the pass-through of RFS costs to wholesale and retail prices (Knittel et al., 2017; Pouliot et al., 2017;

[2]In this context, we refer to "consumers" are the final users of the fuel. As will be discussed further, there are multiple firms along the value chain (i.e. biofuel producers, refineries, blenders, gasoline stations, etc), and in practice each can be impacted differently.

Burkhardt, 2019; Li and Stock, 2019; Lade and Bushnell, 2019). These studies have generally found that short-term changes in RIN prices have been passed onto consumers through fuel prices, especially to E10 prices. However, the amount of RIN pass-through has been found to vary across regions, with incomplete pass-through in the eastern U.S. (Burkhardt, 2019; Pouliot et al., 2017). Further, studies do not generally find complete RIN pass-through to retail prices for E85 (Knittel et al., 2017; Li and Stock, 2019; Lade and Bushnell, 2019).

Thus, we reached our conclusion that this claim is *partially true* considering several factors. There is evidence for pass-through of RIN prices to consumers. The EPA is correct that this price increase can offset compliance costs for refineries, *ceteris paribus*;[3] however, the implication that *because* RFS leads to increases in prices for consumers, and *thus* the program cannot impose hardship on an individual firm, is implausible in our opinion for at least three reasons. First, as discussed in response to Claim 1, not every refinery is impacted the same due to a multitude of reasons (technical, geographic, access to international markets, etc). Some refineries may therefore experience hardship while others can actually benefit from the RFS program in net. Second, while there is evidence of pass-through of RIN prices, especially to E10 in certain markets, there is not sufficient evidence to suggest that *all* RFS compliance costs are passed-through to prices. For example, research has not found complete pass-through for E85. Finally, even if there is 100% pass-through of all RIN prices to final product prices, consumers will respond to the increased price by decreasing the *quantity demanded* for fuels. This reduction in demand will negatively impact the refining sector. Both the effect of equilibrium price and quantity of fuels sold should be considered when assessing the effects of the policy.

[3] Latin for *everything else held constant.*

1 Introduction

The Renewable Fuel Standard (RFS) requires U.S. transportation fuels to contain a minimum volume of fuel that is considered renewable. The RFS was established by the Energy Policy Act of 2005 (P.L. 109-58; EPAct05) and was expanded in 2007 by the Energy Independence and Security Act (P.L. 110-140; EISA) (CRS, 2020). The program was designed to lessen the United States' reliance on imported oil and reduce greenhouse gas emissions from the sector (EPA, 2021c).

Biofuels are blended with gasoline and diesel to comply with the RFS. Each "obligated party"[4] applies the U.S. Environmental Protection Agency's—hereafter simply referred to as "EPA"—annual percentage standard to their own production or importation of gasoline and diesel fuel to calculate their individual renewable volume obligation (RVO or RFS obligation) for each type of renewable fuel.[5] The firm separates Renewable Identification Numbers (RINs) corresponding to the quantity of biofuel blended. Market participants are allowed to trade RINs, and obligated parties must acquire, either by blending themselves or purchasing RINs from the market, and then ultimately retire RINs for compliance (EPA, 2021d).

The EPA administers the RFS and is responsible for several tasks including evaluating which renewable fuels are eligible for the program, establishing the amount of renewable fuel that will be required, and monitoring compliance with the RFS through RINs, among others (CRS, 2020).

One of EPA's responsibilities in administering the RFS is to determine if any refineries qualify for the small refinery exemption (SRE) in consultation with the Secretary of Energy (EPA, 2021a). The CAA provides that small refineries may petition EPA for an exemption from the RFS obligation if the RFS creates a disproportionate economic hardship (DEH) for the small refinery. For perspective, there are currently 124 operating refineries in the U.S. today (EIA, 2021)[6] with a total operating capacity of 17.7 million

[4] Obligated parties include refineries and importers of gasoline and diesel fuel.

[5] See p. 8-9 of EPA (2021b) for an overview of the annual percentage standard and firm-specific obligation.

[6] Includes only operating refineries. Accurate as of January 1, 2021.

barrels per day (EIA, 2021).[7] In 2020, there were 28 small refineries with petitions for the SRE.[8]

In December of 2021, the EPA published its *Notice to Comment on Proposed Denial of Petitions for Small Refinery Exemptions.* Alongside this notice, EPA published a document titled *Proposed RFS Small Refinery Exemption Decision* (EPA, 2021b). With this notice, EPA stated that it is seeking comment on a proposal to establish a change to its statutory interpretation of the Clean Air Act (CAA) small refineries provisions. According to EPA, this change in interpretation would result in the denial of 65 pending petitions[9] for small refineries to seek SREs from the RFS program. More specifically, EPA is proposing that the small refineries with pending petitions have failed to demonstrate the DEH that the CAA requires for EPA to grant such exemptions.

The conclusions relied upon by EPA are (EPA, 2021b) *(underline added for emphasis)*:

> 1. Regardless of the mechanism by which small refineries and other obligated parties comply with their RFS obligations, the RFS compliance costs are the same for all obligated parties and thus no party bears RFS compliance costs that are disproportionate relative to others' costs.
> 2. Obligated parties, including small refineries, recover their compliance costs through the market price they receive when they sell their fuel products and thus do not bear a hardship created by compliance with the RFS program.
> 3. With no disproportionality and no economic hardship, there can be no disproportionate economic hardship pursuant to the statute.

[7] Includes only operating refineries. Accurate as of January 1, 2021.

[8] The names of the refineries that have applied for this exemption are not available to the public. Although, assuming that each of these refineries has a 75,000 bpd capacity (the threshold for a small refinery), these would make up at most 12% of U.S. refining capacity. The actual share is likely lower.

[9] Note that these petitions span the compliance years 2016 to 2021. A single refinery can have petitions in multiple years. See page 6 of EPA (2021b).

Hereafter, these will be referenced as Claim 1, Claim 2, and Claim 3.

In this report, we provide an opinion on the plausibility of Claim 1 and Claim 2. Specifically, two questions will be considered. First *are RFS compliance costs plausibly the same for all parties?* Second, *is it plausible that small refineries recover their compliance costs through the market price they receive when they sell their fuel products to the market?* We view Claim 3 as a legal question. We therefore leave Claim 3 to be evaluated by legal experts perhaps guided by the answers to the questions above. Further, we will not address whether specific refineries should qualify for this DEH exemption. Instead, this report will narrowly focus on these two questions that are central to EPA's proposed denial of SRE petitions. This opinion will be informed by economic theory and corroborated with a review of prior literature, analysis of publicly available data, and the authors' general knowledge of liquid fuel markets.

There are many points made and specific data analyzed in EPA (2021b). Given the inherent quick timeline associated with the comment period, we focus on providing a broad assessment of these major claims as opposed to analyzing particular details or ancillary points in EPA (2021b). Additional analysis of other particular details or ancillary points would of course be possible with more time. The omission of a discussion on any specific claim made by EPA should not be interpreted as either agreeing or disagreeing.

Finally, we make no claims regarding whether the particular conditions and assumptions required for Claim 1 and/or Claim 2 to be valid for any one refinery in particular, or any specific refinery at all within the industry. We instead highlight whether these claims are plausible broadly. The burden of providing evidence of DEH for a specific refinery is on the refinery itself.

2 Economic Theory

Neoclassical economic theory is based on two related problems, the maximization of profits by firms and the maximization of utility (wellbeing) by individuals. It is the simultaneous solution of these two problems that yields an economic equilibrium where prices and quantities are observed. Through-

out the discussion, notation will be largely borrowed from Varian (2009)[10], but the general economic theory can be found in any modern micro-economic theory text.[11] Discussion of economic principles will be generally based on Krugman and Wells (2014), but again similar concepts can be found in any undergraduate introductory economics text book.

The purpose of this section is not to teach these principles. Instead the purpose is to provide a refresher for readers with prior undergraduate economics training, reference relevant texts, and discuss how these core economic principles apply to the questions at hand.

2.1 Supply Curve

The goal of a firm is to *maximize profits* subject to market prices and technological constraints. A firm's profit (π_i) can be written as:

$$\pi_i = r_i - c_i \tag{1}$$

Individual firms are indexed by i. r_i is the firm's revenue, and c_i is the firm's costs. Intuitively, Equation (1) simply states that a firm's profits are equal to its revenues less its costs.

Equation (1) can be expanded with additional details as follows:

$$\pi_i = \underbrace{(p_i \times q_i)}_{r_i} - \underbrace{\Big[F_i + (w_i \times x_i)\Big]}_{c_i} \tag{2}$$

The firm's revenues (r_i) are equal to the price that the firm sells its output (p_i) times the quantity of output it produces (q_i). The firm's costs (c_i) can be divided into two components, fixed and variable costs. Fixed costs (F_i) are costs that do not vary with the amount of output produced and are incurred by the firm even when they choose to produce nothing

[10] Modifications to notation will be utilized where appropriate for clarity and consistency within this context.

[11] The modern neoclassical economic framework, which is the standard economics curriculum taught in universities, can be traced back to Samuelson (1947), written by the winner of the Nobel Memorial Prize in Economic Sciences in 1970.

