An Analysis of the Price of Renewable Identification Numbers (RINs) and Small Refineries

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NOTICE

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Contents

Key Findings

- EPA analyzed over 2.2 million Renewable Identification Number (RIN) transactions (140 billion RINs) for companies that traded separated RINs for conventional renewable fuel (D6) and biomass-based diesel (D4). This is approximately 675,000 additional (43% more) separated RIN transactions than were analyzed in a recent GAO Report.[1]

- These transactions include RIN price data for 24 small refineries that purchased and/or sold RINs as separate facilities. All of these small refineries have petitioned EPA for a small refinery exemption (SRE) in at least one year of the Renewable Fuel Standard (RFS) program.

- The analysis found that on average these 24 small refineries paid 1.1% (1.2¢) more per RIN when buying separated RINs when compared to the average daily price and 0.5% (0.6¢) more per RIN than the largest 20 refiners.

- For conventional renewable fuel (D6) RINs, this analysis finds that on average these 24 small refineries paid 0.6% (0.9¢) more per RIN than the average daily price and 0.2% (0.1¢) less per RIN than the 20 largest refineries.

- For biomass-based diesel (D4) RINs, this analysis finds that on average these 24 small refineries paid 2.7% (2.4¢) more per RIN when compared to the daily average prices and 2.6% (2.3¢) more per RIN than the largest 20 refineries.

- Separating out this effect by RIN vintage, the analysis finds that on average these 24 small refineries paid 1.3% more for RINs generated in the same year that the RINs were traded, 0.5% more for RINs generated in the prior year, and 0.9% less for RINs generated two years before they were traded.

- These results are sensitive to modeling assumptions. When analyzing three alternative modeling assumptions imposed in the GAO Report this analysis found that these 24 small refineries paid anywhere from 5.3% less to 7.5% more for RINs when compared to the daily average price.

- These estimates should not be interpreted as the actual spot prices that these 24 small refineries paid compared to daily spot market prices. The prices analyzed are self-reported, have limited quality assurance and quality control, in some cases are the result of term contracts unique to the trading parties, and limitations exist in analyzing the type of purchase or sale (e.g., unable to separate out spot and term contract trades for 2013 through 2019).

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[1] "Renewable Fuel Standard: Actions Needed to Improve Decision-Making in the Small Refinery Exemption Program," November 2022, GAO-23-104273 (hereinafter the "GAO Report"). The GAO Report is located at https://www.gao.gov/products/gao-23-105801.

Purpose

The purpose of this technical memorandum is to document EPA's analysis of the self-reported prices that small refineries paid or received when trading RINs and compare those prices to the average daily prices and the prices that large refineries paid or received.[2] This memorandum provides details on the data and methods used in this assessment. The analysis was conducted by the National Center for Environmental Economics (NCEE) at EPA using the EPA Moderated Transaction System (EMTS) RIN transaction data from 2013 through 2021 for both conventional renewable fuel (D6) and biomass-based diesel (D4) separated RINs.

Data

The data source is transactions of separated RINs under the RFS program as reported to EPA in EMTS.[3] The dataset includes transactions with a transfer year from 2013 through 2021. In the final analysis, over 2.2 million RIN transactions for approximately 140 billion RINs were analyzed. This analysis includes all RIN vintages and does not restrict the analysis to only RINs generated and transferred in the same year as was done in the GAO Report. This is the primary reason EPA's analysis includes approximately 675,000 additional (43% more) transactions than the GAO Report. Including these additional RINs is important because obligated parties under the RFS program can meet compliance obligations using RINs generated in the compliance year and prior year. Furthermore, compliance dates are generally March 31 of the year following the compliance year, unless otherwise extended. As such, it is common for companies to transact RINs in the year after they are generated, or even two years after they are generated. Restricting RIN transactions to those where the RIN was generated in the same year as the transfer would exclude RINs generated one year but transferred in the next year or two (e.g., RINs generated in 2020 but transferred during 2021 or the first 3 months of 2022).

