Fuels Institute

Retailing E85: An Analysis of Market Performance, July 2014-August 2015

Fuels Institute

NACS®

The Fuels Institute was founded in 2013 by NACS, the international association that advances convenience and fuel retailing. Through recurring financial contributions and daily operational support, NACS helps the Fuels Institute to invest in and carry out its work to foster collaboration among the various stakeholders with interests in the transportation energy market and to promote a comprehensive and objective evaluation of issues affecting that market and its customers both today and in the future. NACS was founded August 14, 1961, as the National Association of Convenience Stores, and represents more than 2,100 retail and 1,600 supplier company members.

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Introduction

The biofuels market in the United States continues to expand, with nearly every gallon of gasoline sold in 2015 containing 10% ethanol. Supported in part by the federal Renewable Fuel Standard (RFS), which sets a schedule for annually increasing the use of qualified renewable fuels, culminating in a target market of 36 billion gallons by 2022, the ethanol and biodiesel industry have continued to increase production and market penetration. (Figure 1)

The targets established by the RFS, however, cannot be satisfied without increasing biofuel blends beyond the traditional 10% for ethanol and the 2%–5% for biodiesel. One option for contributing additional volumes towards compliance is the alternative fuel E85. By ASTM International's definition, fuel is considered E85 when it contains between 51%–83% ethanol. E85 is suitable for use only in specially designed flexible fuel vehicles (FFVs), which are certified to

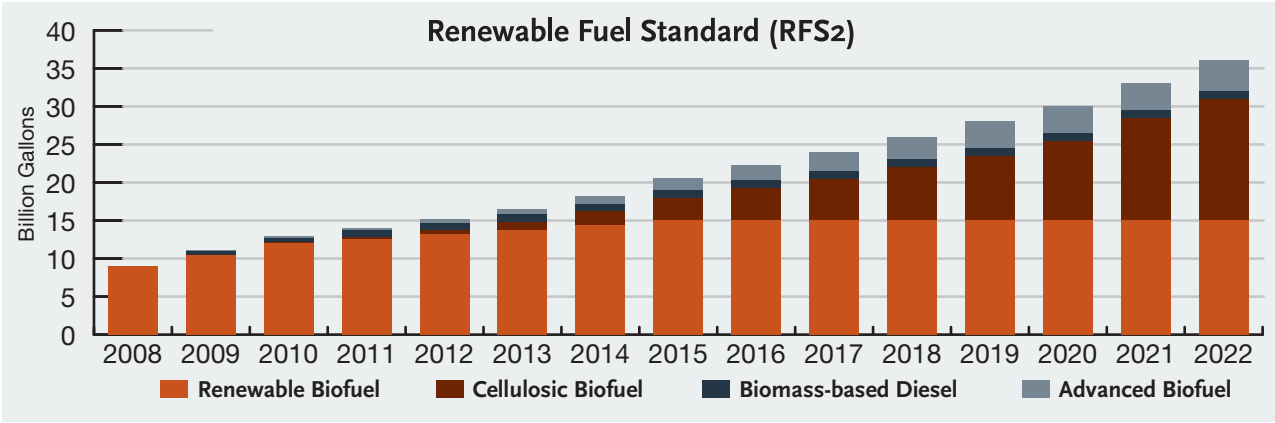


Figure 1: *Renewable Fuel Standard (Source: Energy Independence and Security Act)*

[1] http://www.eia.gov/totalenergy/data/monthly/#renewable

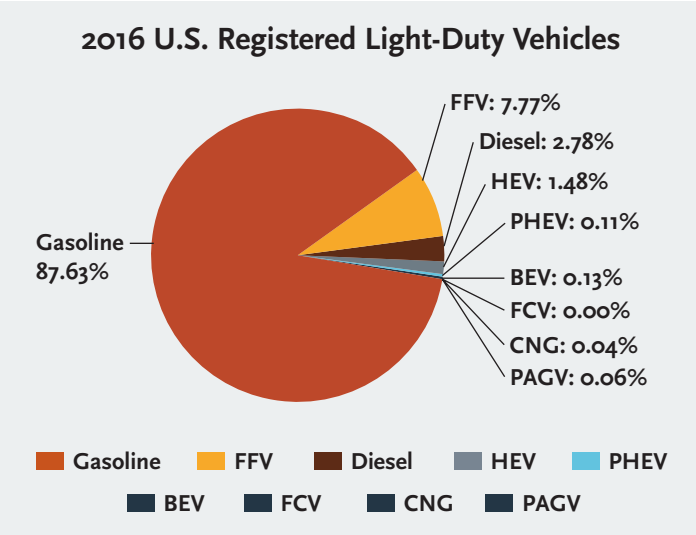


Figure 2: *2016 U.S. Registered Light-Duty Vehicles (Source: Navigant Research)*

operate on fuels containing between 0% and 83% ethanol. It is estimated that there were nearly 20 million FFVs registered in the United States in 2016, representing about 8% of the light-duty fleet. Because E85 is restricted to use only in FFVs, these vehicles represent the potential demand in the U.S. market for E85 in 2016. (Figure 2)

Background information on the RFS and the market for FFVs and E85 is contained in the 2014 Fuels Institute report, "E85: A Market Performance Analysis and Forecast." That report analyzes data from three different sets: the Minnesota Department of Commerce, the NACS-CSX database and daily sales data contributed directly to the Fuels Institute from 304 E85 retail facilities. From this data, the report presents a range of forecasts concerning the market potential for E85 through 2023.

The Fuels Institute received original data directly from E85 retailers in the previous report, which covered January 2013 through July 2014. During that time, regular unleaded averaged $3.487 per gallon, E85 was sold at an average price that was $0.449 per gallon below unleaded and E85 sales averaged 2.9% of unleaded sales.

Following the report's release, retail gasoline prices tumbled and by the end of 2014, retail prices were $2.307 per gallon and have remained in that range since. This change in market dynamics raised several questions about the performance of E85. Specifically, the Fuels Institute was asked what effect the drop in retail gasoline prices had on E85 sales.

To answer this question, the Fuels Institute reached out to E85 retailers to collect additional store-level data from July 2014 through August 2015, a time when national average retail gasoline prices dropped from a weekly national price of $3.661 per gallon to $2.502, with a low of $2.038, according to Oil Price Information Service (OPIS) data. The belief is that analyzing such a range in retail fuel price movements would better illuminate the relative price elasticity of E85 compared with unleaded gasoline. (Figure 3)

The Fuels Institute was pleased with the response from retailers, who contributed daily sales data reporting prices and volumes for both unleaded and E85 from 620 stores. This data set represents 22.2% of the 2,782 facilities that sell E85, according to the Department of Energy's Alternative Fuels Data Center (as of September 1, 2016). The Fuels Institute collected and assembled this data in a consistent format to ensure the sources of the information remained anonymous.

From the data collected for this report and for the report released in 2014, it is evident that the decline in retail gasoline prices did not have a negative effect on E85 demand, at least for the stores in the sample sets. Prior to analysis of the most recent data, some questioned if the decline in

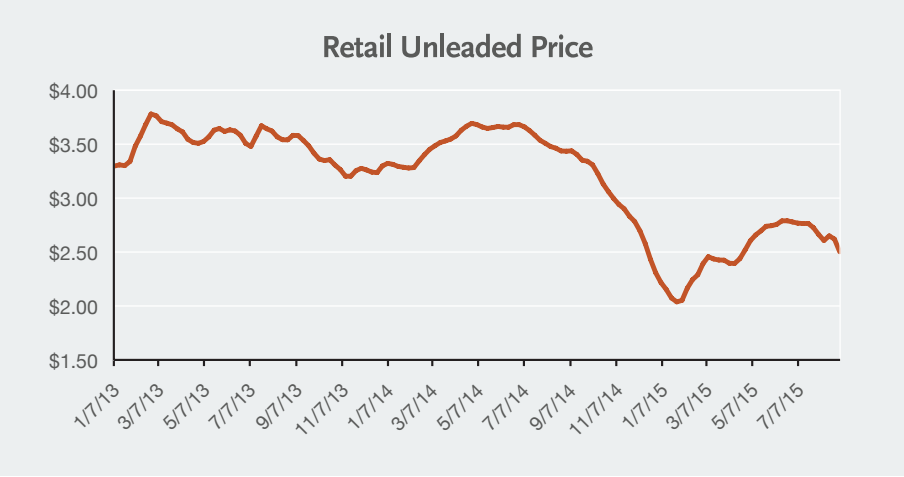


Figure 3: *Retail Unleaded Price (Source: OPIS "Retail Fuel Watch")*

[2] http://www.astm.org/Standards/D5798.htm

Sample Set	UL Volume Gallons/Day	E85 Volume Gallons/Day	E85 Volume as % UL	UL Price	E85 Price	E85 Price $ Below UL	E85 Price $ % Below UL
2014	6,633	185	2.79%	$3.487	$3.051	$0.436	12.60%
2016	5,920	241	4.77%	$2.651	$2.213	$0.438	16.10%