(e.g., the cost of constructing a building). It is usually assumed that firms cannot change their fixed costs in the short run. The second component, collectively referred to as variable costs ($w_i \times x_i$), is equal to the price of inputs (w_i) times the amount of inputs purchased (x_i). Variable costs, as the name suggests, change with the amount of output produced. In this simplistic example, the firm sells only one output (q) and purchases only one input (x), but this theory is generally applied to include multiple input and outputs. In the context of refining, three logical outputs are gasoline, jet fuel, and diesel fuel. Each of these outputs is produced in different quantities and sold at different prices. Two logical inputs are hydrocarbon feedstocks and labor.

Next, economic theory introduces a *production function* that describes the process through which inputs (x) are transformed into outputs (q). Equation (3) can be written to include the firm's production function ($q_i(x_i)$) as follows:

$$\pi_i = (p_i \times \underbrace{q_i(x_i)}_{q_i}) - \Big[F_i + (w_i \times x_i)\Big] \tag{3}$$

where the level of output produced by the firm (q_i) is a function of the inputs used (x_i). For example, a refinery can produce some quantity of outputs (i.e. gallons of gasoline, diesel, and jet fuel) for a given amount of inputs (i.e. hydrocarbon feedstocks such as crude oil). This production function is influenced by physical and technological constraints, as well as a specific refinery's configuration. Note that each refinery's production function is unique, as refineries have different configurations and therefore are able to process different varieties of crude oil, have different ratios of outputs (i.e. different shares of gasoline, diesel, jet fuel, etc), use different amounts of energy to run, among other factors (EIA, 2015).

A firm will choose the amount of output it produces (q_i) such that profits are maximized. Economic theory suggests that, in a purely competitive market, the firm's solution to this maximization problem results in a willingness to supply an additional unit of output (q_i) to the market as long as the extra revenue (Δr_i) gained by one more unit of output is greater than

the extra cost (Δc_i) of producing that unit. More rigorously, a firm will produce an additional unit of output as long as $\Delta r_i \geq \Delta c_i$. Under pure competition, the firm's supply curve is then equivalent to its *marginal* cost curve.[12]

Shutdown Condition The discussion above assumes that it is profitable to produce *something*; however, it could be that the most profitable option for the firm is to produce zero. If the profits from producing zero output and paying only the firm's fixed costs exceed the profits of producing where price equals marginal cost (the solution outlined above), the firm will choose to produce nothing. In this instance, the firm will not be profitable.

Another scenario is that a firm will choose to produce some amount of output up until the point where marginal revenues equal marginal costs, but that the revenues received are not large enough to pay the firm's total costs. In this instance, a firm might choose to produce some level of output in the short run, but will not be profitable and will make the economic decision to exit the market in the long run.

In both cases, although firms might choose to operate at a negative profit in the short run, in the long run the firm will choose to exit the market. It is possible for a policy, such as a RFS, to impact a firm's choice to continue to operate or shut down.

2.2 Demand Curve

The goal of an individual is to *maximize utility*. Philosophers and economists use the term "utility" to describe an individual's overall wellbeing, or happiness. In the same way that firms face tradeoffs to maximize profits as discussed in Section 2.1, people make tradeoffs in order to maximize utility. Individuals decide how much time to spend working (thus earning income) and how much time to spend on leisure. Individuals observe market prices of goods and services and a wage rate based on their skill level. The utility maximization problem is used to derive the individual's *demand curve*.

[12] See Chapters 19-22 of Varian (2009) for more information on profit maximization and supply.

Economic theory suggests that an individual is willing to purchase an additional unit from the market if the marginal benefit they receive from that unit is greater than or equal to the cost of purchasing that unit. Thus, the individual's demand curve is equivalent to their marginal benefit curve. As the current problem being addressed is largely focused on producers, the demand curve is considered fixed throughout the discussion.[13]

2.3 Market Equilibrium

In a competitive market with many buyers and sellers, the *market supply* curve (S) can be written as the aggregation of each firm's individual supply curve ($\sum_i s_i$).[14] Similarly, the *market demand* curve (D) can be written as the aggregation of each consumer's demand curve ($\sum_i d_i$).

This economic theory is summarized in Figure 1. P represents the market price and Q represents the total quantity of the good that is supplied to, and purchased from, the market.

S represents the market supply curve, which is equivalent to the summation of the marginal cost curves of all firms (MC). Notice that the market supply curve shows a positive relationship between the market price and the amount firms are willing to supply. Intuitively, as the price increases, firms are willing to supply more of the good or service.

D represents the market demand curve, which is equivalent to the summation of the marginal benefit of each consumer in the market from consuming an additional unit of this good or service. Notice that the market demand curve shows a negative relationship between the market price and the amount consumers are willing to purchase.

The intersection of the market supply and market demand curves creates the market equilibrium. P^* is the market equilibrium price that is observed and Q^* is the equilibrium quantity that will be produced (and consumed) at this price. Deviations from this equilibrium generate a mismatch in the

[13] See Chapters 4-6 of Varian (2009) for more information on utility maximization and consumer demand.

[14] More specifically, the market supply curve is the horizontal summation of the individual supply curves.

market between the quantity supplied and demanded.

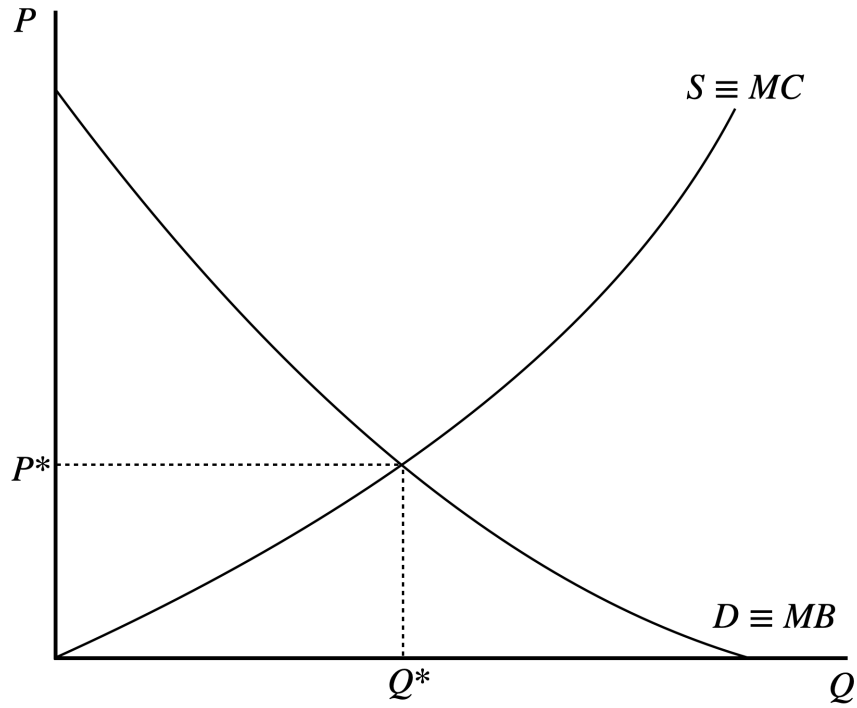

Figure 1: Market Equilibrium

Source: Authors' sketch

Unless stated otherwise, both individuals' demand curves and the market demand curve will implicitly be fixed. Any change in the equilibrium price or quantity of liquid fuels in the discussion will come from changes to the firms' cost curves and profit maximization problems in conjunction with movements along the demand curve.

2.4 Producer and Consumer Surplus

One way to measure the welfare of producers and consumers is through the concepts of *producer surplus (PS)* and *consumer surplus (CS)*.

Consumer Surplus (CS) CS is the difference between the price a consumer pays for a good or service and the consumer's willingness to pay for the good or service. Willingness to pay is defined as the maximum price at which the consumer would pay for a good or service. In other words, the consumer would choose to not purchase the good or service if the price is greater than the consumer's willingness to pay. The willingness to pay is represented by the consumer's demand curve.[15] The price the consumer faces is the market equilibrium price (P^*). Thus, an individual's consumer surplus is the difference between their willingness to pay and P^* while the aggregate market consumer surplus is the summation of all individuals' consumer surplus. The total consumer surplus is represented by the triangular area above the equilibrium price and below the market demand curve shown in Figure 2.

Producer Surplus (PS) Just as some buyers of a good would have been willing to pay more than the market price they face, some sellers of a good would have been willing to sell it for less than the price they actually receive. As a corollary to CS, PS is the difference between the price that a firm is willing to supply a good or service to market and the price it actually receives for the good or service. The price that the firm is willing and able to supply to the market is represented by the firm's supply curve. The price the firm receives for the good or service is the market equilibrium price (P^*). Thus, the aggregate market producer surplus is represented by the triangular area below the market equilibrium price down to the market supply curve shown in Figure 2.[16]

Total Surplus (TS) Total surplus is simply the sum of producer and consumer surplus. It can be written mathematically as:

$$TS = PS + CS \tag{4}$$

[15] See Module 11 of Krugman and Wells (2014) for more information regarding the consumer's demand curve and consumer surplus.

[16] Again, see Module 11 of Krugman and Wells (2014) for more information regarding the firm's supply curve, costs and producer surplus.

