## Key Findings

- Changes in prices of renewable identification numbers (RINs) did not cause changes in retail gasoline prices in 2013.
- Retail gasoline prices were driven primarily by movements in crude oil prices and secondarily by changes in the spread between domestic and international crude oil prices and the level of vehicle miles driven in the U.S., which varies seasonally.

## Background and Introduction

The Renewable Fuel Standard, which requires gasoline sold in the U.S. to contain at least certain minimum volumes of biofuel, was created by the Energy Policy Act of 2005. Two years later, the Energy Independence and Security Act of 2007 significantly expanded the previous targets, and the revised Renewable Fuel Standard (known as RFS2) was allocated among specific categories of renewable fuels.

A system of renewable identification numbers was designed by the EPA and is used by parties (mainly refiners) that are obligated to comply with RFS2. A RIN is a 38-digit code representing a specific volume of renewable fuel. RINs are generated by a producer or importer of renewable fuel, and once the fuel is blended the separated RINs can be used for compliance purposes, held in inventory for future compliance, or traded.

Market participants began to realize in early 2013 that ethanol usage could fall well short of the level needed to meet RFS2, and prices of conventional ethanol RINs rose to levels that were multiples of any that had been experienced previously, spiking to nearly $1.50 during the summer. This was in part a result of the 2012 drought, which reduced the size of the corn crop and led to record-high prices and the idling of ethanol plants in late 2012 and early 2013, as market prices for ethanol were not sufficient to allow producers to offset higher production costs and sustain significantly positive margins.

The retail price of gasoline in the U.S. also increased during the late winter and early spring of 2013. Although this is consistent with seasonal patterns that have historically been experienced in advance of the summertime "driving season" – and gasoline prices actually declined somewhat during the late spring and then remained within a relatively well-defined range over the summer – the coincidental timing led some commentators to speculate that RIN prices might be driving retail gasoline prices higher.
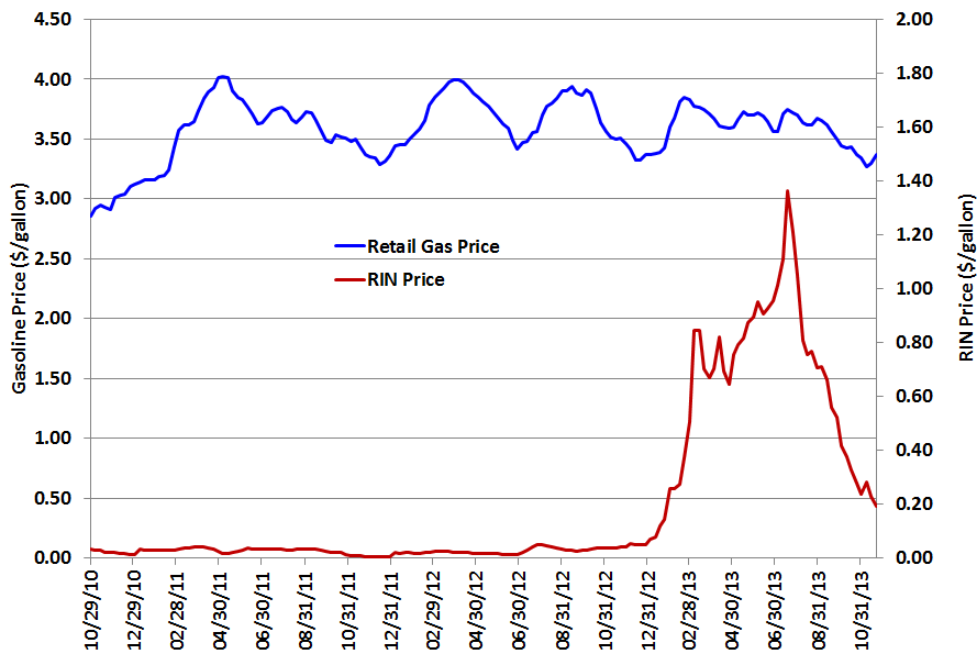
Now that 2013 has ended and gasoline prices have declined, the Renewable Fuels Association ("RFA") commissioned Informa Economics, Inc. to conduct an analysis of whether the significant increase in RIN prices led to higher gasoline prices for U.S. consumers, or if not, what did contribute to higher gasoline prices during the middle of 2013. Informa conducted its analysis in two phases. First, Informa used a statistical method to determine whether changes in RIN prices "caused" (i.e., were a significant

driver of) changes in retail gasoline prices. Second, a streamlined statistical regression "explaining" gasoline price movements was developed; it was intended that if the first part of the analysis concluded that changes in RIN prices have "caused" changes in gasoline prices, RIN prices also would be included in the regression during the second phase of the analysis, in order to quantify their impact.

