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Overview of the RIN Compliance System and Pricing of RINs for the U.S. Renewable Fuel Standard

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The U.S. Renewable Fuel Standard (RFS) is key to understanding the policy incentives driving the renewable diesel boom. In a *farmdoc daily* article last week (May 17, 2023), we provided an overview of the RFS, which specifies volumetric mandates for biofuels to be blended into U.S. surface transportation vehicle fuels. To ensure compliance with the annual RFS mandates, the Renewable Identification Number (RIN) system was created. A RIN represents biofuel that has been produced and blended into transportation fuel. RINs are tradeable, and the market price of RINs plays a central role in the functioning of the RFS. In this article, we provide an overview of the RIN compliance system and the pricing of RINs. Both are important in understanding the policy incentives driving the renewable diesel boom. This is the 11th in a series of *farmdoc daily* articles on the renewable diesel boom (see the complete list of articles here).

Renewable Identification Numbers (RINs)

The U.S. Environmental Protection Agency (EPA) is responsible for proposing and enforcing annual renewable volume obligations (RVOs) under the RFS. Specifically, the EPA converts the statutory mandate volumes, where provided, into percentage standards through annual rulemakings. The resulting annual percentage standards specify that for every gallon of petroleum fuel sold into the surface transportation sector in the U.S., a specified fraction of a gallon of biofuel must be blended into the surface transportation fuel supply.

The RFS statutes require annual volume mandates to be established for four categories of biofuels: cellulosic, biomass-based diesel, total advanced (which includes cellulosic and biomass-based diesel), and renewable (referred to as conventional here). The total advanced mandate is a higher volume than the sum of the cellulosic and biomass-based diesel mandates. This difference is referred to as the undifferentiated advanced mandate, which can be satisfied by a combination of qualified advanced biofuels. Conventional biofuels are generally assumed to be corn-based ethanol, but this is not explicitly required by the RFS legislation.

To ensure that annual RVOs are fulfilled, the EPA established a system of compliance based on Renewable Identification Numbers (RINs), which are electronic certificates associated with a specific batch of biofuels. A RIN originates when a qualified biofuel is produced, and it can be bought or sold once that fuel is blended into the surface transportation fuel supply. Refiners and importers of petroleum fuels are the obligated parties under the RFS, and they can obtain RINs through their own blending operations or the purchase of RINs in the secondary market. Once obtained via blending or purchase, RINs can be turned in to the EPA ("retire" the RIN) to demonstrate compliance. For a detailed explanation, see Irwin and Stock (2018).

Each of the four categories of biofuels under the RFS has its own RIN: D3 (cellulosic), D4 (advanced biomass-based diesel), D5 (advanced non-biomass-based diesel), and D6 (conventional). These fuels are nested based on lifecycle greenhouse gas reductions (*farmdoc daily*, May 17, 2023), so that excess D3 and D4 RINs can be used to satisfy the D5 and D6 requirements, and excess D3, D4, and D5 RINs can be used to satisfy the D6 requirement. RINs are generated upon production or import of a qualifying biofuel and are separated (detached) from that fuel when blended or sold into the fuel supply. Detached RINs are tradable, so an obligated party can acquire RINs for compliance either by purchasing the renewable fuel with the RIN attached or by purchasing RINs in the secondary RIN market.