Although we do not include a detailed discussion here, it can be shown that once the market is in equilibrium, there is no way to increase total surplus. In other words, the equilibrium price and quantity that occurs where the supply and demand curves intersect maximize welfare (measured by total surplus), and any other outcome results in a reduction in total surplus.[17]

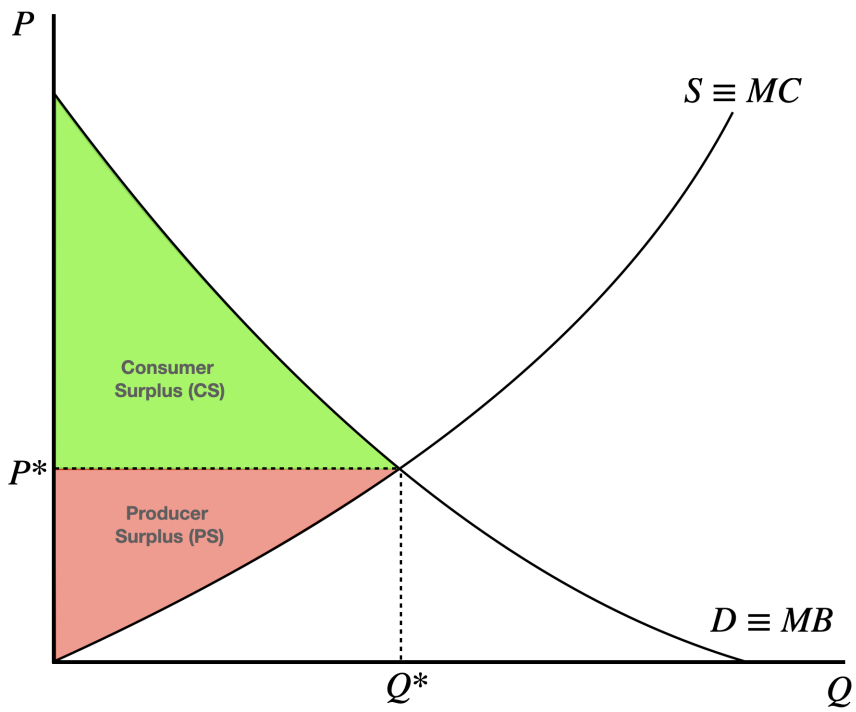

Figure 2: Consumer and Producer Surplus

Source: Authors' sketch

The simplified illustration of the theory presented in Figure 2 relies on several assumptions. Most notably, this basic model does not incorporate market failures, which may justify government intervention in the market and lead to situations where movements from the market equilibrium may improve the welfare of society. There are many examples, such as

[17]See Module 12 of Krugman and Wells (2014) for more information on total surplus.

the presence of externalities[18], concerns about fairness[19], presence of market power[20], among others that can be incorporated into this basic model. Indeed, the transportation sector is a large contributor of greenhouse gas emissions (i.e., a pollution externality). One of the stated goals of the RFS program is to reduce these emissions. Specifically, the transportation sector accounted for 29% of total GHG emissions in the U.S. in 2019, making the sector the largest contributor of such emissions.[21] The conceptual supply and demand framework presented above provides a useful framework to understand a policy's implications for consumers and producers, but we make no claim as to the overall net costs/benefits of the policy, as this is clearly outside of the scope of this specific EPA proposed decision.

2.5 Incorporating RFS into Economic Theory

We next consider how the prior-mentioned economic theory suggests the RFS will impact the market for liquid fuels. Firms can meet the requirements of the RFS in two ways. The first option is that the firm can choose to purchase renewable fuels and blend a sufficient amount into its fuel to meet the RFS obligation. If the firm blends more than its required amount, the firm can sell excess RIN credits to the market. The second option is that a firm can purchase RIN credits from firms that have excess RIN credits. In this instance, money will be shifted away from buyers of RINs to sellers. In effect, the RFS imposes a tax on each gallon of nonrenewable fuel and a subsidy on renewable fuels (Knittel et al., 2017). The contemporaneous price of RINs, and expectations about the future price of RINs, will influence a firm's decision to produce renewable fuels or purchase RINs from the market.

Recall from Section 2.1, that under pure competition, a firm's supply curve is equivalent to its marginal cost curve. Further recall from Section 2.3 that the market supply curve can be written as the summation of each firm's

[18] E.g. see Chapter 34 of Varian (2009).
[19] E.g. see Module 12 of Krugman and Wells (2014).
[20] E.g. see Chapters 24, 25, and 27 of Varian (2009).
[21] United States Environmental Protection Agency website. Greenhouse Gas Emissions. Sources of Greenhouse Gas emissions. Accessed Jan 12, 2022.

individual supply curves. Thus, because the RFS represents an increase in the marketwide marginal cost of supplying fuel to the market, it can be modeled as the vertical shift in the market supply curve from S to S' illustrated in Figure 3. Economic theory suggests that the vertical shift in the supply curve will be equal to the RIN price.[22]

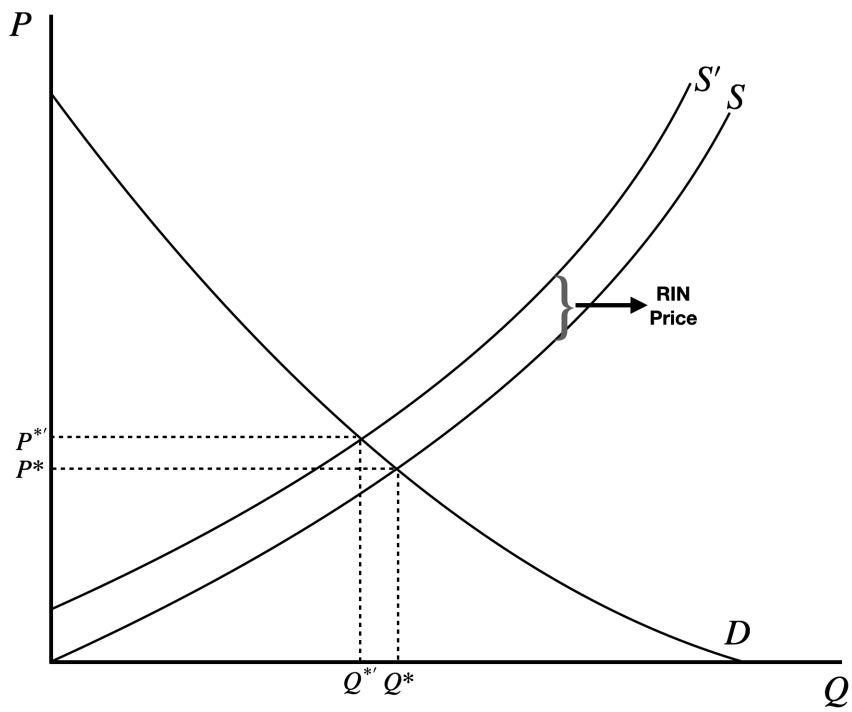

Figure 3: Market Equilibrium with Renewable Fuel Standard

Source: Authors sketch

Economic theory makes two predictions about the effect of the RFS on the market for liquid fuels. First, the price of fuels increases from P^* to $P^{*'}$. Consistent with EPA's claims, economic theory does predict that consumers will have to pay a higher price, and that producers will receive

[22]Tradable permits and taxes are both, in theory, capable of achieving the least-cost solution to increasing biofuel usage. See Chapter 5 of Hanley et al. (2007) for a discussion of practical tradeoffs.

a higher price for the liquid fuels sold. In addition, the quantity of fuel produced (and therefore consumed) will be reduced from Q^* to $Q^{*'}$. The aggregate net effect of the policy on total producer surplus will therefore be influenced by three factors:

1. Firms in aggregate will incur additional costs to comply with the policy. This will be either additional costs to purchase and then blend renewable feedstocks or the cost of purchasing RINs from the market to meet the standard. Although some firms might sell RINs for more than their increased costs, marketwide costs will increase in aggregate.[23] *Ceteris paribus*, this will reduce total industry surplus of firms.

2. Firms will receive a higher price for the liquid fuels sold. *Ceteris paribus*, this will increase total industry surplus of firms.

3. Firms in aggregate will sell less fuel. *Ceteris paribus*, this will reduce total industry surplus of firms. Reductions in fuels supplied will be borne by firms with high compliance costs.

Pass-through of taxes or input costs Pass-through of taxes or input costs into prices has been studied by economists in a number of contexts (Muehlegger and Sweeney, 2022). These concepts are so related, that economists have used cost pass-through to estimate the incidence of actual taxes (e.g., (Marion and Muehlegger, 2011; Fabra and Reguant, 2014)).

Input cost incidence is a measure of who incurs the burden of a change in input costs. Changes in input costs can come from changes in market conditions as well as government policies, such as taxes. Regardless of the source of the change in input costs, the *burden* of the cost increase cannot simply be determined by identifying the party that actually *incurs* the cost.[24] In practice, the burden of a cost increase is allocated between con-

[23] Note that if renewable fuels were less expensive to produce than fuel from crude oil, then all firms would produce renewable fuels regardless of the RFS, and RIN values would trade at zero.

[24] For example, see Module 15 of Krugman and Wells (2014) that states *"the burden of a tax cannot be determined by looking at who writes the check to the government."*

sumers and producers as a function of the price elasticity of supply and the price elasticity of demand as well as other factors that might be specific to the setting.

The consumer and producer surpluses with the RFS are illustrated in Figure 4. Comparison to Figure 2 yields two observations.[25]

1. Consumer surplus from consumption of the private good is reduced due to the RFS. Consumers will pay a higher price for liquid fuels. Further, there will be less liquid fuels sold to consumers due to the higher price.

2. The net effect on producer surplus is negative. Although in aggregate, producers will sell fuels at a higher price, there will be less fuel sold. Further, producers in aggregate will incur higher costs due to RFS compliance. The extent to which producers pass-through the cost of RFS compliance onto consumers is an empirical question.