Figure 4: *Summary of Store Performance in 2014 and 2016 Data Sets (Source: Fuels Institute)*

retail gasoline prices, which reduces the price sensitivity of consumers and their penchant for shopping for the best deal, could diminish the allure of lower-priced E85 and reduce consumption of the fuel. Further, some questioned if E85 could be priced at a sufficient discount relative to the lower gasoline price to attract consumers. (Figure 4)

The ability of fuel retailers to offer E85 at a price consistently below unleaded gasoline was not affected by the drop in retail unleaded prices. The average E85 pricing strategy for the stores sampled did not seem to change in terms of the cents per gallon discount from unleaded, although the E85 price did reflect a larger percentage discount. Likewise, it seems that the reduction in unleaded prices was not instrumental in consumer decisions to purchase E85. During the second sample period, with unleaded selling for an average price $0.836 lower than during the period analyzed in the 2014 Fuels Institute report, average E85 sales volume increased 30% and increased its contribution to a store's fuels business, equaling 4.77% of unleaded volume. There are a number of factors contributing to consumer demand for E85, which will be discussed later, but the data indicates that the drop in retail gasoline prices did not independently undermine the market for E85.

The robust nature of the data collected for this report, while contributing directly to answering the initial question posed to the Fuels Institute, lends itself to additional analysis that could be helpful to those seeking to better understand the retail market for E85 and the relationship between price and volume. This report presents an expanded analysis of the data set.

It is not the intent of this report to reach any conclusions about the data presented or the E85 market, but rather to present various analyses of the data that will be informative to those interested in this market.

The Fuels Institute leaves it to readers to reach their own conclusions concerning the data presented; however, when reviewing the data it might be helpful to consider the following for additional insights:

1. **What is the optimum E85 price point relative to unleaded demonstrated by the stores within the sample set to generate the highest sales volume of E85?**
2. **Must E85 be priced at a level that will compensate consumers for its lower energy content, and consequent fewer miles per gallon, to generate demand?**
3. **What is the effect on E85 sales volume when offering E85 at different price points below unleaded? Is there a price range at which E85 seems to perform at its peak?**
4. **What factors, in addition to price, might affect consumer demand for E85 at a given retail facility?**
5. **Based on the reported experience of the 620 stores represented in this sample set, what can be learned regarding potential E85 demand at a given retail facility?**

While the data contained within this report may not be sufficient to fully answer these questions, reviewing the data within the context of these topics could provide the reader with interesting perspective.

About the Data

This current report is designed to provide an overview of E85 sales derived from this exclusive data set. It should be viewed as a strong sample of the market, considering the percentage of E85 retail stations represented. Taken together, the stores average nearly 150,000 gallons of E85 per day and nearly 57 million gallons over the sample period.

However, it should be noted that the retail sites represented in the sample do not necessarily represent a balanced geographical distribution, nor is it possible to determine whether a specific location was operating in a rural or urban setting. Further, the stores don't necessarily represent a balanced distribution of store/firm sizes. All data contained herein was received from companies who operate chains of retail stations, not single-store operators. Further, the firms that contributed data (not disclosed to protect proprietary information) are considered among the top-performing operators within the retail fueling industry. Given the nature of the data, it does not support statistically significant relationships but does reveal interesting trends.

Data that references "unleaded" or "gasoline" should be considered by the reader to refer to gasoline containing 10% ethanol (E10). The companies that supplied data did not declare if the data relative to their "unleaded" sales was E10 or E0. Considering E10 represents the majority of unleaded volume sold in the United States, it is reasonable to assume the data contained in this analysis is exclusively E10.

Throughout the report, data is presented in multiple formats. Sales figures for both unleaded and E85 may be presented as raw numbers representing total or average gallons sold on a given day. Gallons per day, however, can be a misleading metric if not taken in context with overall fuel volume for each store. For example, if a store sold 500 gallons of E85 and 10,000 gallons of unleaded, E85 would not represent a significant share of the store's fuels business. However, if a store that sells only 3,000 gallons of unleaded each day sold 500 gallons of E85, the biofuel represents a much more significant impact on the store's fuels business. More instructive, therefore, is evaluating E85 sales as a percent of unleaded sales, enabling the comparison of respective volume to the store's overall operation. Consequently, sales data for E85 is often presented as a percent of a store's unleaded sales to provide additional context.

Similarly, pricing data is presented often as the price when a retailer offered unleaded and E85 for sale to its customers. Because ethanol does not contain as much energy per gallon as gasoline, blends of E85 are not sold on an energy equivalent basis (see below).[1] Therefore, E85 is often sold at a price lower than unleaded. Those who analyze the market are interested in the percent discount at which E85 is sold relative to unleaded, which offers a better understanding of whether the fuel is being offered at a price to compensate for the difference in energy density. For this reason, E85 prices are often presented in a format to show the percent at which they are below (or less often above) the comparable unleaded price.

E85 Energy Efficiency

When evaluating the E85 market, it is important to understand the energy efficiency and performance of E85 as a motor fuel. This is a critical element to understanding the relationship between E85 prices and those for unleaded gasoline.

ASTM International defines E85 as a fuel that contains between 51% and 83% ethanol, with the balance made up of gasoline.[2] Ethanol and gasoline contain different amounts of

[1] The only transportation fuels sold on an energy equivalent basis are compressed and liquefied natural gas, which are priced and taxed as gasoline gallon equivalent and diesel gallon equivalent, respectively.

[2] ASTM Specification D 5798; www.astm.org/Standards/D5798.htm

energy, which means there could be tremendous variability in the energy efficiency of E85 sold at retail. The ratio of each fuel component in the final E85 fuel mix can affect the fuel efficiency of vehicles operating on that fuel, and ultimately affect the consumer experience and satisfaction with the fuel.

To assist with market evaluation, the U.S. Energy Information Administration (EIA) uses an average ethanol concentration of 74%. This level takes into consideration blend ratios that benefit fuel performance in certain weather conditions and provides a valuable bench mark, even though the variability in the fuel can be significant. From information submitted to the Fuels Institute by E85 retailers, the EIA average seems to be a fair approximation of market performance. Retailers reported averaging ethanol concentrations below 60% and as high at 83% during certain times of the year and given blending economics. (Fuel blenders may alter the percentage of ethanol used in E85, depending on the price relationship between ethanol and gasoline, to create a fuel that enables the retailer to charge a competitive price and generate the best opportunity for profitability.)

Because the efficiency of each FFV engine can be different, the most conservative way to evaluate the fuel efficiency of FFVs operating on E85 is to base the analysis on the possible energy value of E85. This would represent the highest potential mileage loss case, with some FFVs performing better. In doing this, we can calculate the relative gasoline gallon equivalent (GGE) value for each E85 concentration. (GGE is used to demonstrate how many gallons of E85 would deliver the same energy as one gallon of gasoline, and by extension propel a vehicle the same distance.) While this is not a precise measurement (the BTU[3] value of each gallon of ethanol and gasoline can vary), it provides a credible benchmark.

Clean Cities[4] reports the following energy values:

Ethanol:	**75,700 BTU/gal**
Gasoline (E0):	**115,400 BTU/gal**
E10:	**111,430 BTU/gal**

[3] BTU – British Thermal Units, a standard measure of energy and represents the amount of energy needed to cool or heat one pound of water one degree Fahrenheit.

[4] "Clean Cities Alternative Fuel Price Report," January 2014, page 16.

Because the majority of gasoline sold in the United States is blended with 10% ethanol, the energy value of this blend will be used as the baseline for comparison and for calculating GGE. The energy value and the GGE for various ethanol concentrations used in E85 is presented in Figure 4 using the following calculations:

(111,430 * % gasoline) + (75,700 * % ethanol) = E85 BTU
E85 BTU / E10 BTU = E85 Energy as % of E10
1 Gallon E10 / E85 Energy as % of E10 = GGE

Ethanol Concentration

Ethanol Concentration	E85 BTU	E85 Energy % of E10	GGE
51%	95,153	85.39%	1.17
60%	91,580	82.19%	1.22
70%	87,610	78.62%	1.27
74%	86,022	77.20%	1.3
83%	82,449	73.99%	1.35

Figure 5: *Ethanol Concentration (Source: Fuels Institute)*

From these calculations, the EIA average ethanol concentration of 74% in each gallon of E85 results in an average energy deficit relative to unleaded gasoline of approximately 23%. If this holds true, and assuming there is no boost in fuel efficiency derived from vehicle configuration, consumers would expect to travel 23% fewer miles per refueling visit when operating on E85 compared with E10. Some believe this suggests E85 prices must be set at a level that approximates energy parity—in other words, 23% below the price charged for unleaded—to deliver economic value to the consumer.