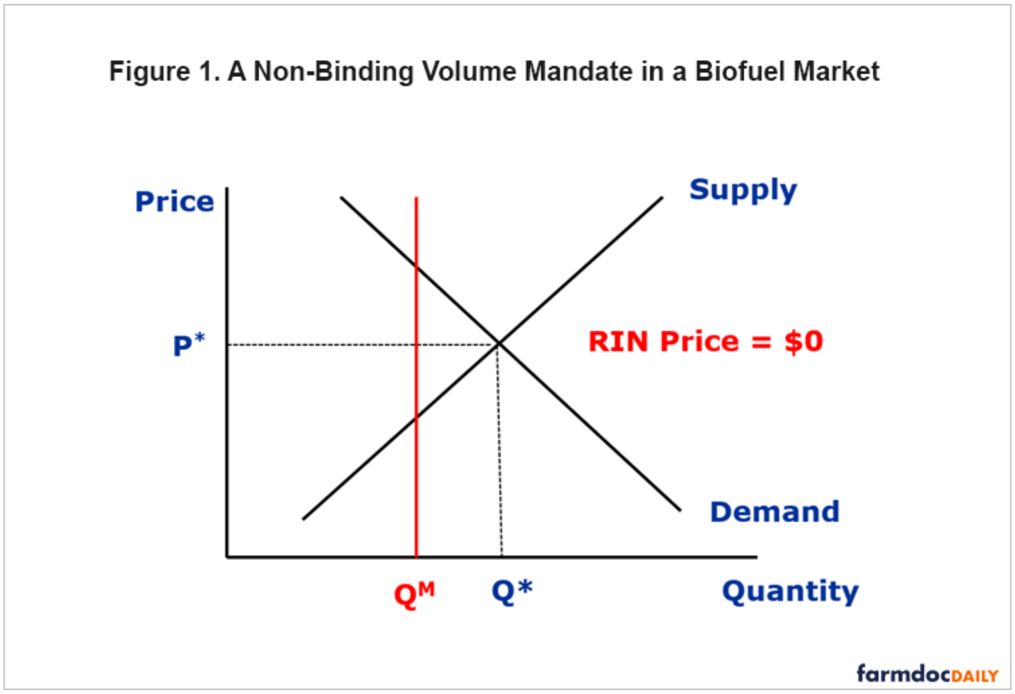
An important feature of the RIN system is that the number of RINs generated per physical gallon of biofuel is based on the energy equivalence value with ethanol. Specifically, blending one gallon of ethanol generates one RIN, blending one gallon of FAME (fatty acid methyl ester) biodiesel generates 1.5 RINs, and blending one gallon of renewable diesel generates 1.6 or 1.7 RINs. Accordingly, it is necessary to distinguish between "wet" (actual physical) gallons of a biofuel and RIN-equivalent gallons. For example, one wet gallon of biodiesel generates 1.5 RIN gallons.

An additional important feature is that RINs are bankable. That is, RINs generated in a given year can be used for compliance with obligation for that calendar year or the following year. For example, RINs generated in 2023 can be used to meet compliance obligations in 2023 or 2024. Being able to bank RINs provides a buffer to fluctuations in fuel supply and demand (although banked RINs cannot exceed 20 percent of a given year's RVO for an obligated party).