3. A market subsidy for biofuels is introduced. Note that this biofuel subsidy can be shared across the value chain, from biofuel producers, transporters, blenders, and perhaps even gasoline stations.[26] To the extent that individual refineries are in the blending business, they may capture some of this subsidy. Therefore, the net effect of this policy on the refinery industry producer surplus as a whole is ambiguous.

In this setting specifically, the incidence of the policy will depend on the elasticity of (i) gasoline and diesel fuel supply, (ii) renewable fuel supply

[25]Though it is beyond the scope of this analysis, total surplus is also shown to be reduced. This reduction is referred to as "deadweight loss"; however, it is important to note that for simplicity, this illustrative example ignores market failures that the RFS may address. The authors therefore make no claim as to the actual welfare effects of the RFS.

[26]For example, Casey's General Store (Nasdaq ticker "CASY") stated in their Q1 2022 Earnings Call that "the company took advantage of a favorable renewable fuel credit environment and sold $18.7 million in RINS" and that "the fuel team has done a tremendous job balancing fuel volume and margin to optimize the profitability of this category." Note that we take no position on whether CASY's profits were actually positively impacted by the RFS in net.

and (iii) fuel demand (Yeh et al., 2016).[27] Economic theory suggests that the more inelastic, or less price sensitive, of the two groups (producers or consumers) will bear more of the policy's costs. Because consumer demand for fuel is inelastic, especially in the short run (Brons et al., 2008; Gillingham et al., 2015), the lion's share of the costs of the RFS are likely to be passed-through to consumers, although this is an empirical question that will be addressed in Section 3.2.

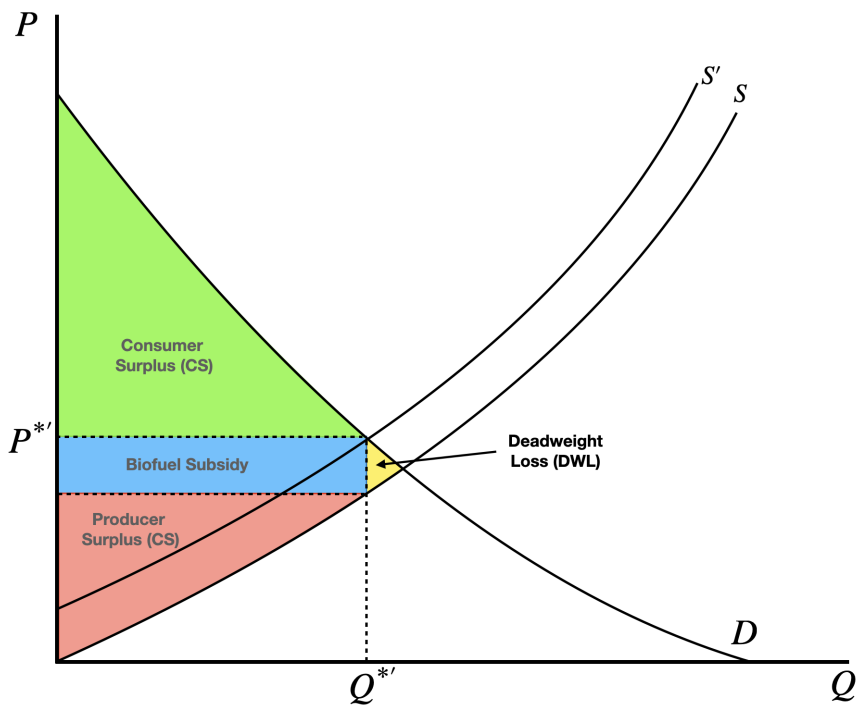

Figure 4: Consumer and Producer Surplus with Renewable Fuel Standard

Source: Authors' sketch

[27] In this specific example, the incidence can also depend on the specifics of the supply chain, i.e. ethanol production, transportation, blending, gasoline sales, etc.

2.6 Tradable Permits

The RFS is an example of a tradable permits program. Tradable permit programs for the purpose of regulating environmental externalities have been studied in the academic literature for decades (Hanley et al., 2007; Dales, 1968; Tietenberg, 2006; Stavins, 2003). Empirical analysis of specific tradable permit programs, both existing and proposed, are also ubiquitous across the literature (Young and Bistline, 2018; Bushnell et al., 2017; Upton and Snyder, 2017; Paltsev et al., 2008; Stavins, 1998). If functioning properly, tradable permit programs are designed to achieve policymakers' desired outcome—in this instance the desired level of biofuels integration into the market—in the least-cost manner. Given the context, we will consider the example of the RFS in discussing tradable permit programs more broadly.

It is important to note, though, that the economic logic for tradable permit programs, in lieu of simply requiring some level of biofuel blending for each individual firm, is based in the assumption that the costs for each firm to comply with a regulation differs across firms. Firms with relatively high marginal compliance costs will be buyers of permits, while firms with low marginal costs of compliance will be sellers of these permits (or "credits" in this context).[28] The tradable permit program, if implemented successfully, will allow these firms to trade credits, thus achieving the least-cost incorporation of biofuels into the market. In this way, economists would describe a well-functioning tradable permit program as "efficient."

Importantly, the total financial burden of a tradable permit program, such as the RFS, to an individual firm will be influenced by both the cost to the specific firm to comply with the program as well as the transfer payments made between firms when permits are bought and sold. Although all firms will have the option to purchase credits from the market at the same price, some firms will be able to produce that credit for less than the credit price. For other firms, the cost to produce credits internally might exceed the permit price, in which case the firm will choose to purchase credits from the market. The marginal compliance cost of the aggregation of all firms

[28] See Section 5.3 of Hanley et al. (2007).

alongside the number of permits required will determine the permit price.[29]

In this specific context, some firms will be able to acquire RINs by blending renewable fuel (that they purchased or produced themselves) for a lower cost than the market RIN price. A tradable permit program, such as the RFS, allows for these firms to over comply by blending more than their requirement and therefore acquiring and selling excess RINs. For other firms, the cost to blend renewable fuel will be higher than the RIN price, and thus these firms will choose to purchase RINs from the over complying firms in lieu of blending. Transfer of RFS obligations is formally accomplished through the market for RINs. The RIN price will be determined by the interaction of buyers (firms with high blending cost) and sellers (over complying firms with low blending costs) in the market.

Stated another way, the fundamental economic rationale for implementing a tradable permit program in lieu of a simple requirement for each individual firm is *because the costs of compliance differ across firms.* Thus, EPA's claim that compliance costs are the same for each firm regardless of whether they blend to produce credits for compliance or purchase credits from the market is not grounded in the economic theory of tradable permits. On a related note, the concept that tradable permit programs (such as RFS), or fluctuations in credit prices (such as RINs), place a proportional burden on all market participants is also not grounded in the economic theory of tradable permit programs.

2.6.1 Tradable Permits Program Example

For clarity, we next present an example of a tradable permit program to illustrate how firms are impacted differently by a tradable permit program, even if that program achieves the least-cost compliance and results in a "Pareto efficient" outcome.[30]

[29] See Figure 5.4 of Hanley et al. (2007) showing the marginal compliance curve is equal to the sum of all individual firms' marginal compliance curves. Note that we use the term "marginal compliance curve" which is the corollary to "marginal abatement curve (MAC)" in Hanley et al. (2007)

[30] Economists refer to a "Pareto efficient" outcome as one in which no individual (or firm in this example) can be made better off without making at least one individual worse

Figure 5 depicts three firms: Firm A, Firm B, and Firm C. Due to the context of the RFS, the vertical axis represents the *Marginal Blending Cost*, denoted MBC, where MBC_A is Firm A's marginal blending cost, MBC_B is Firm B's, etc. While three firms are shown in this example, this concept generally applies to a case with many firms. Also for simplicity, this example includes one type of biofuel and one type of RIN.

To clarify semantics, blending costs include the cost of obtaining, transporting and blending the biofuel into the final product (E10, E85, biodiesel, etc). In other words, blending costs can be described as the entirety of extra costs needed to produce the renewable fuel blend in lieu of producing fuel without the RFS.

In this example, there is a positive relationship between marginal blending cost and quantity blended, as is the classic example presented in economics curriculums, although, we will show below that the overall conclusion is similar in the case in which marginal blending costs is constant for each firm up until some physical capacity constraint is met.

Referencing Figure 5, the RIN cost (in dollars per gallon) is shared by all firms. In other words, each firm has the option to purchase RINs at the market price shown. The RIN price is represented as a dashed horizontal line. Each firm also has a renewable volume obligation (RVO) that is set by the EPA. The RVO is represented by a vertical dashed line. In this example, all three firms produce the same quantity of fuels subject to the RVO, and therefore have the same obligation. In practice, firms of different sizes will have different obligations, and firms will, with some limitations, be able to adjust the volume of fuels sold to impact their RVO obligation. In this simplistic example, the RVO is fixed.

Focusing first on Firm A: This firm is able to blend its RVO at lower cost than the RIN price. Instead of purchasing RINs from the market to meet the RVO, Firm A will instead blend the renewable fuel and satisfy the obligation itself. Once Firm A meets its RVO obligations, the marginal cost of blending additional units is still below the RIN price (i.e. $MBC < RIN$). Firm A will therefore make the profit maximizing choice to increase the amount

off. See Section 1.9 of Varian (2009).