Value of RINs and E85 Pricing

An additional factor in E85 pricing not reflected in the data analyzed for this report is the value of RINs, or Renewable Identification Numbers. RINs were established to provide a mechanism for parties obligated by the RFS to blend renewable fuels and demonstrate compliance to the U.S. Environmental Protection Agency (EPA). For every respective gallon of qualified renewable fuels blended into the fuel supply, the blender of record is issued a certain number of RINs, per a regulatory formula. These RINs can then be traded on the open market, sold by the blender and purchased by an obligated party to demonstrate compliance with the RFS program.

For retailers who blend ethanol into gasoline (rather than obtaining pre-blended product), the relative value of the RINs they generate can be a strong motivator to increasing overall biofuel sales. It has been argued that if retailers were to factor the value of RINs into their pricing strategy, E85 would be much more competitively priced than it has been witnessed in the market.

Theoretically, this argument makes sense. However, it is unclear and inconsistent how retailers are accounting for their RINs. Some might be factoring the relative value into the price of E85, while others may be applying it to their overall bottom line. (Margins reported in this data set are pure margins—price sold at retail less laid in cost of fuel product—and are assumed to be independent of associated RIN values.) Further complicating the analysis is the fact that RINs are not sold at the same time as E85. Rather, RINs are generated and then sold to an obligated party at a later time. Because RINs are traded on the commodities market, the value of each RIN changes every day. Consequently, at the time of blending the blender may not know what the value of a RIN will be once it is sold. (Figure 6)

Looking at historical RINs values, it is difficult to anticipate how the market may behave in the future. Further, there is uncertainty surrounding the reaction of policymakers to the movement of the RINs market. There are very few commodities markets that are as heavily influenced by Washington, D.C., as is the RINs market. This lack of certainty and predictability further complicates the ability of retailers to incorporate RINs values into their pricing strategies.

How RINs values are factored into retail operations is considered by many to be a critical element affecting the market for E85. Some retailers have reported to the Fuels Institute that RINs cannot be factored into the retail price of E85 because they are too volatile—they can only affect the bottom line. Yet other stakeholders have noted that RINs are the primary way of enabling E85 to be sold at a price that attracts consumers. Some market experts have noted that RINs values must play a role in the economics associated with biofuel blends like E85, either in the pricing decisions or in supporting marketing strategies by delivering a unique revenue line item. Others have suggested that RINs are simply a "pass-through" cost that is incorporated into the cost of goods sold for all market participants, similar to how taxes are incorporated and passed through the system. From this perspective, RINs would not provide financial value to the blender.

For this analysis, it is left to the reader to determine how RINs may be affecting the market. All prices presented within this report are those posted on the dispenser for customers to pay. It is this basic relationship between retail prices for competing fuels that influences the consumer's purchase decision. The way RINs are or are not factored into these pricing decisions may affect the retailer's profitability, but would not have an influence on the consumer selection process.

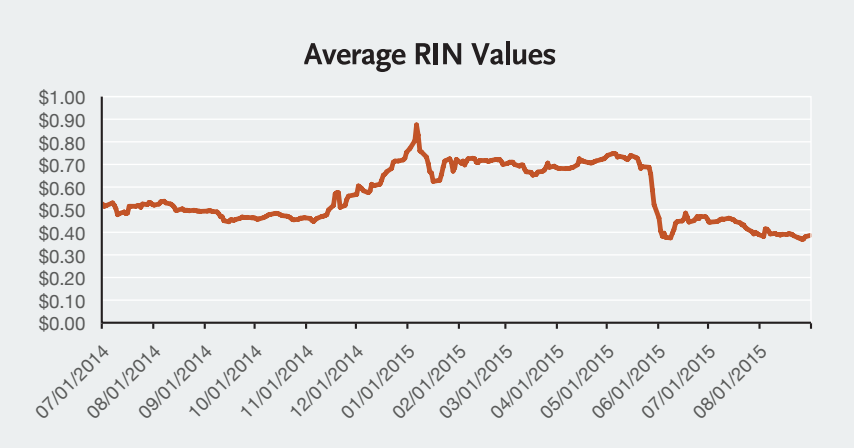


Figure 6: *Average RIN Values (Source: OPIS)*

Government Vehicle Programs

Potentially affecting demand for E85, and influencing the price elasticity of the fuel, are programs requiring certain government vehicles to purchase E85 when available.

According to the U.S. Department of Energy, "The Energy Policy Act (EPAct) of 2005 requires that all Federal alternative-fuel vehicles (AFVs) use alternative fuel all of the time unless it is not available (more than 5 miles or a 15-minute drive away) or is more expensive per gallon than gasoline. In addition, the Energy Independence and Security Act (EISA) of 2007 requires all Federal fleet fueling centers to install at least one renewable fuel pump by 2010."[5]

According to the Federal Automotive Statistical Tool (FAST), in 2015 the federal fleet included 194,210 FFVs.[6] By comparison, the total U.S. fleet in 2015 included approximately 15 million FFVs. Consequently, the federal FFV fleet represented 1.3% of the total FFV population. On a national perspective, it is unlikely that this market share of federal fleets will have a significant impact on E85 sales. However, if these government vehicles are clustered in certain regions of the country, they could have a disproportionate effect on E85 sales within those regions.

Some states have their own alternative vehicle and fuel purchase programs and requirements. The Department of Energy Alternative Fuel Database Center has a tool through which users can search current programs. For details on state programs, readers are encouraged to visit www.afdc.energy.gov/laws.

[5] https://federalfleets.energy.gov/fueling_infrastructure

[6] http://federalfleets.energy.gov/performance_data#inventories

The Data

Overview of All Stores Daily Data

The Fuels Institute collected daily sales data from 620 stores from July 2014 through August 2015. Retailers provided the Institute with the daily retail price of regular unleaded and E85 and the daily sales volume. This section takes a holistic view of that significant collection of data, presenting some general observations that are possible when assessing so many data points. The analysis in this section is by necessity broad, and additional levels of analysis will be presented in later sections based on a consolidation of the raw data into appropriate and more easily analyzed buckets.

Figures 7a and 7b show that the stores in the sample set sold an average of 5,920 gallons of unleaded each day at a price of $2,651 compared with 241 gallons of E85 at a price of $2.213. These averages represent an E85 price that was $0.438 below unleaded, or 16.1% lower. E85 sales averaged 4.77% of total unleaded sales. (Figures 7a and 7b)

The range of price differentials between unleaded and E85 daily from all 620 stores is significant, from E85 priced $3.43 higher than unleaded to as much as $2.32 lower than unleaded at a given store on a given day. Figure 8 plots the daily volume of E85, expressed as a percent of unleaded volume, from each store when E85 was priced at a certain percentage below (or more rarely above) unleaded. (The peaks in the chart represent days in which stores reported

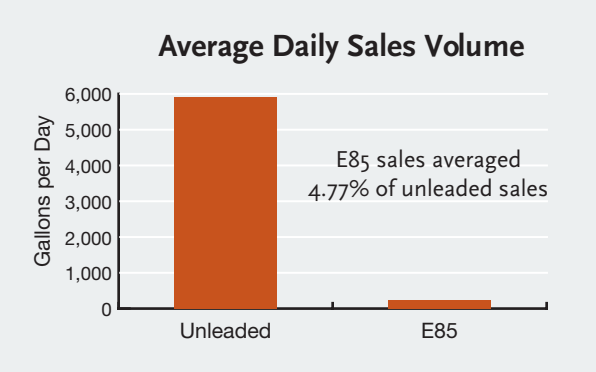


Figure 7a: *Average Daily Sales Volume (Source: Fuels Institute)*

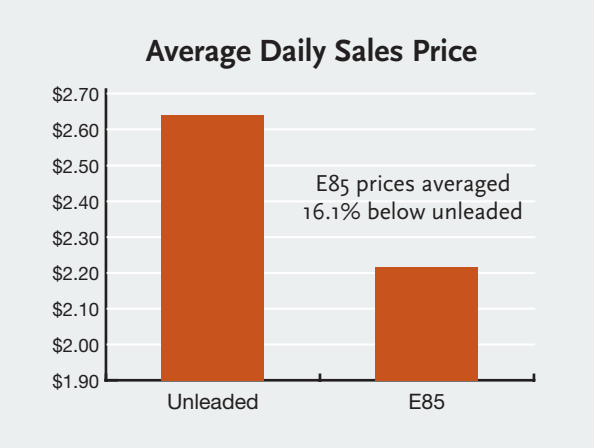


Figure 7b: *Average Daily Sales Price (Source: Fuels Institute)*

that E85 volume exceeded that of unleaded, resulting in a percentage that exceeds 100%.)