Small Refineries

In the RFS program, a refinery qualifies as a small refinery for a particular year if it processes no more than 75,000 barrels per day of crude oil on an annual average basis.[4] However, RIN transaction data is reported on a company-level basis in EMTS, where companies may report commingled RIN transaction data for multiple refineries and/or import facilities. Therefore, EPA limited its analysis to 24 small refineries that reported RIN transactions on a facility-specific basis. There are 13 additional small refineries that are not reflected in this analysis because EPA is unable to disaggregate their RIN purchases from purchases reported by a parent company for other owned

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[2] This technical memorandum constitutes the "final analysis" EPA indicated it would provide in its response to GAO's Draft Report, which is included as Appendix IV in the GAO Report ("EPA has also conducted additional analyses to address specific concerns with GAO's analysis. The preliminary results of these analyses are provided in Attachment 2. Given the limited time EPA had to prepare this response to the Draft Report, our final analysis will be available after GAO issues its final report.").

[3] https://www.epa.gov/fuels-registration-reporting-and-compliance-help/how-use-emts-report-transactions-fuel-programs

[4] CAA section 211(*o*)(1)(K); 40 CFR 80.1401, 80.1441(e)(2)(iii). EPA uses total annual refinery-specific crude input volumes reported (as CBI) by the refinery owner to the Energy Information Administration to determine a refinery's daily annual average crude processing rate.

refineries or import facilities. All 24 of these small refineries have petitioned EPA for an SRE in at least one year of the RFS program.

Large Refineries

EPA identified the 20 companies with the largest total reported renewable volume obligation (RVO) for all obligated parties from 2013 through 2019 and used their EMTS RIN transaction data for comparison with the 24 small refineries mentioned above. These 20 companies represented approximately 87% of the total reported RVO for all obligated parties from 2013 through 2019.

Data Filters

This analysis uses an initial set of price filters similar to those that are used by EPA to remove outliers for the RIN price information provided on its website to the public.[5] These price filters are:

- 2013–2019 RINs with transfer date before January 1, 2020
    - D4 RIN Price – Min. Price: $0.05 & Max. Price: $2.00
    - D6 RIN Price – Min. Price: $0.05* & Max. Price: $2.00
- Any RINs with transfer date after December 31, 2019
    - D4 RIN Price – Min. Price: $0.05 & Max. Price: $3.00
    - D6 RIN Price – Min. Price: $0.05 & Max. Price: $3.00

* The minimum D6 price is changed from $0.01 to $0.05 so that all the minimum prices for all the years are equal. While D6 RIN prices at or below $0.05 were prevalent in the early years of the RFS program from 2010–2012, in the time period of this analysis D6 RIN prices were consistently above $0.05.

EPA also removed any transactions with a sell reason code that indicated that the transaction was a "Remedial Action - Incorrect Trade" or "Consignment Trade." These transaction types are either not reflective of the open market (such as the spot market) or are correcting other types of data entry errors. The remaining trades are standard trades for 2013 through 2019 and either spot or term contract trades for 2020 through 2021. Starting in 2020, EPA made changes to EMTS to split out standard trades into spot, term contract, and consignment trades. Before 2020, details on the type of standard trade are not available. Therefore, trades from 2013 through 2019 may contain consignment trades. Only approximately 5,500 trades were remedial action or consignment trades.

Even with the price filters and the removal of non-standard trades, outliers are still present in the data. The EPA price filters are not dependent on the market price. For example, a standard trade for $0.15 when the market price is $1.50 would not be filtered out of the analysis with the EPA price filters above. Therefore, EPA included an additional price filter that does depend on the market price. For comparative purposes, the additional price filter matches the additional price filter used in the GAO Report. The price filter from the GAO Report keeps transactions that are ±90% from the median. This additional price filter is applied subsequent to the initial EPA price filters above (before and after January 1, 2020). This sequential application of the price filters is similar to the method used in the GAO Report where they first applied EPA's static price filters

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[5] https://www.epa.gov/fuels-registration-reporting-and-compliance-help/rin-trades-and-price-information

and then used an additional filter to remove prices that were outside ±90% from the median. Like GAO, EPA believes that these outliers are not indicative of actual prices paid or received for RINs on the spot market. They are likely a reporting error, in incorrect units or due to a unique contract between two companies. See the section below on data quality and the unique nature of some contracts for trades found in EMTS. These price filters removed approximately 215,000 trades (see Table 1).