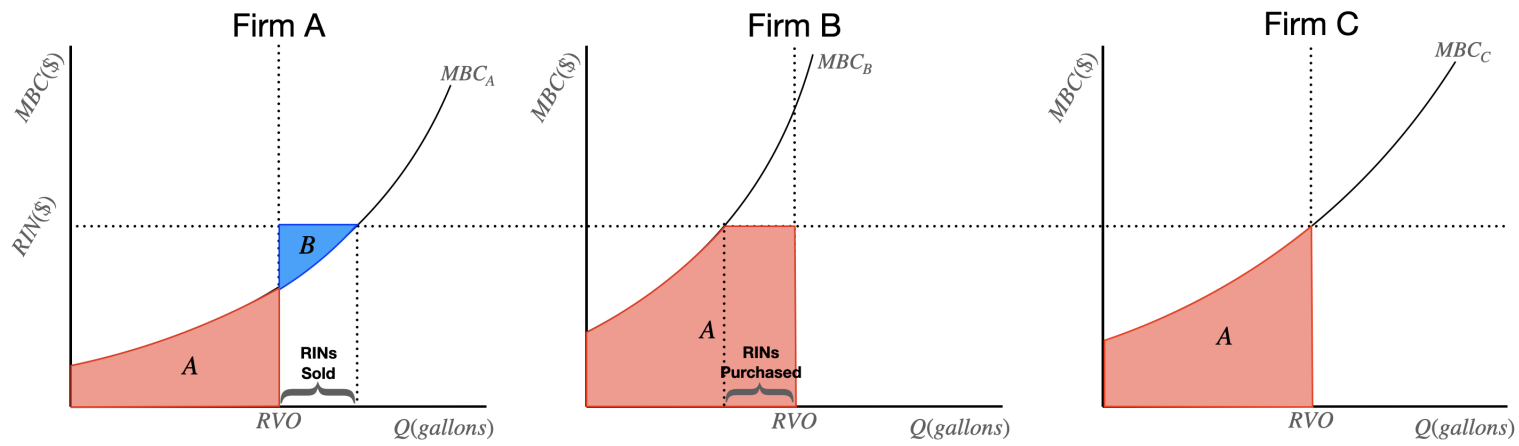

Figure 5: Marginal Blending Costs and Compliance

Source: Authors' sketch

of renewable fuel it blends up until the point where the marginal blending cost is exactly equal to the RIN price (i.e. $MBC = RIN$). At the point where blending one more gallon costs more than the revenues the firm would receive from selling the RIN, it will make the profit maximizing choice to not blend in the next gallon of renewable fuel.

In summary, Firm A will make the profit maximizing decision to satisfy its RVO by blending and then generate excess RINs, which it will sell to the market. Firm A's total compliance cost will be equal to the shaded area A less the revenues it receives in excess of blending costs for RINs sold to the market, shown in shaded area B.

Next, we focus on Firm B. Like Firm A, the marginal cost of purchasing RINs is higher than the blending cost up until some point. Unlike Firm A, Firm B will not blend its entire RVO. At the point where the marginal blending costs exceed the price of RINs, Firm B will make the profit-maximizing decision to purchase RINs from the market, in lieu of blending. Note that Firm B *could* choose to meet its RVO by blending, but the least-cost way to meet its obligation is a combination of blending and RIN purchasing. Both Firm A and Firm B are made better off by engaging in the trade of RINs.

In summary, Firm B makes the profit-maximizing decision to blend to achieve part of its RVO and also purchase RINs from the market to meet the residual RVO not met internally. Firm B's total compliance cost will be equal to the shaded area A. Comparison of Firm A and Firm B shows that the total compliance cost to Firm B is larger than the total compliance cost to Firm A.

Finally, focusing on Firm C, we see that, like Firm A, Firm C will also meet its RVO entirely by blending. Once the RVO has been reached, the marginal cost of blending additional gallons of biofuels will be higher than the RIN price. Firm C will therefore choose to meet its RVO exactly by generating RINs through blending and will not engage in the market for RINs. Their total compliance costs are again equal to the red shaded area A.

The main takeaway from Figure 5 is that although each firm has the option to purchase RINs from the market at the same price, each firm will

have different compliance costs. Thus, although the market for RINs might be considered "efficient" and allow for the least-cost compliance, individual firms are impacted differently by the policy.

RIN Price Change Next consider the effect of a change in RIN prices for these three firms by comparing Figure 5 and Appendix Figure A1.

In the event that the RIN price were to increase *ceteris paribus*, Firm A would be better off. This is because area A that represents the firm's compliance cost would remain unchanged, but area B that represents the producer surplus from the sale of RINs would get larger for two reasons. First, the difference between Firm A's marginal blending cost and the RIN price will increase for the RINs the firm is already selling to the market. Second, the firm will make the profit maximizing choice to now blend more biofuels up until the point where $MBC = RIN$. Firm A will now sell more RINs at a higher price. Thus, if RIN prices increase, *ceteris paribus*, Firm A will be better off.

Consider the effect of an increase in the price of RINs next for Firm B by again comparing Figure 5 and Appendix Figure A1. In this example, Firm B would be worse off for two reasons. First, Firm B will choose to blend more in lieu of purchasing RINs, but this blending will come at a higher cost than it's prior option to purchase RINs at the lower price. If the price of RINs were to increase sufficiently, Firm B might even decide to blend all of its RVO instead of purchasing RINs. Second, Firm B will still purchase some RINs from the market in this example, but at a higher price than before the RIN price increase. Thus, if RIN prices increase, *ceteris paribus*, Firm B will be worse off.

Finally, consider the effect of a RIN price increase for Firm C, *ceteris paribus*. Like Firm A, Firm C was already meeting its RVO internally through blending. When the price of RINs increases, Firm C will not incur any additional costs to meet its RVO, but Firm C will at that point make the profit-maximizing decision to blend more than its RVO and sell RINs up until the point where $MBC = RIN$. Firm C will increase its blending, generating excess RINs that it can then sell to the market for a profit. Thus,

if RIN prices increase, *ceteris paribus*, Firm C will be better off.

Note that in reality, RIN prices and firm specific marginal blending cost (MBC) curves will have some feedback (i.e. a change in marketwide MBC can cause a change in RIN prices); however, this simple example illustrates that changes in RIN prices can affect refineries differently.

Constant Marginal Blending Cost Curve Example The examples in Figure 5 and Appendix Figure A1 include specific assumptions about the marginal blending cost (MBC) for each refinery. Specifically, economists would describe the MBC curves as depicted in these figures as *monotonic* and *convex*. Perhaps a more simplistic representation is one in which the blending cost is the same for each unit, up until some threshold that represents a physical constraint such as the "blend wall" or some refinery specific constraints. An illustration is shown in Appendix Figure A2.

Notice that in Figure 5, each firm's marginal blending curve (MBC) is *upward sloping*;[31] each additional unit of blending was more expensive than the prior unit. In contrast, the blending cost *is the same* for each unit blended (until the threshold is met) in the example shown in Appendix Figure A2.

Focusing now on the example shown in Appedix Figure A2, Firm A will blend sufficient quantities to meet its RVO. At that point, Firm A will make the profit maximizing decision to exceed its RVO by blending additional volumes because the value of the RIN the firm sells to the market exceeds the marginal blending cost (i.e. $RIN > MBC$). It will do so until it reaches its constraint where it can no longer blend.[32] Firm A's compliance costs are again shaded area A less shaded area B.

Firm B in this example has marginal blending costs that are above the price of RINs ($MBC > RIN$). Firm B will therefore make the profit maximizing decision to purchase all RINs from the market. Note that Firm B *could* choose to blend and generate the RINs internally, but the tradable

[31] In math, has a positive slope.

[32] Another way to state this is that the marginal cost of blending increases rapidly once the blend wall or technological constraint is met.

permit program allows the firm to instead purchase RINs from the market at a lower cost. Although this trade would be described as efficient by economists, Firm B's compliance costs (shaded area A) are larger than the compliance costs of Firm A.

Firm C's blending cost is exactly equal to the RIN price. Firm C will be indifferent between blending to meet its RVO and purchasing RINs from the market. Regardless of which option Firm C chooses (blending or purchasing RINs), its compliance costs will be the same as Firm B, i.e. the shaded area A.

Notably, the option to purchase RINs from the market puts an implicit cap on the total compliance costs that is equal to the RVO times the RIN price. But again in this example, the RIN market does not ensure that compliance costs are the same for all obligated parties.

The main takeaway from comparison of Figures 5 and Appendix A2 is that, regardless of the assumptions made about the shape of the marginal blending cost curves, as long as different firms have different MBC curves, the compliance costs of individual firms will be different. This is true even though each firm has the option to purchase RINs from the market at the same price.

2.7 Conclusions Reached from Economic Theory

In Section 2, economic theory has been presented and applied to the market for liquid fuels to assess the effects of a RFS on consumers and producers. We conclude by assessing what economic theory predicts regarding EPA's two claims.

Claim 1 Recall that Claim 1 by the EPA was that the RFS compliance costs are the same for all obligated parties. As discussed in Section 2.1, each individual firm can experience differences in input prices, output prices, as well as cost curves. As discussed in Section 2.3, the market supply curve is the aggregation of each individual supply curve.[33] Thus, economic theory

[33] Again, the aggregation is the horizontal summation of the individual supply curves.

does not require that each firm's supply curve be identical. Nor does economic theory require that the effect of a tradable permits program, such as an RFS, or fluctuations in permit prices (such as RINs) will be the same for all parties. An illustrative example under different assumptions about individual firms' costs of blending is presented in Section 2.6 to illustrate this point.