The data represents every day for every store in the sample set and shows a real range in pricing strategies and relative performance. Presented in this manner, the data demonstrates that E85 sales have a correlation to the price of E85 relative to unleaded, but this is by no means absolute or linear. In addition, individual stores recorded significant variations from the rule. Yet it is instructive that, in general, there was an observable, if inconsistent, increase in E85 volumes as the discount from unleaded increased. (Figure 8)

Although the price at which E85 is sold relative to unleaded also varies greatly, there is some consistency. Figure 9 plots every price point recorded by every store for every day in the sample period, showing E85's price discount relative to unleaded as a percent. The data shows the average daily price difference was 16.1% below unleaded. (Figure 9)

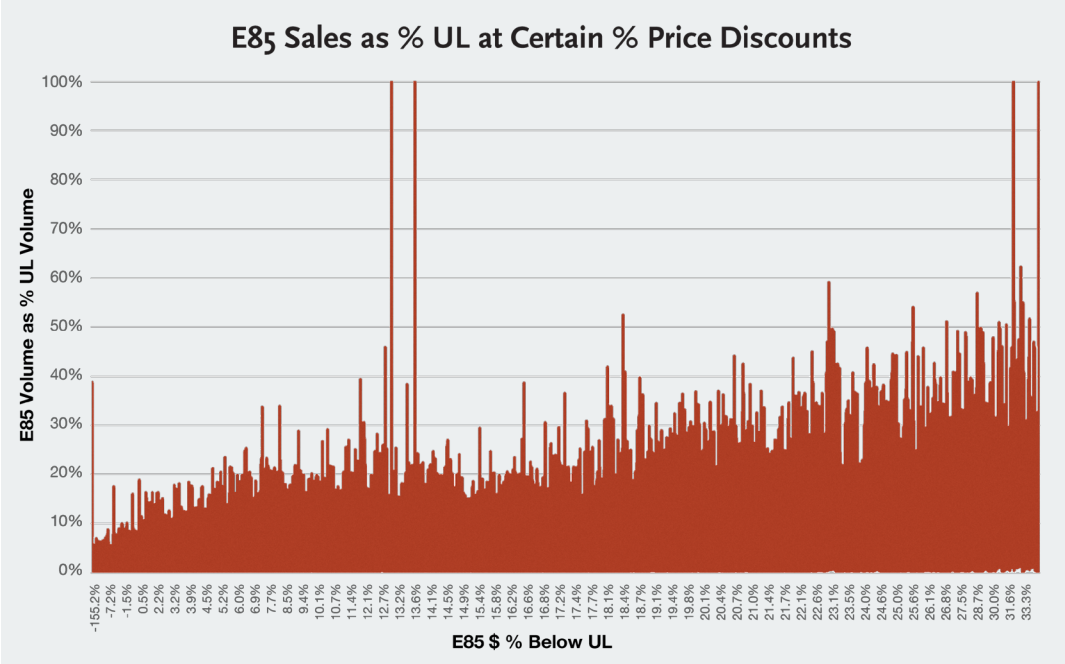


Figure 8: *E85 Sales as % UL at Certain % Price Discounts (Source: Fuels Institute)*

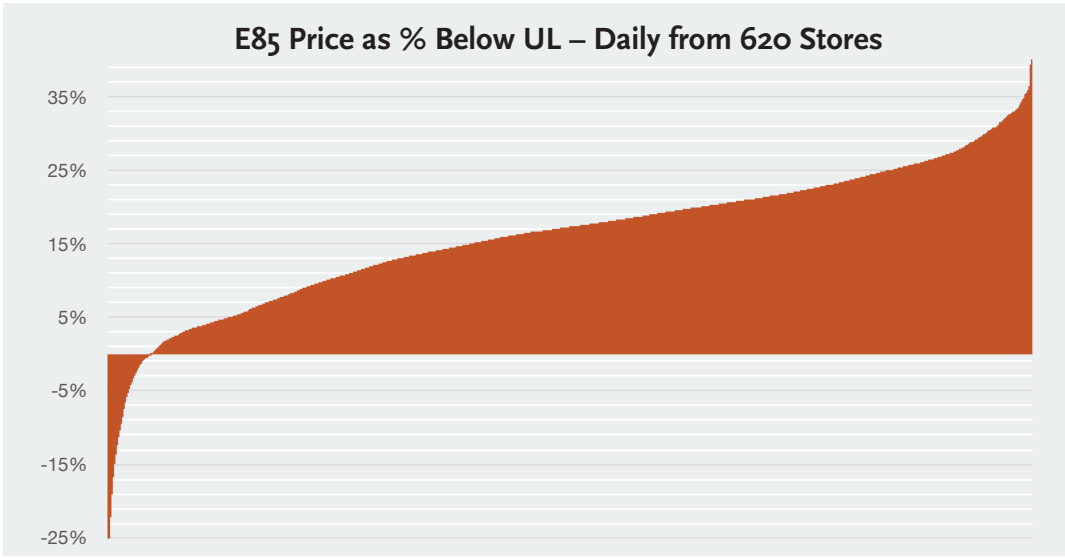


Figure 9: *E85 Price as % Below UL – Daily from 620 Stores (Source: Fuels Institute)*

Figure 10 plots the relationship between the price of E85 expressed as a percent below unleaded and the volume of E85 expressed as a percent of unleaded volume. Included in the chart are the applicable R and R^2 values. (Figure 10)

The R value, the correlation coefficient, refers to the relationship between the variables. An R value of 1.0 or -1.0 indicates the variables are perfectly related, whereas a value of 0.0 indicates no observed relation. In this case, the data from all 620 stores for every day over the 14-month period observed returned a positive R value of 0.3979 for E85 price as a percent of unleaded and E85 volume as a percent of unleaded. It is important to note that correlation does not prove or disprove causation. There are a wide number of variables that can influence E85 sales volumes– the relation between price and volume relative to unleaded is just one metric available for analysis.

The R^2 value refers to the degree to which the data "fits" a model, in this case the linear trendline drawn on the chart. An R^2 value of 1.0 indicates a perfect fit, meaning that the observed data is consistent and predictable with the model. A value of 0.0 indicates the data does not fit the model well. The R^2 value is determined by an analysis of the distance of data points from the trendline. In this case, the data returns an R^2 value of 0.1583, indicating that the data is not closely following the trendline "model." Consequently, if one wanted to extend the trendline beyond the bounds of the graphic it would have very little predictive value to future data points that might be observed. (Additional R and R^2 analyses will be presented for select individual stores later in this report.)