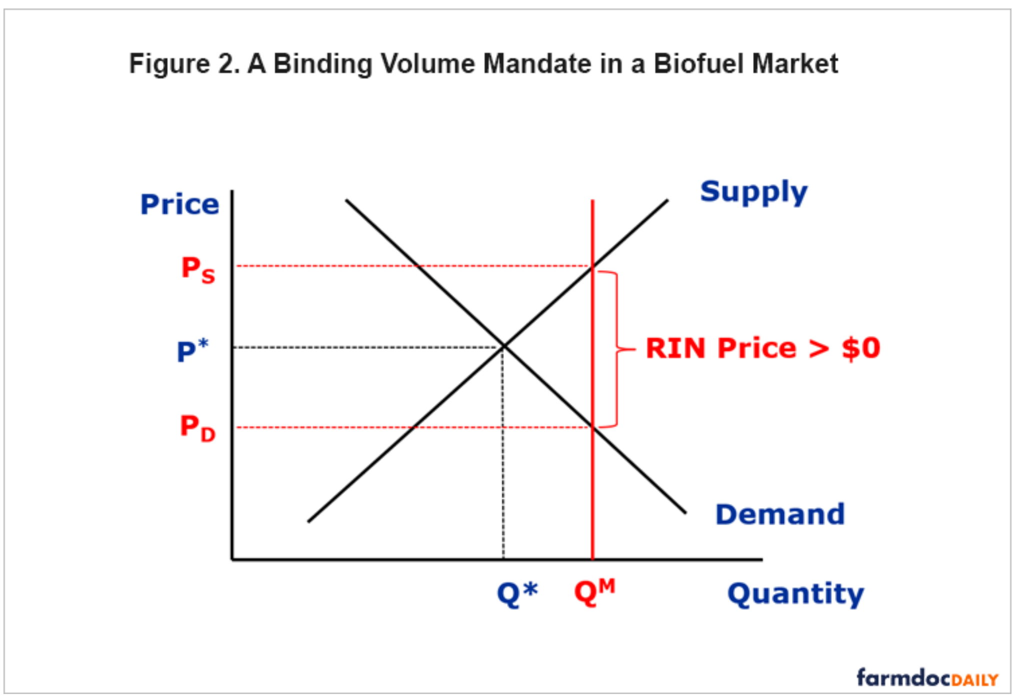
Lastly, because of uncertainty surrounding cellulosic ethanol production, the RFS statutes allow the EPA to make cellulosic waiver credits available to obligated parties to fulfill their cellulosic obligations. The cost of cellulosic waiver credits is capped, and the credit can be combined with a D5 advanced RIN to satisfy the cellulosic RVO.

RIN Pricing

The price of RINs is central to the functioning of the RFS. Specifically, the price of RINs serves to equate supply and demand so that the fraction of renewable fuel actually blended and consumed equals the fraction specified in the EPA's annual RVO. This equilibrating role is demonstrated in Figures 1 and 2. Figure 1 presents standard supply and demand curves for a hypothetical biofuel market. In this case, the mandated quantity, Q^M, is below the market equilibrium quantity, Q^*. Since the competitive equilibrium results in more of the biofuel being consumed than the mandate requires, the mandate is "non-binding" in economic terms. Further, since no additional incentive is needed to fulfill the mandate, the RIN price is theoretically zero.



The non-binding mandate illustrated in Figure 1 is contrasted in Figure 2 with a binding mandate. Here, the mandated quantity, Q^M, is above the market equilibrium quantity, Q*. To incentivize production at Q^M, producers must be offered a higher price, P_S. At the same time, consumers must be offered a lower price, P_D, to consume the higher mandate quantity. The result is a wedge between the supply price and demand price, which equals the market value, or price, of the RIN. The price of the RIN represents the incentive needed to enforce production and consumption at the mandated quantity.