As will be discussed in Section 3.1, in practice it is implausible that each refinery has the identical marginal blending costs in the context of the refining industry. While economic theory does not rule out the possibility that the supply curves and marginal blending cost curves of every firm are identical, this is not an intuitive or required assumption of standard economic models. In fact, one of the fundamental purposes of tradable permits, such as an RFS program, in lieu of a simple requirement for each individual firm, is based in the assumption that the costs of compliance differ across firms.

Claim 2 Recall that Claim 2 by the EPA was that obligated parties recover their compliance costs through the market price they receive, and thus do not bear a hardship created by compliance with the RFS program. Economic theory predicts that compliance with the RFS will lead to higher costs for consumers.[34] The effect of the RFS program on market-wide refinery profits, however, will be determined by three factors: (1) the compliance cost incurred by the refineries; (2) the increase in price received for liquid fuels; and (3) the reduction in total liquid fuels sold.

Again, while economic theory does not rule out the possibility that the compliance costs are fully passed onto consumers, this outcome depends on the relative elasticities of supply and demand in the market. Therefore, the extent to which refineries are able to pass-through the cost of compliance (either through production or purchasing of RINs) to customers is ultimately an empirical question that will be addressed in the subsequent sections of this report.

[34] In this context, we refer to "consumers" are the final users of the fuel.

3 Empirical Evidence of Theoretical Predictions

We next evaluate how the empirical evidence and existing literature support the plausibility of Claims 1 and 2 made by the EPA.

3.1 EPA Claim 1: RFS compliance costs are the same for all obligated parties

The executive summary of EPA (2021b) contains the following quote:

> *Regardless of the mechanism by which small refineries and other obligated parties comply with their RFS obligations, the RFS compliance costs are the same for all obligated parties and thus no party bears RFS compliance costs that are disproportionate relative to others' costs.*[35]

In this section, we will assess the plausibility of this claim utilizing the economic theory presented in Section 2 alongside results of empirical research.

Recall equation 3 above that is reproduced here:

$$\pi_i = (p_i \times \underbrace{q_i(x_i)}_{q_i}) - \Big[F_i + (w_i \times x_i)\Big] \tag{5}$$

where π_i is firm i's profits. p_i is the price firm i receives for its output, and q_i is the quantity of output sold. w_i is the price of the inputs the firm purchases and x_i is the quantity of inputs the firm purchases. Each of these factors can impact the firm's marginal blending costs described in Section 2.6.

We will next conduct a review of the empirical literature to document the extent to which these factors might differ across refineries. Further, the effect of the introduction of the RFS, or changes in the market prices of RINs, can impact each firm differently based on these factors. This can be shown by delving briefly into each factor.

[35] Underline added for emphasis.

Output Price (p_i) The price for which a refinery sells its outputs will vary for a multitude of reasons. Refineries are located in different geographic locations, thus selling into different markets. While it is theoretically possible for a refinery to transport its fuel to any market in the country (or world), this ability varies across refineries due to differences in access to refined product pipelines and other modes of transportation. Transportation costs limit the ability of refiners to economically compete in geographically distant markets. Further, some refineries have access to international markets via export, while others do not.

In addition to a varying ability to economically compete in geographically distant markets, the price of fuels varies greatly across regions. Some of the difference is in part determined by the transportation costs mentioned above, but other factors are also important. Environmental regulations like Reformulated Gasoline and Reid Vapor Pressure regulations lead to variation in prices at a very local level (Brown et al., 2008; Chakravorty et al., 2008; Nehiba, 2022).[36] Gasoline and diesel taxes also vary considerably across space, with the gas tax ranging from under \$0.10/gallon to over \$0.57/gallon.[37] These fuel taxes have been shown to have varying levels of pass-through to drivers in some circumstances, suggesting producers and consumers share their burden to some extent (Marion and Muehlegger, 2011; Kopczuk et al., 2016). Further, the rate of this pass-through has been shown to depend on local market structures and proximity to jurisdictional boundaries (i.e., distance to a region with a different fuel tax) (Hurtado, 2019; Stolper, 2021). Other regional transportation policies are likely to affect the market and thus fuel prices. In addition, it is possible for the demand for renewable fuels to vary across regions.

As will be discussed in more detail in Section 3.2, RIN price pass-through to wholesale and retail prices has also been shown to vary across products (i.e. E10 and E85 (Knittel et al., 2017; Li and Stock, 2019)) and across

[36] These regulations are often levied at the county level, but can sometimes be applied to even smaller geographies.

[37] U.S. Department of Transportation. Federal Highway Administration. Policy and Governmental Affairs. Office of Highway Policy Information. Monthly Motor Fuel Reported by States. Tax Rates on Motor Fuels. Cents Per Gallon.

geographic locations (i.e. different regions of the country (Burkhardt, 2019) and urban versus rural areas (Li and Stock, 2019)). Burkhardt (2019) also finds that RIN cost increases are associated with higher jet fuel production and lower jet fuel prices, thus impacting the relative price of outputs.

Thus, the effect of the RFS, and fluctuations in RIN prices, on the price of the final output likely impacts individual refineries differently.

Production function ($q_i(x_i)$) Each refinery has different processing units which make up its configuration. Processing units include: atmospheric distillation, coker, hydrocracker, thermal cracker, alkylation, reformer, vacuum distillation, and many other types of units (Olsen, 2014). While the goal of this report is not to outline the refining process, suffice it to say the types, quantity, and capabilities of units at refineries are varied. Each firm's production function is therefore different due to the availability of capital. In other words, the quantity and share of outputs q_i could be different for each refinery even if they were provided identical inputs x_i.

Refineries do have some ability to change the outputs they produce in the short run by shifting their operations. For example, the EIA noted that downstream units associated with gasoline production, like catalytic crackers, were operated at a lower intensity than other downstream units in response to the drop in demand for gasoline at the start of the COVID-19 pandemic.[38] Changes in other inputs (e.g., feedstocks discussed below) can also lead to changes in output shares. These capabilities of course have physical limitations, but they do highlight the potential for some refineries to "avoid" the RFS by changing outputs to those that are not covered by the standard. An individual firm's ability to do this will depend on that specific refinery's production function.

In the case where some firms produce multiple products that are differentially affected by a policy, it is possible for the policy to have distributional consequences due to firms' disproportionate ability to reoptimize outputs when RIN prices change (Lesser et al., 1997). As previously mentioned,

[38] U.S. Energy Information Administration. Today In Energy. August 28, 2020. *Changing demand for petroleum products has led to operational changes at U.S. refineries.*

Burkhardt (2019) finds that RIN cost increases are associated with higher jet fuel production, providing empirical evidence that firms substitute between outputs in response to the program.

Specifically, EPA claims that the "RFS program places a proportional burden on all obligated parties based on their gasoline and diesel fuel production volume." Although it is true that each party will have the same RIN requirement based on their gasoline and diesel fuel production volume, differences in the firms' production functions and the ability to substitute between RFS regulated outputs and non-RFS regulated outputs suggest that the burden of the RFS program, and fluctuations in RIN prices, will disproportionately affect parties based on, in part, their production function that is relatively fixed in the short run. Although firms have the ability to make some changes to their production functions in the long run, this requires firms incur costs in the short run with the (hopeful) payout being influenced by future market conditions and the price of RINs.

All of these factors considered, the effect of an RFS on an individual refinery is influenced by the specific production function of that refinery, and the production function of the larger chemical complex that some refineries are integrated into.

Input Quantities (x_i) The main input of refineries is of course crude oil, but there can be significant variation in crude oil that impacts the refining process and the outputs produced. Crude oil is traditionally categorized along two dimensions, density and sulfur content.[39] Density is measured using the API gravity index with higher values indicating lower density (lighter) oil. Lighter crude oil tends to be higher in value because refineries can produce high-value products (e.g., gasoline, diesel, or jet fuel) with simple distillation. Heavy crude requires additional and expensive refining to yield the same high-value outputs as lighter crude oil and is therefore more generally associated with creating feedstock for petrochemicals and plastics or for road surfacing.

[39] U.S. Energy Information Administration. Oil and petroleum products explained. Refining crude oil. Inputs and Outputs. Last updated: October 15, 2021.

High-sulfur crude oil, often called "sour" crude, has a sulfur content above 0.5% by weight. Sour crude requires more impurities to be removed from it throughout the refining process than low-sulfur or "sweet" crude. Thus, the type of crude oil a refinery uses as an input can determine what share of its output is high-value light products like gasoline or diesel fuel. Given the variation in refining requirements to create outputs from different types of crude, a refinery's configuration (i.e. its production function as discussed in the prior section) will play a role in its input decisions. Thus, inputs of a refinery are directly related to the refinery's production function. This is another channel through which the RFS requirement, and fluctuations in RIN prices, can impact individual refineries differently.

Input Prices (w_i) As discussed above, refineries can purchase a variety of different crude oils. Their decisions are determined both by the availability of crude oil variants and their particular configuration, which itself may be in part determined by the ease of accessing different crude inputs and current market conditions (EIA, 2015). Although refineries can adjust their configurations based on market conditions, these adjustments take time and can require the refinery to incur additional costs.