Data Quality and Limitations

EPA relies on companies to self-report RIN transactions and the prices paid for RINs in EMTS. The self-reporting process raises potential data quality concerns with this data. Transactions in EMTS are reported by both the buyer and the seller and so provide a natural check for data consistency. To avoid transactions with potential reporting errors, only transactions where the buyer and seller report the same price are analyzed, as it is unknown whether the buyer or seller's reported price is correct in cases where there is a discrepancy. This control on the transactions does reduce reporting errors but may not eliminate them altogether. For example, assigned RINs could have been reported as separated RINs and vice versa.

Prior to 2020, reporting parties primarily reported their buy/sell transactions under a single reason code identified as "standard trade". Quality assurance checks were limited to only requiring each standard trade to include the price unit in either a "price per gallon" or a "price per RIN" with the record. Beyond requiring the reporting party to confirm that the information entered is accurate, automated EMTS quality assurance checks do not compare self-reported values to other reported prices entered for the same transfer date for either assigned or separated RINs. Starting in 2020, reporting parties could choose new additional reason codes to include "spot", "term-contract", and "consignment" trades. Additionally, the price per RIN was required when trading separated RINs.

Many transactions where a small refinery sold RINs are recorded on different days at the same static nominal price. These transactions occur on days with different market prices. In contrast, the price that many companies pay for RINs changes on a daily basis. Upon further discussions with the companies involved in these transactions, EPA was informed that these RINs, while technically separated, were associated with renewable fuel and were "placeholders" used by the companies. The reported prices were not indicative of any actual price as the transaction was for the sale of a gallon of ethanol and a RIN together, similar to an assigned RIN.[6] Assigned RINs were not included in this analysis because those RINs travel with a batch of fuel and companies purchase both the renewable fuel and RINs together. Separating out the prices paid/received for the RINs from the prices paid/received for the renewable fuel is not possible with the bundled product.

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[6] It is unclear as to how often RIN sales, which are essentially assigned for practical purposes, are reported as sales of separated RINs. EPA has not yet determined an objective way in which to filter these transactions out. With the large number of companies that trade and an even larger number of trading relationships, it is not feasible to investigate all trades to determine the existence of all unique trading relationships and agreements.

Table 1: Number of transactions filtered from the analysis.

	Number of Transactions	Difference
Separated RINs	2,496,671	
Separated RINs; Matching prices for buyer and seller	2,465,581	-31,090
Separated RINs; Matching prices; Price Filters; Standard Trades	2,245,685	-219,896

Methods

Due to the dynamic nature of RIN prices, it is insufficient to simply compare the average prices that small refineries trade at to the average price for all transactions. If a company trades on different days than other companies, they may trade at different prices. Instead, the appropriate comparison is the price that small refineries traded at relative to the going market price on the same day. Therefore, this analysis controls for the daily average price. This is accomplished by using a time-fixed effect or time effect as was done in the GAO Report. For any day in which RINs are traded by any company, this analysis estimates the daily average price for each RIN vintage and fuel code. Therefore, the analysis compares the price small refineries trade at relative to the daily average price. The regression is:

$$p_t = \alpha_{SB} BuyerSR + \alpha_{SS} SellerSR + \alpha_{LB} BuyerLR + \alpha_{LS} SellerLR + \bar{p}_{tYF} D_t RIN\_YEAR_Y FUEL\_CODE_F + \varepsilon_t,$$

where p is the price of the transaction, $BuyerSR$ and $SellerSR$ are indicators for whether the buyer or the seller (respectively) are small refineries, $BuyerLR$ and $SellerLR$ are indicators for whether the buyer or the seller (respectively) are large refineries, D is an indicator for each day (t), RIN_YEAR is the vintage year of the RIN, and $FUEL\_CODE$ is the renewable fuel category. The parameter $\bar{p}$ is an estimate of the daily average price for each RIN vintage and fuel code. The parameter α_{SB} (α_{LB}) is the average price that small (large) refineries pay relative to the daily average price. A positive (negative) α_{*B} is an estimate that refineries pay more (less) when they buy. The parameter α_{SS} (α_{LS}) is the average price that small (large) refineries receive relative to the average daily price. A negative (positive) α_{*S} is an estimate that refineries receive less (more) when they sell.