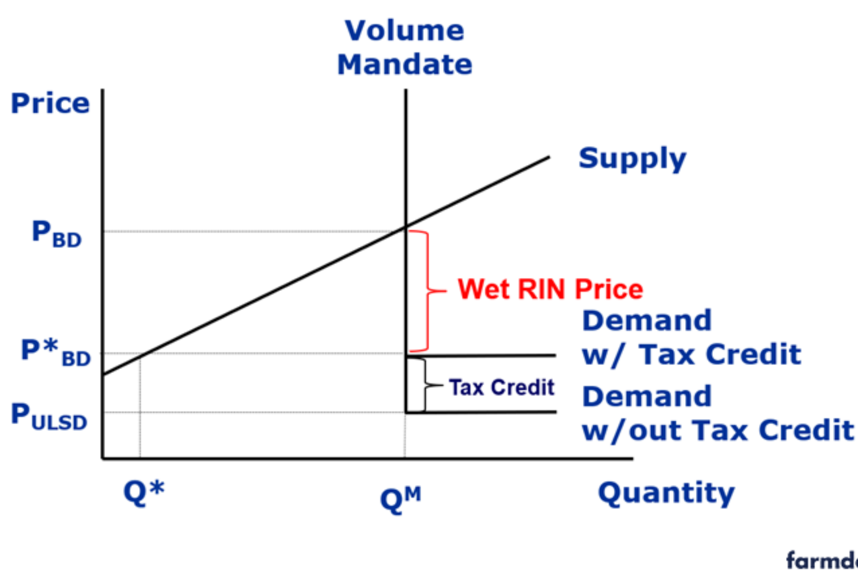


There is still the question of who ultimately pays for the added costs necessary to incentivize production and consumption at the higher-than-equilibrium mandated quantity in Figure 2. This is determined by the "pass-through" of RIN costs through the surface transportation fuel supply chain and the cost of the biofuel relative to the petroleum fuel that it replaces. Detailed discussions of this issue can be found in Knittel, Meiselman, and Stock (2017), Irwin and Stock (2018), and Lade and Bushnell (2019).

We now move from a conceptual demonstration of RIN pricing to analysis of actual RIN pricing, with a focus on D4 "biodiesel" RINs. As noted above, D4 RINs are technically "biomass-based diesel" RINs that potentially represent a variety of biofuels, including FAME biodiesel, renewable diesel, and renewable heating oil. A common industry shorthand is to refer to D4 RINs as biodiesel RINs, and we will follow that terminology here. Our analysis of D4 RIN prices is keyed off FAME biodiesel prices for three reasons. First, FAME biodiesel has been the marginal ("last") gallon for filling the biomass-based diesel mandate for nearly the entire history of the RFS. Second, FAME biodiesel has also been the marginal gallon for filling the undifferentiated advanced and conventional mandates for most of the history of the RFS, which means biodiesel plays a key role in setting the level of not only D4 RIN prices but also D5 and D6 prices. Third, market prices are readily available for FAME biodiesel.

The model we use to analyze D4 biodiesel RIN prices is the same partial equilibrium economic model used in several earlier articles on the RFS and RIN pricing (e.g., *farmdoc daily*, April 5, 2017; August 23, 2017, February 15, 2023) The model shown in Figure 3 represents the supply of biodiesel producers and demand from diesel blenders at the wholesale level in a competitive market. It is important to note that supply represents the total of domestic and imported production. The supply curve is upward sloping to reflect the increasing marginal cost of biodiesel as the quantity supplied increases. Retail demand at the consumer level is implicitly represented by a simple percentage markup of the wholesale demand shown in Figure 3. This implies full pass-through of wholesale price changes to the retail level.

Figure 3. Economic Model of the FAME Biodiesel Market with a Binding Volume Mandate and Blenders Tax Credit



The model in Figure 3 also assumes that biodiesel demand is perfectly elastic (horizontal) at the level of ultra-low sulfur diesel (ULSD) prices. This reflects an assumption that biodiesel and diesel are perfect substitutes (after adjusting for the lower energy value of biodiesel) and that biodiesel is a small enough part of the diesel market that changes in the BBD price do not impact the overall demand for diesel fuel, including any "rebound" effects (e.g., Lewis, 2016). The implication is that the biodiesel price must be the same as the ULSD price in order for there to be a positive biodiesel demand. If the biodiesel price is above the ULSD price, then no biodiesel will be demanded.

The policy scenario we consider in Figure 3 includes both a volume mandate and a blenders tax credit. This scenario reflects the situation for most of the last 15 years when both the RFS mandate and the $1 per gallon blenders tax credit have been in place in the U.S. The mandate is assumed to be binding because it requires a higher level of FAME biodiesel production than under a tax credit alone ($Q^M>Q^*$). To incentivize the higher production, biodiesel producers must be paid a higher price than the ULSD price. This means that the demand for FAME biodiesel effectively becomes perfectly inelastic at the mandated quantity. The entire demand curve becomes L-shaped, with the vertical and perfectly inelastic portion equal to the volume mandate and the horizontal perfectly elastic portion above the mandate equal to the

ULSD price. The effect of the tax credit under this scenario is purely distributive because the FAME biodiesel price and quantity are unaffected by the blenders tax credit.