## Causality Analysis

In order to test whether or not changes in RIN prices "caused" changes in retail gasoline prices, a statistical method called a Granger causality analysis was utilized. Weekly average RIN prices reported by OPIS for the period spanning from October 29, 2010, to November 22, 2013, were paired with weekly average retail gasoline prices reported by EIA for the same time period (Exhibit 1). The chart below provides a look at the raw data involved in the analysis. Prior to use in the Granger models, the data were differenced, and thus, the resulting models were built using the weekly change in RIN prices compared to the weekly change in gasoline prices.

**Exhibit 1: Weekly Retail Gasoline and Conventional Ethanol RIN Prices**



Sources: DOE-EIA (Gasoline Prices), OPIS (RIN Prices)

Of primary interest was the question: Did increasing RIN prices cause gasoline prices to rise? To test this, an initial model was developed that specified the current change in gasoline price as a function of the previous week's change in the price of gasoline. Next, a secondary model was constructed identical to the first, except that the previous week's change in the RIN value was added as an explanatory variable.

The idea behind the Granger causality analysis is simple: If the second model (containing the lagged RIN variable) is superior to the initial model, then this means that

the previous week's RIN price has some explanatory power relative to the current week's gasoline price. If this is found to be the case, then it can be asserted that gasoline price changes are "caused" by changes in the RIN price. The term "caused" is used loosely here, since it does not imply that the RIN price was the only factor affecting gasoline prices. In the context of this analysis, the term "caused" would simply refer to the presence of some connection between the change in the RIN price and subsequent changes in gasoline prices.

To determine if one model is superior to another, it is appropriate to look at the size of the error terms associated with each model (i.e., the difference between the actual prices observed and the prices that would have been predicted by the model). If the errors from one model are significantly smaller than those of the other, this implies that the model has superior predictive power, and thus, is a better representation of reality.

Granger causality analysis compares the sum of squared errors associated with the model containing the RIN variable with same statistic for the model that does not contain the RIN variable. Exhibit 2 provides the results of the Granger causality analysis. The P-values reported in the table measure the probability that the errors from the unrestricted model (the one containing RIN values) are the same as the errors from the restricted model (no RIN value). There is a 74% chance these model errors are not significantly different, leading to the conclusion that changes in RIN prices do not appear to cause changes in gasoline prices.

**Exhibit 2: Results of the Granger Causality Test**

|  | ---- P Values ----- |
| --- | --- |
| **RIN Price Causes Gas Price** | **0.741** |
| **Gas Price Causes RIN Price** | **0.107** |
|  |  |
|  | ---- Significant at 5% Level? ----- |
| **RIN Price Causes Gas Price** | **N** |
| **Gas Price Causes RIN Price** | **N** |

P-values are the probability that the sum of squared errors in the unrestricted model is not
different from the sum of squared errors in the restricted model.

It is worth noting that as an auxiliary part of this analysis, a second set of models was prepared that reversed the flow of causality, in order to examine whether or not changes in the gasoline price caused changes in RIN values. In the reverse case, there is a 10% chance that there is no difference between the models, and though this probability is much lower than for the RIN-to-gasoline case – implying that there is a higher probability that changes in gasoline prices "caused" changes in RIN prices – this is generally not considered strong enough to make this conclusion. Technically, most scientists like to see a probability of 5% or smaller in order to reject the hypothesis that the models are not different.
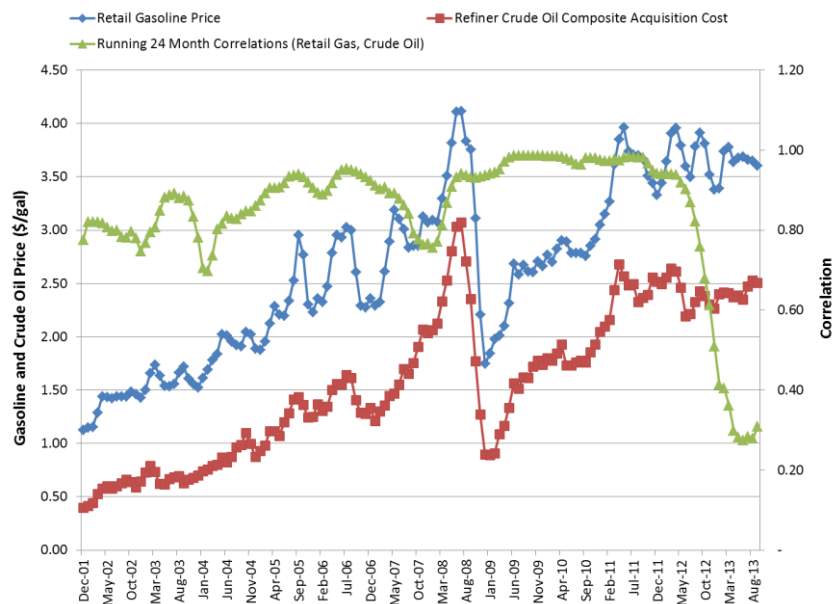
In summary, the evidence from the Granger causality work leads to the conclusion that changes in RIN prices have not caused changes in retail gasoline prices (or vice-versa). To any extent that the two are related, it is not a direct causal relationship.