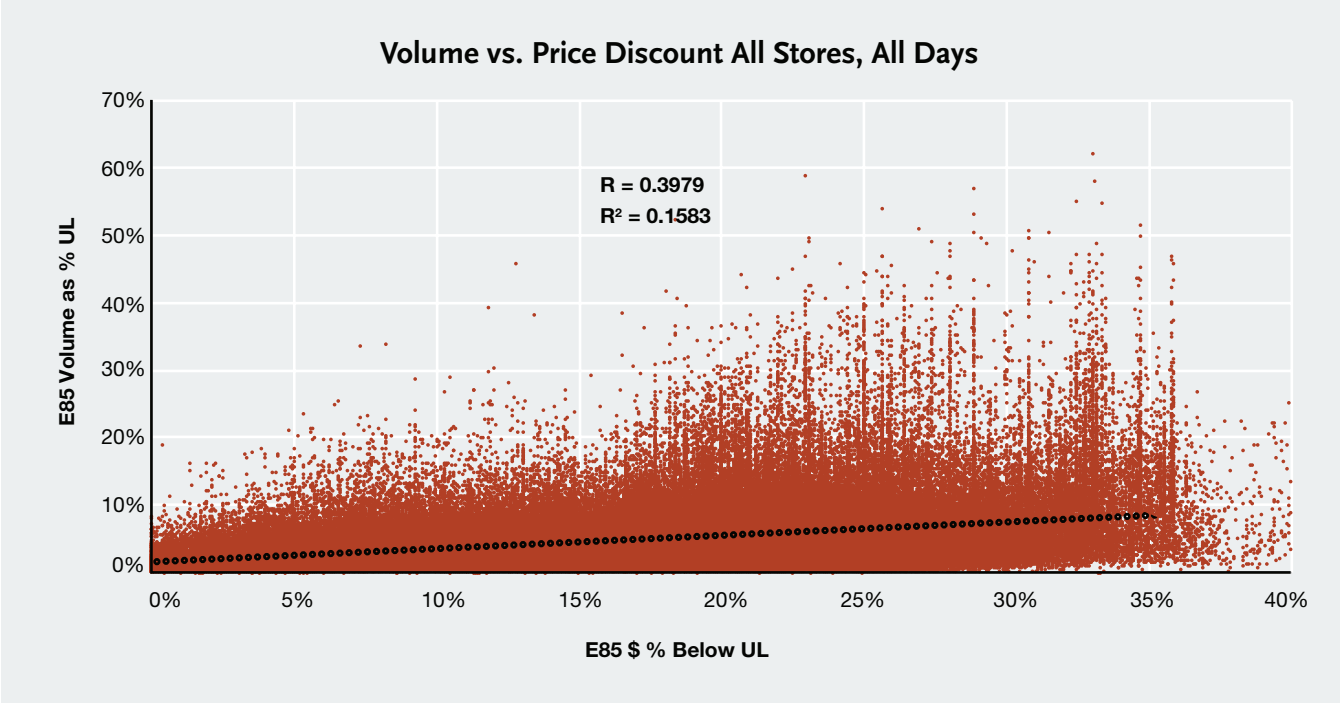


Figure 10: *Volume vs. Price Discount at All Stores, All Days (Source: Fuels Institute)*

To more clearly show the price elasticity of E85 compared to unleaded, Figure 11 presents the average price of unleaded and E85, along with the volume of E85 (as a percent of unleaded volume) for all stores that provided data for a specific date. While the stores in the sample set vary by region and operator, and therefore respective market price influences vary greatly, the chart demonstrates that as the retail price of unleaded changed, E85 prices did not immediately mirror the change in price. Consequently, as the prices of unleaded and E85 converged, the volume of E85 sales declined significantly. As the prices diverged and retailers resumed offering a discount for E85, sales recovered. This supports the assertion that E85 sales are largely dependent upon the price at which a retailer offers the product for sale relative to the price charged for unleaded. (Figure 11)

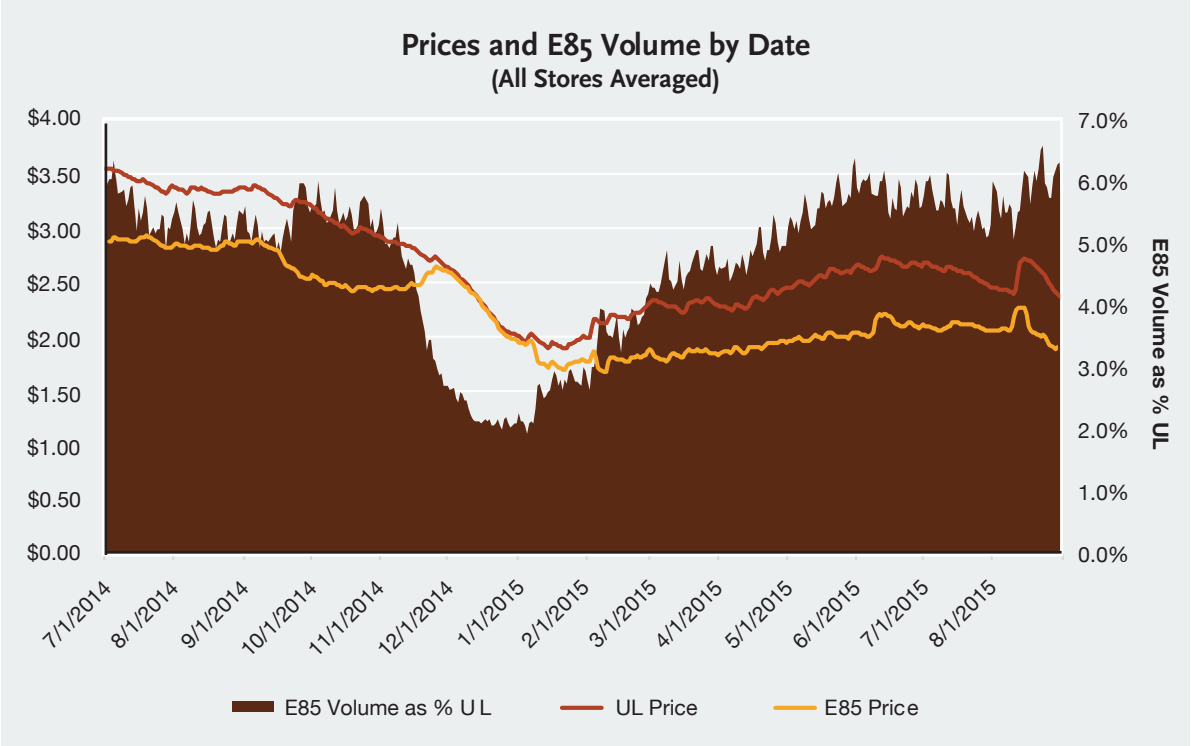


Figure 11: *Prices and E85 Volume by Date (All Stores Averaged) (Source: Fuels Institute)*

Figure 12 presents the difference in retail prices and the resulting E85 volume as a percent of unleaded. This graph shows clearly that E85 volume trends with, but does not perfectly mirror, the E85 discount to unleaded. (Figure 12)

To understand why E85 prices converged with unleaded prices at the end of 2014 and early 2015, it is important to understand what was happening with wholesale prices. Figure 13 plots prices recorded on the Chicago Mercantile Exchange for RBOB (reformulated blendstock for oxygenate blending), CBOB (conventional blendstock for oxygenate blending) and ethanol. Notice that at the end of 2014 and early 2015, ethanol prices rose above those for gasoline blendstocks, which corresponds to the convergence in retail prices reported by the retailers in the Fuels Institute's sample set. The wholesale prices again converged at the end of August 2015, which had not yet manifested itself at the retail level of trade as the Fuels Institute's sample period closed. (It can take weeks for a change in wholesale prices to be fully reflected in prices charged to consumers at the retail facility.) We can compare the data presented in Figures 12 and 13 to better understand the relationship between wholesale prices and retail prices of unleaded and E85.

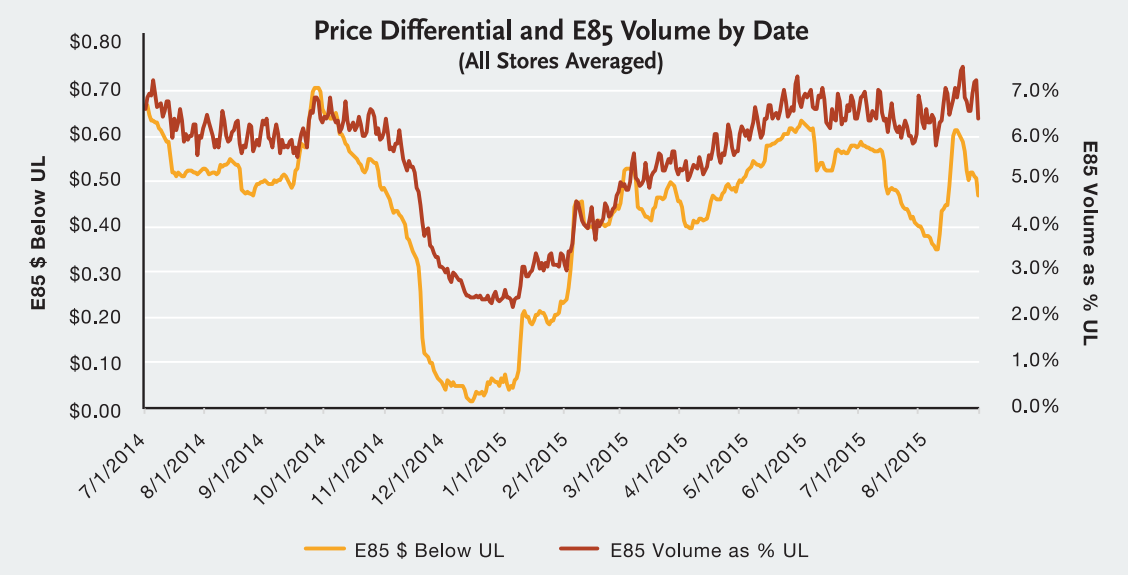


Figure 12: *Price Differential and E85 Volume by Date (All Stores Averaged) (Source: Fuels Institute)*