Although crude oil prices across locations generally move in tandem, there are significant spatial differences that vary across time (Plante and Strickler, 2021; Luong et al., 2019). For example, the West Texas Intermediate crude oil price is often viewed as the benchmark for domestic oil, but it is certainly not the only price oil is traded for in the U.S. One reason for spatial differences is that transportation costs can limit the ability of firms to engage in spatial arbitrage (Agerton and Upton, 2019; McRae, 2017), i.e. to move products from an area of low prices to an area of high prices to take advantage of the price difference.

In addition, crude oil is not the only input used in the production of fuels used by drivers. Other products, like lease condensates, naphthas, and biofuels, are often blended in to create a final product. Like any commodity, access to and prices for these inputs vary spatially and temporally.

For example, access to bio-feedstocks in the U.S. is concentrated in the

Midwest. Figure 6 depicts the refineries across the country and the ethanol capacity of each state. As can be seen, Nebraska, Iowa, Illinois, Minnesota, and South Dakota have the highest concentration of ethanol production. Not surprisingly, there is a very strong correlation between ethanol capacity[40] and corn stover production[41] across states.[42] This is intuitive, as logically one would build an ethanol fuel plant in geographic proximity of its feedstock, corn. Midwestern refineries likely therefore have greater access and lower transportation costs to acquire these bio-feedstocks. These refineries are likely impacted differently to changes in RIN prices relative to refineries that are not in close proximity to ethanol production.

Conclusion EPA's claim that the RFS compliance costs are the same for all obligated parties is implausible. There are many factors that impact an individual firm's output prices, production function, input quantities, and input prices. The effect of the RFS, and changes in RIN prices, on an individual refinery will depend on a combination of these factors.

3.2 EPA Claim 2: obligated parties recover their compliance costs through the market price

EPA (2021b) contains the following quote:

> *Obligated parties, including small refineries, recover their compliance costs through the market price they receive when they sell their fuel products and thus do not bear a hardship created by compliance with the RFS program.*[43]

As a corollary to Section 3.1, in this section, we will assess the plausibility of this claim utilizing economic theory presented in Section 2 alongside results of empirical research. From an empirical perspective, the measurement

[40] U.S. Energy Information Administration. Website. Petroleum & Other Liquids. U.S. Fuel Ethanol Plant Production Capacity (Mbpd). Contains data for U.S. fuel ethanol plants, as of January 1, 2021. Accessed Jan 12, 2022.

[41] National Renewable Energy Laboratory (NREL). Website. The Biofuels Atlas. Crop Residuals - Corn Stover. Accessed January 12, 2022.

[42] Specifically, the correlation coefficient is 0.94.

[43] Underline added for emphasis.

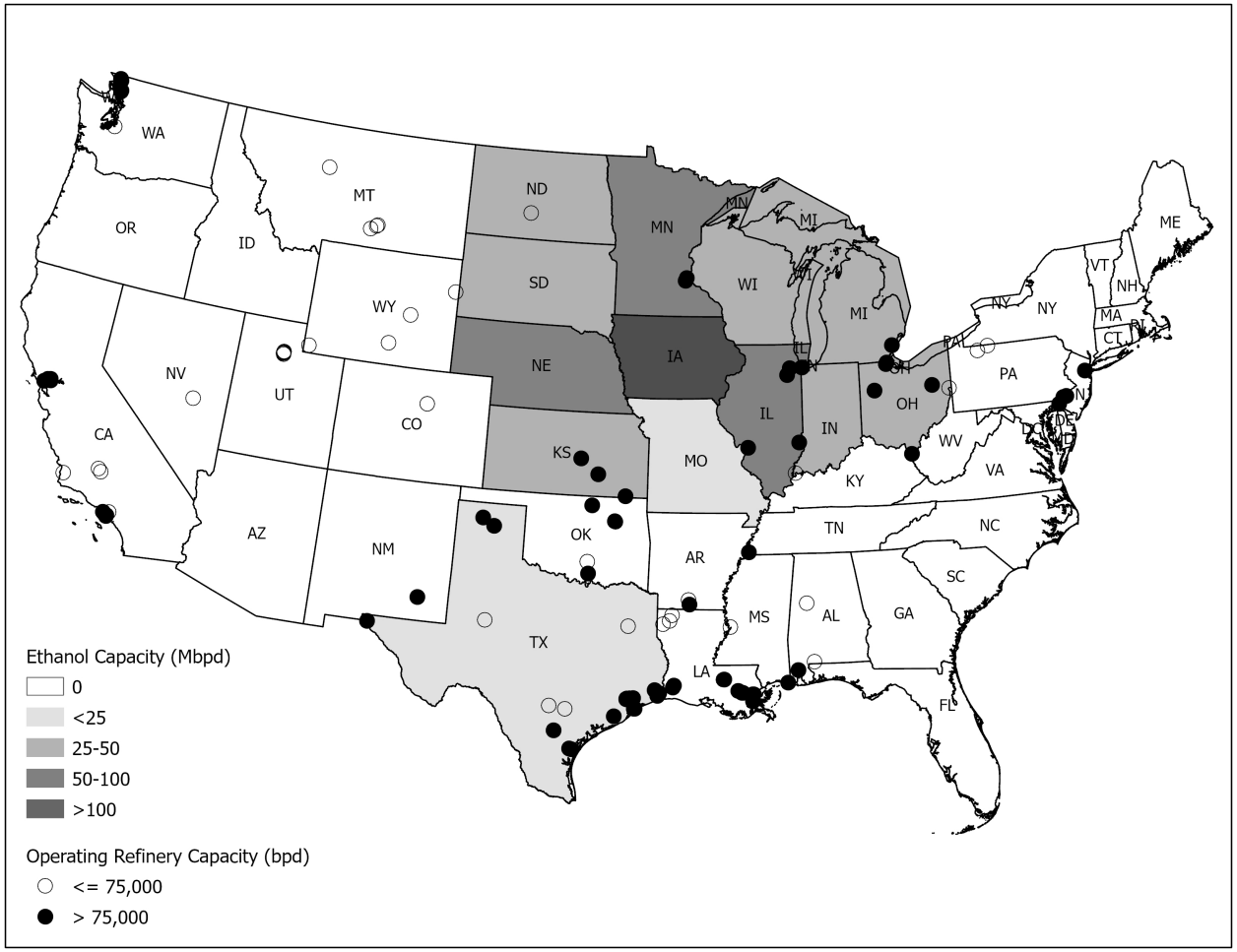

Figure 6: Ethanol Production Capacity and Refinery Locations

Source: U.S. Energy Information Administration. Ethanol production capacity from: Petroleum & Other Liquids. U.S. Fuel Ethanol Plant Production Capacity (Mbpd). Operating refining capacity from: Refining Capacity Report. Data from January 1, 2021. Note that SRE eligibility is based on a firm's actual production, not capacity thus some refineries might be eligible to apply for the exemption even though their capacity exceeds 75,000 bpd.

of pass-through of costs generally has proved to be challenging mainly because marginal costs and markups are typically non-observable in practical applications (Fabra and Reguant, 2014). These challenges are particularly salient in sectors that require large up-front investments (like refining) that necessitate high markups in equilibrium (Miller et al., 2017).

As discussed in Section 2, the incidence of compliance costs between producers and consumers in a competitive market theoretically is determined by the relative elasticities of the supply and demand. However, both the relative elasticities and the incidence of the policy between producers and consumers are empirical questions.

The price elasticity of demand for fuel is a widely studied topic in economics due to its policy relevance. Though obtained using varying empirical methodologies and data sets, estimates of this short-run demand elasticity have most often fallen in the range -0.1 to -0.4 (Levin et al., 2017; Coglianese et al., 2017; Graham and Glaister, 2002; Hughes et al., 2008; Li et al., 2014; Bento et al., 2009). Long-run demand elasticities of gasoline consumption tend to be larger in magnitude than their short-run counterparts, often falling between -0.6 and -0.8 (Graham and Glaister, 2002; Hausman and Newey, 1995). These larger long-run estimates suggest that consumers are more capable of adjusting their fuel consumption over longer time horizons. For example, these adjustments may take the form of purchasing a more fuel efficient vehicle or relocating to reduce commutes that may be difficult to accomplish immediately when fuel prices increase.

In contrast to the demand elasticity, the elasticity of supply has received less attention in the empirical literature. Researchers have often made assumptions about the magnitude of the supply elasticity—assumptions have included an elasticity of 2.0 and perfectly inelastic in the short run and perfectly elastic in the long run (Davis and Lutz, 2011; Austin and Dinan, 2005). However, Coyle et al. (2012) estimate a supply elasticity of gasoline of 0.29.

Assumptions and estimates of the supply elasticity appear to be larger in magnitude than the demand elasticities, suggesting more of the burden of the RFS program will fall on consumers. Given the general lack of estimates

of the supply elasticity of gasoline and that the existing estimates overlap with demand elasticity estimates, it is difficult to infer what share of the RFS compliance costs will fall on consumers and producers using this literature alone. However, several empirical papers have conveniently aimed to directly measure the extent that RIN prices are passed-through to consumers.