## Gasoline Price Drivers

Since it was determined that RIN prices have not driven retail gasoline prices, a second question naturally arises: What did cause gasoline prices to be higher during the middle of 2013? Accordingly, the second phase of the analysis examines the key factors that do "explain" retail gasoline price movements. It should be remembered that RINs were created only in the aftermath of the establishment of the Renewable Fuel Standard in 2005, and the differentiation of RINs by biofuel category did not take effect until 2010, whereas gasoline prices have been volatile for decades.

The primary driver of retail gasoline prices is crude oil prices, as crude oil is the primary input in gasoline production. Historically, the running 24-month correlation between crude oil[1] and retail gasoline prices has generally been between 0.80 and 0.99, which indicates a very strong relationship given that a coefficient of 1.00 would indicate perfect positive correlation (Exhibit 3).

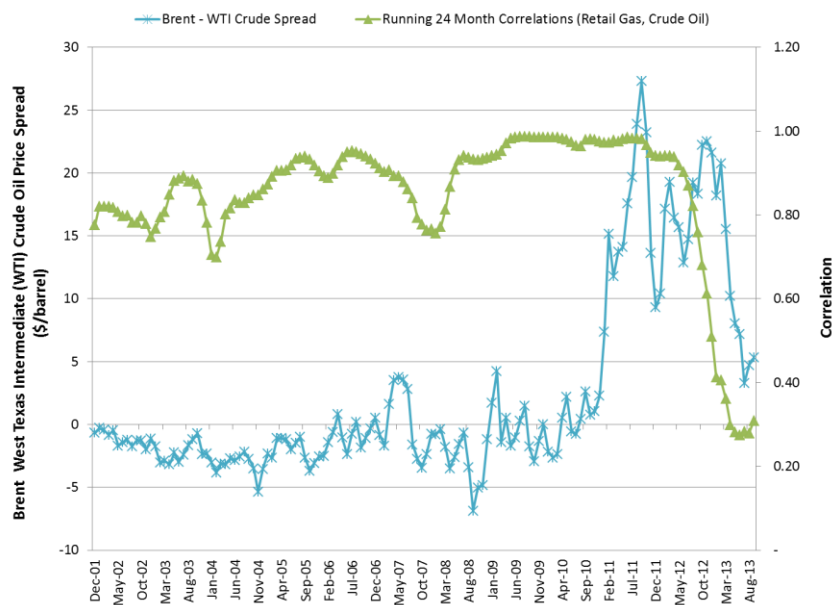**Exhibit 3: Monthly Retail Gasoline and Crude Oil Price Relationship**



Sources: EIA (Prices); Informa Economics (Analysis)

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[1] For each month illustrated in Exhibit 3, the correlation between crude oil and retail gasoline prices over the previous 24 months was examined. Refinery composite crude oil acquisition cost data was utilized to represent crude oil costs for U.S. refineries, as this reflects a weighted U.S. average of imported and domestic crude oil used to produce gasoline.

However, this relationship began to show signs of weakening starting in the spring of 2012. One of the key factors behind this weakening has been the divergence between international and domestic crude oil prices and the heightened volatility of the spread between these prices[2]. This divergence was mainly attributable to growing crude oil stocks at inland locations – especially the delivery point for NYMEX crude oil futures at Cushing, Oklahoma – as a result of a combination of increased domestic oil production from shale plays such as North Dakota's Bakken formation and lagging infrastructure build-out to move the oil to consumption centers. Conversely, this spread has narrowed throughout 2013, as infrastructure has come online to facilitate movements of crude to the Gulf Coast. At the same time, the U.S. has emerged as an exporter of gasoline. Consequently, a layer of complexity has been added to U.S. gasoline pricing dynamics, as the price of Brent crude oil, which serves as an international benchmark and influences the pricing of gasoline in international markets, has been elevated relative to domestic crude.

As illustrated within Exhibit 4, the weakening price relationship between crude oil and retail gasoline price followed the growing spread between U.S. West Texas Intermediate (WTI) and Brent crude oil prices[3]. It is also notable that this weakening price relationship preceded the increase in RIN prices.