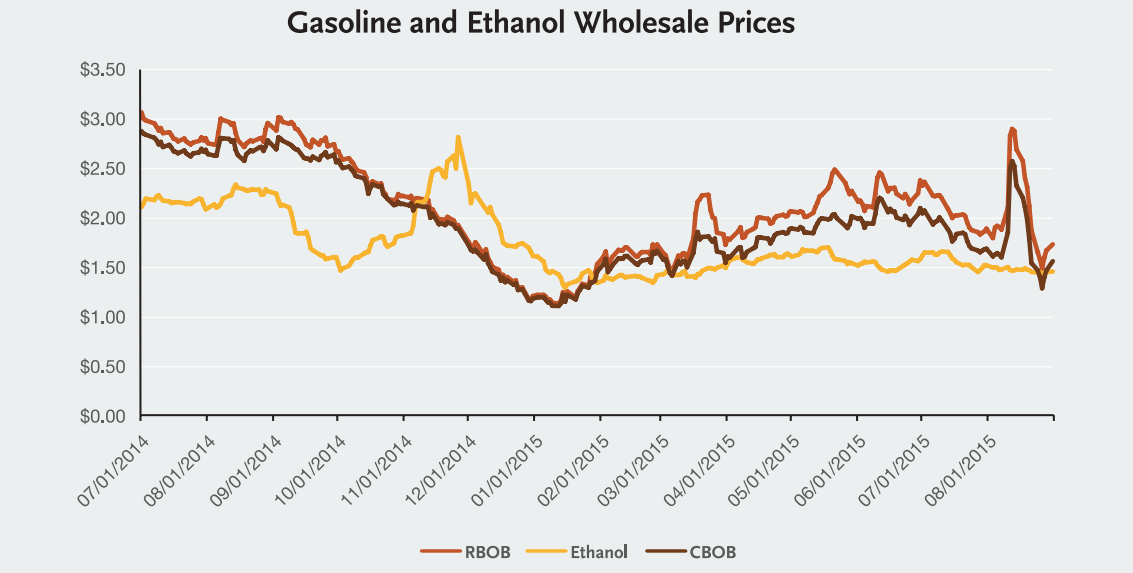


Figure 13: *Gasoline and Ethanol Wholesale Prices (Source: Oil Price Information Service)*

Average Store Level Analysis

To provide an additional method for analyzing the data from the sample set, this section averages the performance of each store from July 2014–August 2015, and compares each store against the others based upon these calculated daily average values.

E85 sales for individual stores varied significantly from the average. Figure 14 plots each store's average E85 volume in pure gallons sold each day over the time period. The E85 daily sales volume ranged from a low of 31 gallons per day at one store to 1,469 gallons per day at another. (Figure 14)

As noted in the introduction, however, gallons per day can be misleading. Therefore, Figure 15 shows each store's average E85 volume expressed as a percent of the store's average daily unleaded volume. In this context, E85 sales ranged from a low of 0.63% of unleaded volume at one store, with an average price $0.459 (18.6%) below unleaded, to a high volume of 38.61% at another store, with an average price $0.693 (26.51%) below unleaded. As seen from the chart, and seen again later in this report, stores within this sample set with lower unleaded volumes tend to have higher E85 sales when expressed as a percent of unleaded volume. (Figure 15)

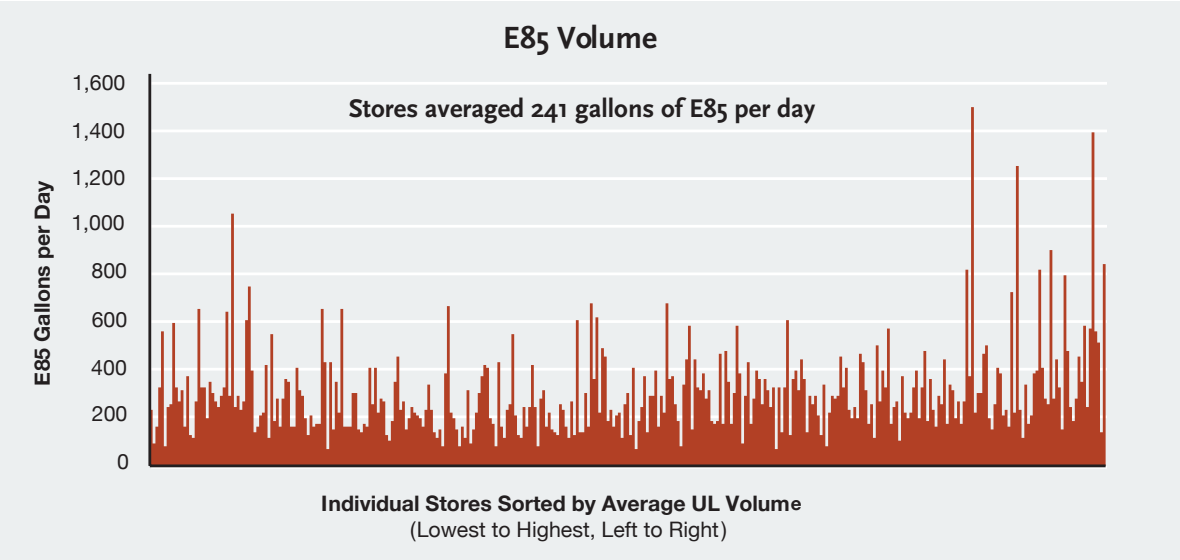


Figure 14: *E85 Volume (Source: Fuels Institute)*

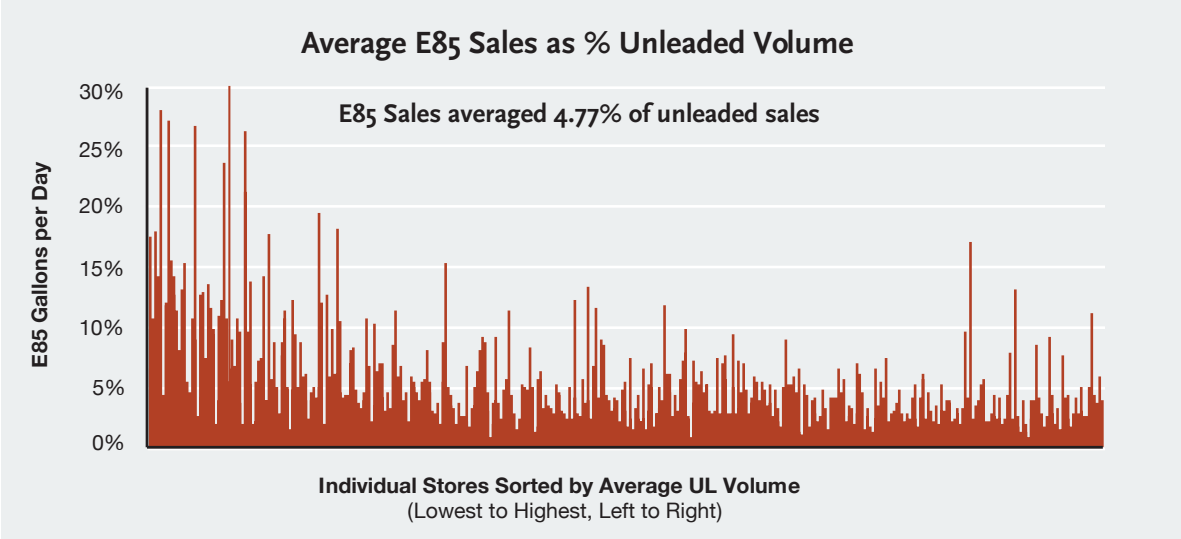


Figure 15: *Average E85 Sales as % Unleaded Volume (Source: Fuels Institute)*

The pricing strategy for E85 was quite varied across the sample set. Figure 16 plots the average price of E85 and the average price of unleaded for each store during the sample period. (Figure 16)