In this analysis we make subsequent disaggregations of the main estimates. This is accomplished by interacting either indicators for fuel code or RIN vintage with the refinery indictors. As part of a sensitivity analysis, we also impose symmetry across purchases and sales by restricting the parameters. This imposition is implicit in the functional form of the regression utilized in the GAO Report. The model in the GAO report could have included the log of buyer's size and the log of seller's size as separate variables. This would have made the model more generalized and an assumption of symmetry could have been tested.

Weighting

The unit of observation in this analysis is a transaction in EMTS. Each transaction or trade includes many RINs and the quantity of RINs traded can vary from a few RINs to millions of RINs in a single transaction. What this analysis is interested in is the average price per RIN at which small refineries trade RINs compared to the daily average price and not the daily average price per trade.

To accomplish this, the analysis weighted the trades by the quantity of RINs. This is important because companies, even companies of the same size, may differ in how often they trade and in what quantities.

For example, one small refinery might trade 1,000 RINs each weekday (5 days a week), where another small refinery trades 5,000 RINs on a single day each week. In this example, if this analysis did not weight by the quantity of RINs, then the small refinery that trades each weekday would dominate the analysis. In weighting by RINs this analysis treats these two small refineries equal in their influence over the statistical estimates given that they are trading the same number of RINs. Weighting is not just important for comparing across companies. Companies themselves trade different quantities of RINs in different transactions. One company might pay 10¢ over market price for 100 RINs in one transaction and 1¢ under for 1,000 RINs. The average price of a transaction compared to the market price in this example is 5.5¢. But for the average RIN this company paid market price (10¢ * 100 – 1¢ * 1000 = 0).

Statistical Uncertainty

Given concerns regarding data quality and the inability to verify the self-reported prices, an analysis of transactions should allow for modeling errors to be correlated within a company. That is to say that it is unreasonable to assume that transactions are independent within each company. To account for this, an analysis should cluster the standard errors at the seller company and buyer company.

EMTS contains data on all transfers of RINs and most of the RIN transactions are analyzed. For this reason, it is not reasonable to assume, as is the default in many statistical software packages and in the GAO Report, that the sample of RIN transactions is much smaller (i.e., less than 5%) than the universe of RIN transactions. This assumption would over-estimate the sampling uncertainty in the results. Therefore, an analysis would correct estimates of the standard error using an appropriate correction, such as a finite population correction.[7]

Given the large number of transactions in the analysis, the requirement that all RIN transfers and transactions be recorded in EMTS, and the large share of the total number of transactions analyzed, the sampling uncertainty in the analysis is low. Therefore, in the discussion of the results, this analysis instead focuses in on the magnitudes of the estimates. This is not to say that sampling uncertainty is zero or that there are not any other unquantified factors that could increase uncertainty in EPA's estimates (e.g., modeling uncertainty). Furthermore, given the data quality issues, this analysis cannot rule out bias in EPA's estimates, the direction to which is unknown.

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[7] For example, $FPC = \sqrt{\frac{(N-n)}{(N-1)}}$, where N is the total number of separated RINs transferred in the EMTS system and n is the number of separated RINs in the analysis.

Analysis

This section presents the results of EPA's analysis. Table 2 presents the results for the overall effect of small refineries and large refineries as buyers for D4 and D6 RINs combined. Model (1) from Table 2 is an estimate of the percentage difference in prices. Model (2) from Table 2 is an estimate of the difference in cents per RIN. These results are all weighted by the quantity of RINs in the transaction. The results in this table suggest that on average small refineries pay 1.1% (1.2¢) more when purchasing RINs.