Utilizing daily price data from January of 2013 to March of 2015, Knittel et al. (2017) find that RIN prices pass-through to wholesale and retail fuel prices. Notably, while this study does find evidence of RIN price pass-through, the study states that "the fluctuations in the net RIN obligations are sufficiently small that for many spreads the pass-through coefficients and dynamics are imprecisely estimated." The paper also states that due to "the short span of the data . . . controlling for seasonal [fluctuations] also introduces imprecision." The authors also note that RIN prices do not appear to be passed-through to the national average E85 retail price.

Utilizing monthly confidential refinery-level data from 2012 to 2014, Burkhardt (2019) also finds that changes in the RIN prices were passed-through to nationwide wholesale gasoline and diesel prices on average. However, their results exhibit some spatial heterogeneity, with less pass-through occurring on the East Coast. This analysis finds the pass-through rates of the smallest and largest firms are not statistically significantly different from one another in the gasoline market. Interestingly, it appears that diesel production decreases with RIN prices while jet fuel production increases, suggesting refineries may attempt to avoid the costs associated with the RFS by shifting production to fuels not included in RFS. Further, they note that although aggregate crude oil price changes are fully passed-through, *refinery specific* crude oil costs are *not* fully passed-through.

Lade and Bushnell (2019) utilizes daily RIN and commodity price data from August 2012 through May of 2014, focusing on E85. The analysis estimates that half to three-quarters of the E85 subsidy is passed-through to consumers. However, this pass-through takes six to eight weeks, and station-level pass-through rates exhibit substantial heterogeneity, with the retailers' market structure influencing both the speed and level of pass-through.

Finally, Li and Stock (2019) analyze monthly data from 2007 to March

of 2015 on wholesale and retail prices for 274 Minnesota gas stations that sell both E10 and E85. They find evidence of RIN price pass-through to E10, but incomplete pass-through to E85. They argue the incomplete pass-through of E85 is a function of local market structure. In particular, the E85 market is sparse in many areas: "In the Twin Cities, which has a high density of E85 stations, pass-through is nearly complete, but outside the Twin Cities slightly less than half the wholesale discount of E85, relative to E10, is passed on to the consumer."

The literature appears to agree that RIN prices are largely or completely passed-through to national average E10 prices. Pass-through rates, however, appear to vary across space and are influenced by the local market structure. RIN price pass-through to diesel prices has received less attention than E10 and E85 prices, though the studies estimating this have found approximately full pass-through (Burkhardt, 2019; Knittel et al., 2017). Further, the literature does not find full pass-through to E85 prices. Indeed, the same disparities in pass-through to E10 prices that occur due to variation in local markets structure may be exacerbated for the much smaller E85 market.

In reviewing the literature, it is important to note that prior research largely has focused on ethanol based fuels, which are represented by D6 RINs. This is perhaps for good reason, as in 2019, D6 RIN retirements made up approximately 75 percent of the quantity of RINs.[44] D6 RINs also traded for the lowest value in 2019, averaging less than 20 cents per RIN throughout the year.[45] D6 RINs made up approximately half of the market value of all RINs, with D4 RINs (needed to meet biomass based diesel and advanced biofuels RVO) making up approximately 35 percent of market value.[46] Thus, empirical evidence finding complete pass-through of

[44]Source: United States EPA. Annual Compliance Data for Obligated Parties and Renewable Fuel Exporters under the Renewable Fuel Standard (RFS) Program. Table 3: Total RIN Retirements for Annual Completion. Data current as of November 10, 2020. Most recent compliance year available was 2019.

[45]Source: United States EPA. RIN Trades and Price Information. Simple average of Q-RINs for the 2019 transfer year.

[46]Market value obtained by multiplying total RIN retirements for annual compliance in 2019 times the Average RIN trading price in 2019. This calculation is meant to be descriptive. Not all RINs generated will be traded. Further, some traded RINs have

a specific RIN type to a specific market average product price should not be interpreted to mean that the cost of *all* RINs passes-through to final product prices for *all* obligated parties.

Conclusion EPA's claim that obligated parties recover compliance costs through the market price they receive when they sell their product is partially true.

The empirical literature corroborates EPA's claim that the RFS has lead to an increase in the price of fuel for consumers, thus increasing the price received by refineries. A review of the literature suggests that RIN prices are passed through to nation-wide average wholesale and retail prices, especially for E10. But the evidence does not suggest full pass-through of all RINs to all fuels in all locations. Thus, it is unlikely that market participants *in all situations* are able to recover their firm-specific compliance costs through the market price they receive when they sell fuel.

Further, EPA's statement notably omits that refineries will sell less liquid fuels because the market price is higher. The literature suggests a 1%–4% drop in short-run demand for a 10% increase in fuel prices and even larger decreases over longer horizons. The net effect of the RFS on aggregate refining producer surplus will be determined by a balance of (1) compliance costs, (2) higher market prices, and (3) reduced market demand due to higher market price. Thus, some of the incidence of the RFS very likely falls on refineries.

prices that are unverified by EPA, and therefore not included. Also, RIN prices change over time and this number represents the average weekly price as listed by EPA over the 2019 calendar year.

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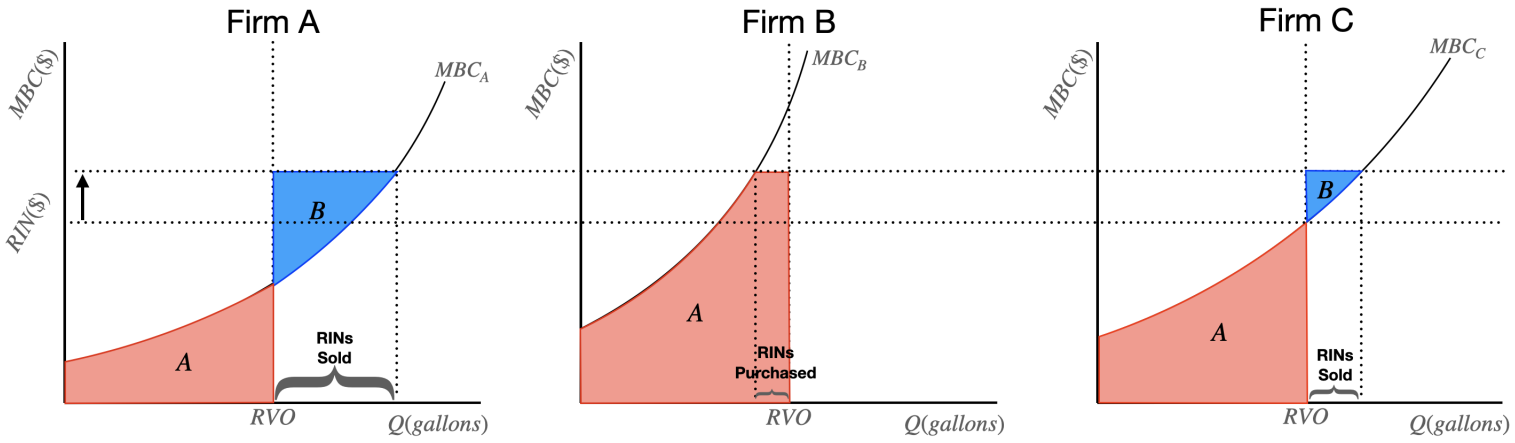

Figure A1: RIN Price Increase Illustrative Example

Source: Authors' sketch

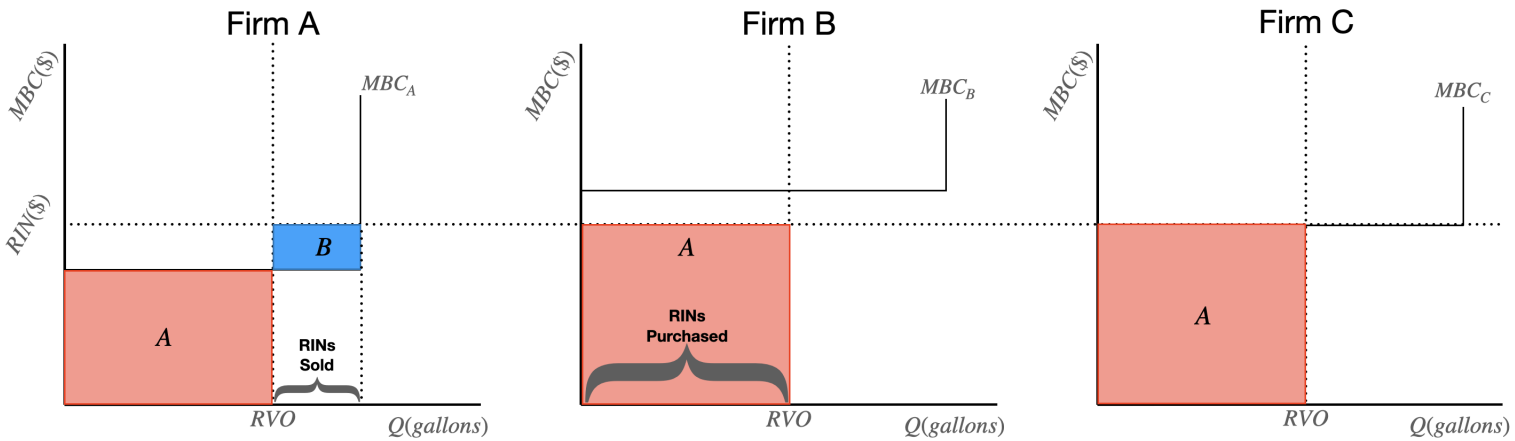

Figure A2: Marginal Blending Costs and Compliance - Constant Marginal Cost

Source: Authors' sketch