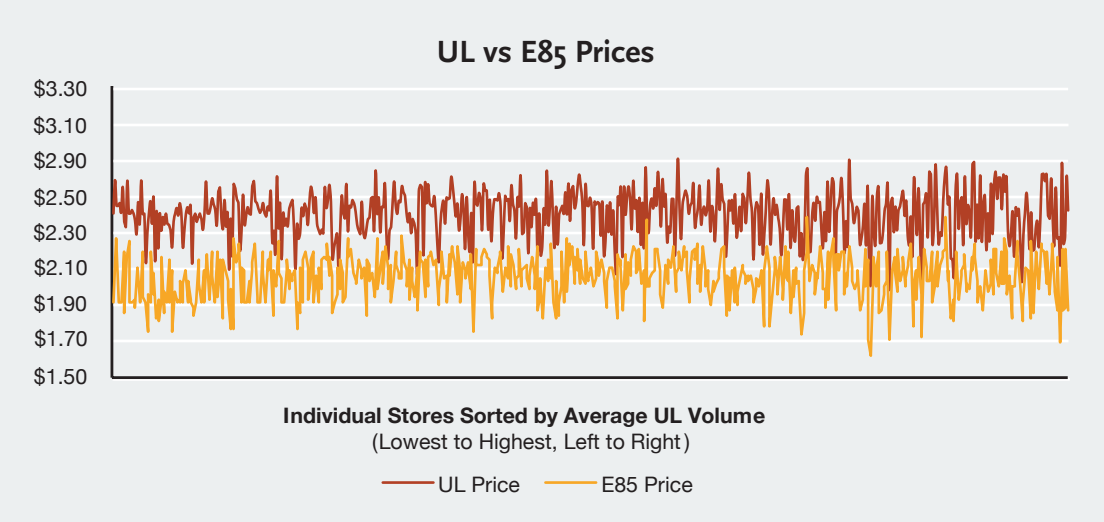


Figure 16: *UL vs E85 Prices (Source: Fuels Institute)*

On average, E85 was priced $0.438 below unleaded, which was equal to a 16.1% discount. However, during the sample period, the average price at which E85 was offered for sale relative to unleaded ranged from $0.112 (4.57%) below unleaded at one store, to $0.892 (31.0%) below unleaded at another store. Figures 17–18 show the average price below unleaded that E85 was offered for sale at each store in the sample set in both real terms (dollars per gallon) and as a percent below unleaded. (Figures 17 and 18)

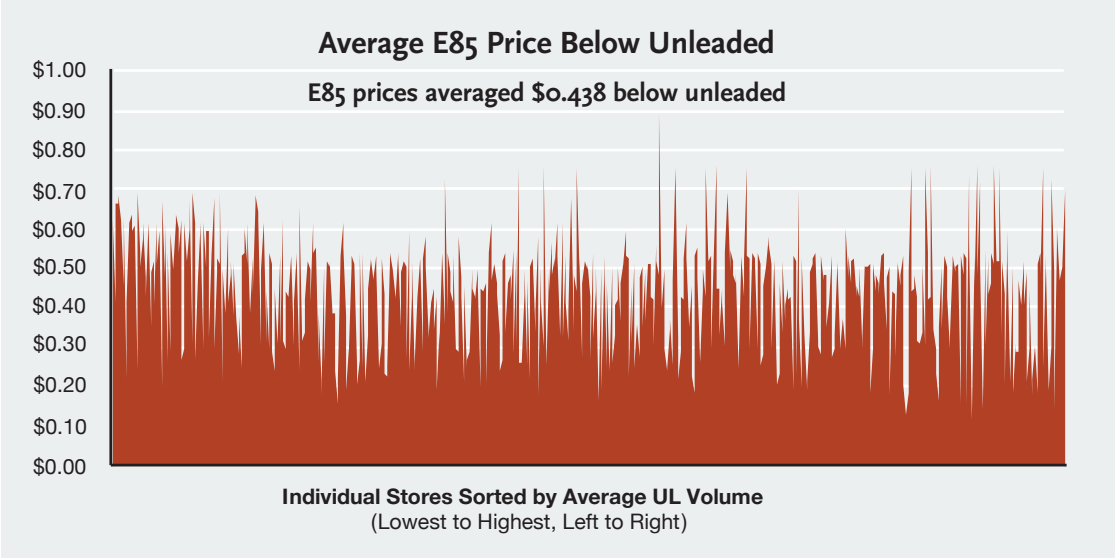


Figure 17: *Average E85 Price Below Unleaded (Source: Fuels Institute)*

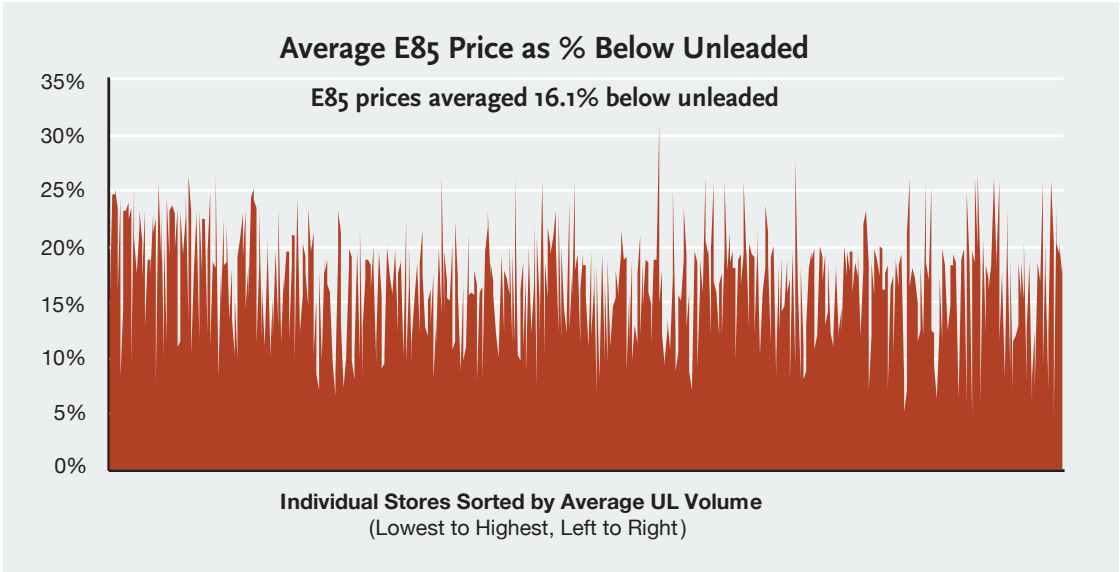


Figure 18: *Average E85 Price as % Below Unleaded (Source: Fuels Institute)*

When evaluating the raw data from each store on every day during the sample period, it was evident that there is a degree of price sensitivity affecting E85 sales: The larger the price difference between unleaded and E85, the more likely a store is to generate a higher volume of E85 sales. However, the effect of E85's price discount relative to unleaded and its impact on E85 sales is not a straight line relationship. Figure 19 plots each store's average price discount (expressed as percent below unleaded) compared directly with the E85 volume (expressed as a percent of unleaded volume). The two values are plotted against each for each store. (Figure 19)

There appears to be some consistency for stores that price E85 closer to the price of unleaded in that they tend to have a lower E85 sales volume, but there is inconsistency regarding greater discounts and the effect on sales volume. Also of note is the relatively few retail locations that average an E85 price that is 23% or more below unleaded. Remember, the correlation coefficient (R value) for the 620 stores based on their daily values was 0.3979, and the coefficient for the store averages is not much different at 0.3732, which is reflected in Figure 19. This shows how the correlation between price and volume is limited. When isolating attention on those stores that priced E85 at estimated energy parity, the effect on volume was likewise inconsistent—not every store that approached parity reported noticeably higher sales volumes.