Table 2: Regression estimates of the difference in RIN prices for small and large refineries.

Dependent Variable:	Natural Log of Prices Model (1)	Prices Model (2)
Buyer		
Small Refinery	1.1%	1.2¢
Large Refinery	0.6%	0.6¢
Seller		
Small Refinery	-3.2%	-1.2¢
Large Refinery	-0.03%	0.1¢
Daily Average Price by Fuel Code and RIN Year	Yes	Yes
Weighted by RIN Quantity	Yes	Yes
Require Transfer Year = RIN Year	No	No
Transactions	2,245,685	2,245,685
RINs	140,793,211,859	140,793,211,859

Table 3 presents various disaggregations of the estimates presented in Table 2. Model (1) from Table 2 is included as a point of comparison. The results of the analysis presented in Model (3) from Table 3 separate out the estimate of the differences in prices paid and received by small and large refineries for D4 and D6 RINs. On average, small refineries pay 0.5% more for D6 RINs and pay 2.7% more for D4 RINs when compared to the daily average price. On the sell side, Model (3) from Table 3 estimates that on average small refineries receive less for both categories of RINs. However, due to significant data quality issues for the small refinery sales data (see section above on data quality), it is indeterminate if the effect is simply due to outliers. Model (4) from Table 3 presents the results of the analysis that separates out the estimate of the differences in prices paid and received by small and large refineries by the vintage of the RIN, with the D4 and D6 RINs aggregated together. The estimates of the relative difference that small refineries pay and receive for RINs traded in the same year as they are generated (transaction year matches RIN year) is larger than for RINs generated in the prior year (transaction year is one year after the RIN year). Typically, RINs generated in a compliance year can be retired for compliance in that year or the next year. Most of the transactions are for RINs generated in the same year or the year prior to the transaction year.

Table 3: Estimates of the percent difference in RIN prices by fuel code and RIN vintage traded by small and large refineries.

Dependent Variable: Natural Log of Prices	Aggregate from Table 2 Model (1)	By fuel code Model (3)	By RIN vintage Model (4)
Buyer			
Small Refinery	1.1%		
D6 Fuel Code		0.6%	
D4 Fuel Code		2.7%	
Transfer Year - RIN Year = 0			1.3%
Transfer Year - RIN Year = 1			0.5%
Transfer Year - RIN Year = 2			-0.9%
Large Refinery	0.6%		
D6 Fuel Code		0.8%	
D4 Fuel Code		0.06%	
Transfer Year - RIN Year = 0			1.0%
Transfer Year - RIN Year = 1			-1.3%
Transfer Year - RIN Year = 2			7.0%
Transfer Year - RIN Year = 3			4.7%
Seller			
Small Refinery	-3.2%		
D6 Fuel Code		-3.3%	
D4 Fuel Code		-2.6%	
Transfer Year - RIN Year = 0			-3.0%
Transfer Year - RIN Year = 1			-2.9%
Transfer Year - RIN Year = 2			-11.4%
Transfer Year - RIN Year = 3			-67.7%
Large Refinery	-0.03%		
D6 Fuel Code		-0.4%	
D4 Fuel Code		1.9%	
Transfer Year - RIN Year = 0			-0.3%
Transfer Year - RIN Year = 1			1.3%
Transfer Year - RIN Year = 2			1.7%
Transfer Year - RIN Year = 3			4.7%
Average Daily Price by Fuel Code and RIN Year	Yes	Yes	Yes
Weighted by RIN Quantity	Yes	Yes	Yes
Require Transfer Year = RIN Year	No	No	No
Transactions	2,245,685	2,245,685	2,245,685