**Exhibit 4: Monthly Brent-to-WTI Crude Oil Price Spread vs. Retail Gasoline and Crude Oil Price Correlation**
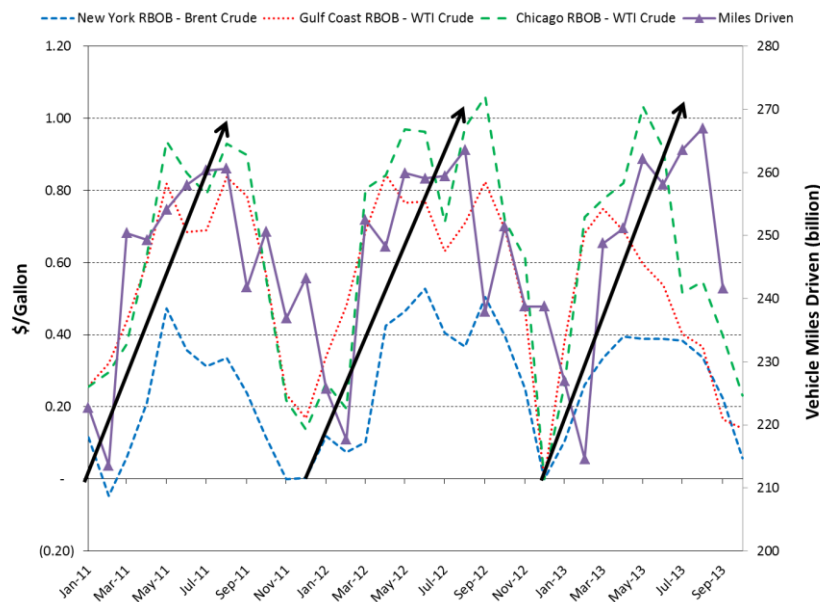


Sources: EIA (Prices); Informa Economics (Analysis)

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[2] Brent crude oil prices were utilized to represent prices in the international market, and WTI prices were utilized to represent prices in the domestic market.

[3] It is notable that the chart uses a 24-month correlation, and thus there is a lag between when the Brent-WTI price spread begins to expand and when the correlation between crude oil and retail gasoline prices appears to weaken in the chart.

Another factor effecting retail gasoline prices is seasonal demand.  There is a distinct seasonal pattern to gasoline prices and crack spreads (i.e., the margins refiners earn by processing crude oil into transportation fuels, in this case gasoline).  Gasoline prices and crack spreads tend to slump during the last quarter of the calendar year, particularly November and December, and then strengthen considerably through the first quarter of the year and remain strong through the summertime driving season (see Exhibit 5).  A key factor in this is the increase in vehicle miles driven during the summer months, which is anticipated by the markets and prepared for by refiners.

**Exhibit 5: Seasonal Crack Spreads and Vehicle Miles Driven**



Sources: EIA (crude oil prices), OPIS (RBOB prices), U.S. Department of Transportation (miles driven), and Informa Economics (analysis)

The relative role of each of the above factors in "explaining" movements in retail gasoline prices was estimated econometrically[4], and results are presented in Exhibit 6. The majority of gasoline price movements can be explained by crude oil prices.  A $0.10/gallon increase in crude oil prices ($4.20/barrel) has resulted in a roughly $0.10/gallon increase in retail gasoline prices, all else being held equal.  In the model, variables for the Brent-WTI crude oil price spread and vehicle miles driven were also statistically significant, and they improved model performance somewhat.  Together these variables explain 95% of the historical retail gasoline price movements (as indicated by the adjusted R-squared statistic).  It should be noted that this model was also run with conventional ethanol RIN prices included, but RIN prices were not found to be statistically significant at a 5% level.

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[4] Monthly data from April 2008 – September 2013 was utilized within this regression.

**Exhibit 6: Retail Gas Price Model**

**Dependent Variable = U.S. Retail Gasoline Price**

| Explanatory Variable | Coefficient | Statistically Significant at 5% Level |
|---|---|---|
| Intercept | 0.098 | |
| Refiner Crude Oil Composite Acquisition Cost | 1.049 | Yes |
| Brent - WTI Crude Oil Price Spread | 0.010 | Yes |
| Vehicle Miles Driven | $3.432 * 10^6$ | Yes |

**Adjusted R-Squared = .954**

Source: Informa Economics

## Conclusions

Although retail gasoline prices and RIN prices both increased in early 2013 and remained elevated (though volatile) during the middle of the year, this was mainly coincidental, and upon closer examination it can be determined that these changes generally occurred for different reasons. In fact, the increase in gasoline price early in the year actually pre-dated the increase in RIN prices. Based on statistical analysis, it can be concluded that changes in RIN prices did not "cause" the changes in retail gasoline prices in 2013.