The wet D4 RIN price in the policy scenario considered in Figure 3 is easily computed. It is simply the difference between the biodiesel price at the mandated quantity, P_{BD}, and the biodiesel price at the tax credit quantity, P^*_{BD}. This can be expressed in mathematical terms as follows,

$$\text{Wet D4 RIN Price} = P_{BD} – (0.927*P_{ULSD} + 1),$$

which can be converted into ethanol equivalent terms,

$$\text{D4 RIN Price} = [P_{BD} – (0.927*P_{ULSD} + 1)]/1.5.$$

Irwin, McCormick, and Stock (2020) consider this last relationship to be the "fundamental" in the D4 RIN market. This is also similar to the pricing model developed in an earlier *farmdoc daily* article (August 23, 2017).

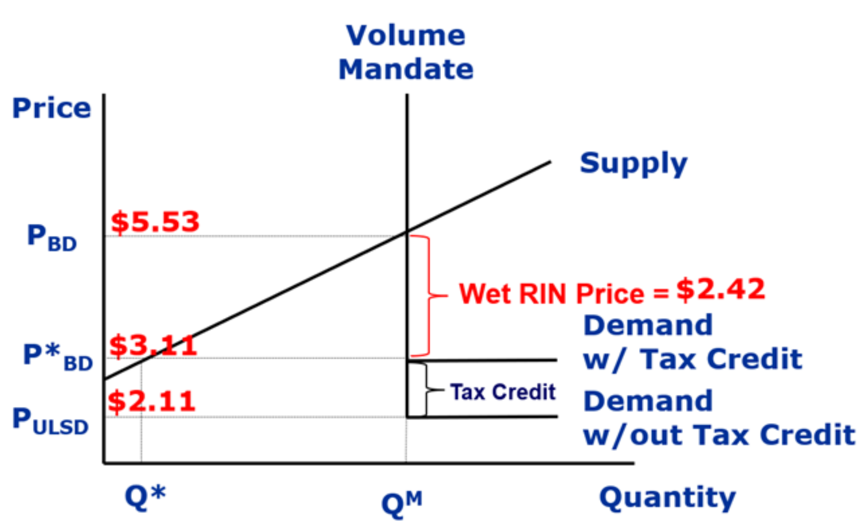
Figure 4 considers an application of this simple D4 biodiesel pricing model on May 4, 2023. On this date, the wholesale price of FAME biodiesel and ULSD in Chicago was $5.53 and $2.28 per gallon, respectively. The energy adjusted ULSD price was $2.11 = (0.927*$2.25). The prediction of the pricing model is as follows:

Wet D4 RIN Price = $2.42 = $5.53 – ($2.11 + $1),

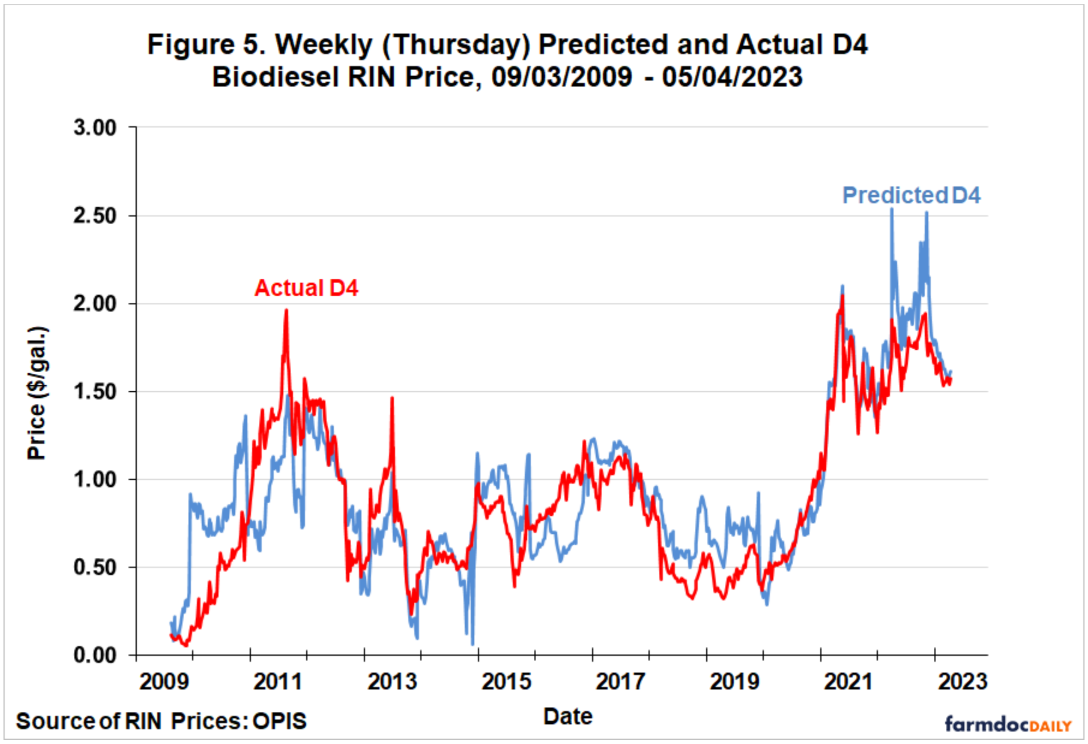
D4 RIN Price $1.61 = $2.42/1.5.

On this same date, May 4, 2023, the traded market price for 2023 vintage D4 biodiesel RINs was $1.58 per gallon.

Figure 4. D4 Biodiesel RIN Pricing Example for May 4, 2023



To gain a longer-term perspective on the accuracy of this simple D4 pricing model, Figure 5 presents the same computations as above for each week over September 3, 2009 through May 4, 2023. The red line in the figure is the actual D4 biodiesel price, and the blue line is the predicted price. While there are periods where the predictions and prices diverge, the simple model tracks actual market D4 prices reasonably well. The R-squared from a regression of the predictions on actual D4 prices is 75 percent. Our point is not that this is the best possible D4 RIN pricing model, but rather to demonstrate that D4 RIN prices follow a relatively simple pricing process that can be easily understood. This also implies that D4 and D5 RIN prices follow the same simple pricing process, as long as FAME biodiesel is the marginal gallon for complying with the undifferentiated advanced and conventional mandates. Finally, see Irwin, McCormick, and Stock (2020) for a more sophisticated D4 pricing model that incorporates uncertainty over the status of the blender's tax credit.



Implications

The Renewable Identification Number (RIN) system ensures compliance with annual mandates under the U.S. Renewable Fuel Standard (RFS). A RIN represents biofuel that has been produced and blended into transportation fuel. If an RFS mandate is binding, this means the policy requires more of a biofuel to be blended into the fuel supply than otherwise would be the case. The price of a RIN with a binding mandate is positive and, in theory, equal to the difference between the supply price that incentivizes production at the mandated quantity and the demand price that induces consumers to utilize the mandated quantity. A simple pricing model based on this insight is developed for the D4 biodiesel market. Despite its simplicity, the model explains 75 percent of the variation in D4 market RIN prices since 2009. This indicates that D4 RIN prices follow a relatively simple pricing process that can be easily understood.

The next article in this series will examine the proposed EPA rulemaking for 2023, 2024, and 2025 and potential implications for the trajectory of the renewable diesel boom.

Disclaimer: The findings and conclusions in this publication are those of the authors and should not be construed to represent any official USDA or U.S. Government determination or policy. This work was supported in part by the U.S. Department of Agriculture, Economic Research Service.

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