Sensitivity Analysis

Table 4 presents sensitivity results of the main aggregated results in Table 2. Models (5), (6), and (7) from Table 4 do not weight the regression by the quantity of RINs in the transactions (GAO also did not weight its regression by RIN quantity in its report). Model (5) estimates that small refineries pay 1.9% less than the average daily price to purchase RINs. Model (6) further restricts the data to include only transactions where the transfer year is the same as the RIN generation year (same as the GAO Report). Model (6) estimates that on average small refineries paid 5.3% less than the average daily prices. In both Models (6) and (7), the results of the sensitivity analysis find that small refineries received 31.6% to 42.2% less than the market price when selling RINs. These estimates are driven by the large number of nominal fixed price transactions for at least one of the small refineries (see data quality section). Each transaction is for a relatively small number of RINs and when the analysis is not weighted by RINs these transactions dominate the analysis. Model (7) presents the results of the analysis with imposing symmetry on the price effects of refinery size for purchases and sales (same as the GAO Report). Imposition of symmetry increases the estimate of the prices that small refineries pay. The differences in the estimates in Model (6) and (7) provide further evidence that the assumption of symmetry on purchases and sales is unreasonable. In addition, data quality issues for transactions where small refineries are the sellers can impact estimates of the prices small refineries pays when this symmetry is imposed.

Table 4: Sensitivity estimates of the percent difference in RIN prices traded by small and large refineries

Dependent Variable: Natural Log of Prices	Aggregate from Table 2 Model (1)	Model (5)	Model (6)	Model (7)
Buyer				
Small Refinery	1.1%	-1.9%	-5.3%	7.5%
Large Refinery	0.6%	-0.07%	-0.2%	-0.5%
Seller				
Small Refinery	-3.2%	-31.6%	-42.2%	-7.5%
Large Refinery	-0.03%	2.5%	1.9%	0.5%
Average Daily Price by Fuel Code and RIN Year	Yes	Yes	Yes	Yes
Weighted by RIN Quantity	Yes	No	No	No
Require Transfer Year = RIN Year	No	No	Yes	Yes
Impose symmetry on buy and sell	No	No	No	Yes
Transactions	2,245,685	2,245,685	1,744,793	1,744,793

Comparison to GAO Report

The purpose of this technical memorandum is to provide EPA's analysis of the prices for RIN transactions for small refineries. This analysis shares similarities and differences from the analysis in the GAO Report in several ways. Where relevant, specific comparisons are made with GAO's results throughout this final analysis.

Both this analysis and the GAO Report use EMTS transaction data from 2013 through 2021 for D4 and D6 RINs. Both analyses applied comparable price filters. The largest difference in the final data set is that EPA's analysis includes an additional 675,000 transactions where the RINs were generated in the years prior to the transfer of the RIN.

This analysis estimates the difference in daily prices between reported averages for all parties and 24 small refineries that transact RINs on a facility basis. The GAO Report analyzes RIN prices as a function of the ratio of buyer size to seller size (where sizes are determined by past quantities of RINs transacted) but does not specifically evaluate RIN transactions by small refineries. Companies buying small quantities of RINs (relative to quantities of RINs sold by the seller) are not necessarily small refineries, but could instead be other parties such as importers or refiners who simply blend additional blendstocks into gasoline produced by another refiner.

The GAO Report assumed symmetry in the estimates of the relative prices paid to the prices received. This is a testable assumption in both the GAO Report and this analysis.[8] This analysis finds that this assumption of symmetry on the buyer and seller side is not reasonable. In EPA's analysis, small refineries on average pay 1.1% more when buying RINs but receive 3.2% less. Imposing symmetry in this analysis increases the estimate of the prices that small refineries paid relative to the daily average price.

This analysis weights transactions by the quantity of RIN traded, while the GAO Report does not weight by the quantity of RINs. Thus, EPA's analysis estimates the average price per RIN while the GAO Report is an analysis of the average price per transaction.

Given the number of differences between this analysis and the GAO Report, comparing and providing detailed explanations of the results are beyond the scope of this technical memorandum. This analysis disaggregated the estimates by fuel code and RIN vintage to better breakdown the aggregate estimates and to facilitate comparison with the results in the GAO Report. In addition, a sensitivity analysis that included estimates with some of the GAO Report's assumptions were included to help facilitate this comparison.

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[8] In the GAO Report, the model could have included the log of buyer's size and the log of seller's size as separate variables. The statistical test would be that these coefficients are of equal but opposite sign.