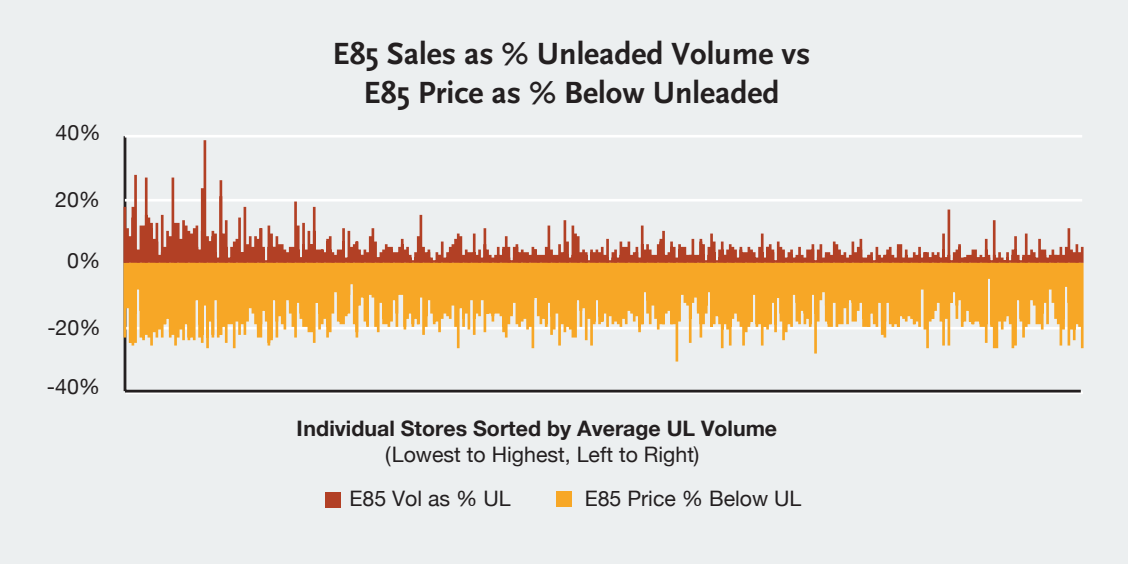


Figure 19: *E85 Sales as % Unleaded Volume vs E85 Price as % Below Unleaded (Source: Fuels Institute)*

Sales Impact

The primary business of fuel retailers is to generate customer transactions and make money. Profitability at the fuel dispenser is expressed as margins: the difference between what the retailer paid to acquire the product and the price at which the customer purchased it. This gross margin does not necessarily equate to profit because it does not account for other associated costs, but it is the basis for calculating profitability. For E85, the margins expressed in this section may or may not factor a value for RINs (renewable identification number). This information was not requested nor supplied by the firms providing data. (See introduction for further discussion on RINs and E85 pricing.)

For this report, not every firm that submitted data to the Fuels Institute submitted information pertaining to fuel margins, so a full analysis of the 620 stores is not available. However, 189 stores did provide this full set of information. For this section, we will analyze retail prices and volumes for all 620 stores and margin data for the 189 stores that provided such information.

The effect of fuel sales on overall store transaction value is a product of price times volume. Among the stores in the sample, the revenue value of unleaded sales on a daily basis ranged from a low of $3,629 at one store to a high of $43,403 at another store. By comparison, E85 sales revenue ranged from a low of $67 at one store to a high of $3,314 at another store. (Note the different ranges of each vertical axis in Figure 20; the range of each is similar, but the values plotted differ in magnitude by a ratio of 10:1.)

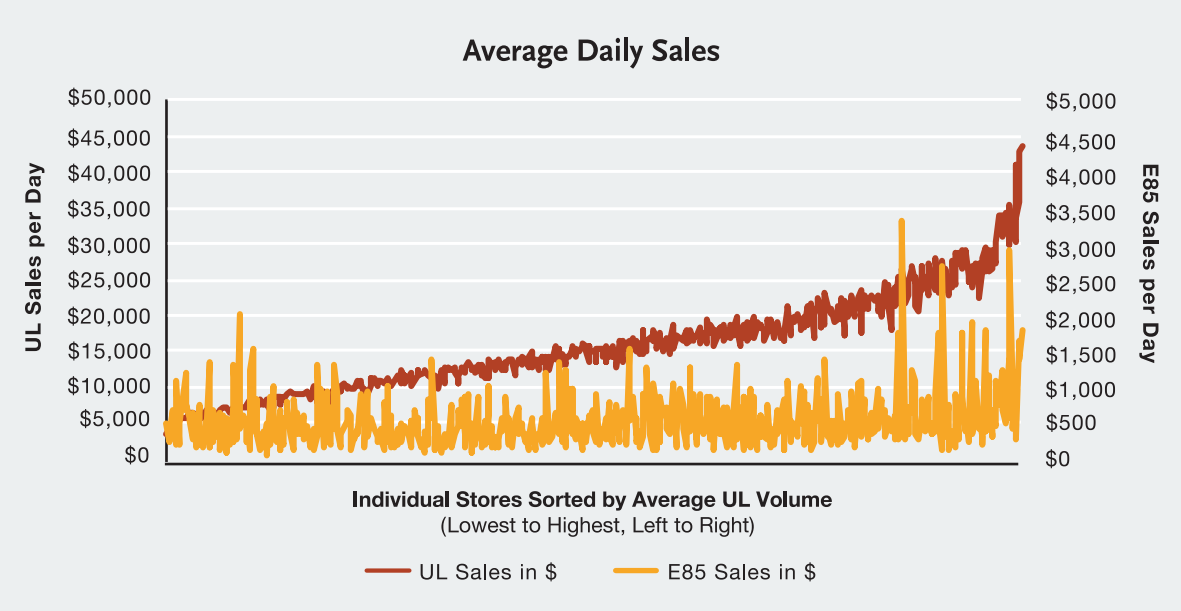


Figure 20: *Average Daily Sales (Source: Fuels Institute)*

In terms of profitability, the smaller sample set of stores that provided margin data is presented in Figure 21. Profitability is defined in this chart as gross margins times volume. In this sample set, average daily margins for unleaded sales ranged from a loss of ($482) at one store to a profit of $4,333 at another. Unleaded margins on a per gallon basis ranged from a negative ($0.121) at one store to $0.337 at another. E85 sales profits ranged from a loss of ($78) at one store to a profit of $218 at another. Per gallon margins ranged from a loss of ($0.884) at one store to a profit of $0.461 at another. The stores that reported margins averaged $0.157 per gallon for unleaded and $0.006 per gallon for E85. (Note the different ranges of each vertical axis in Figure 21; the range of each is similar, but the values plotted differ in magnitude by a 10:1 ratio.)

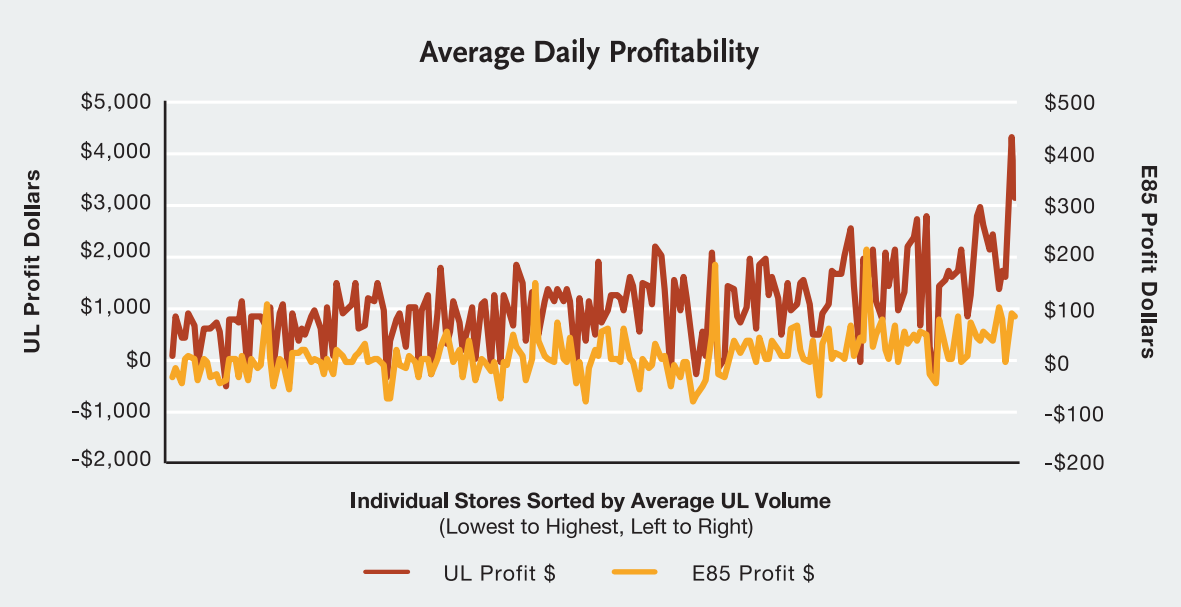


Figure 21: *Average Daily Profitability (Source: Fuels Institute)*

Quartiles Analysis

Analyzing the average performance of each store, as provided in the previous section, provides a strong frame of reference—and it demonstrates clearly that retailers make marketing decisions independently. Yet it may be difficult to determine what strategies yielded the best performance. An instructive comparison method is provided by breaking the stores into quartiles, based on the importance of E85 to the overall fuels business and E85 volume as a percent of unleaded volume. The top quartile represents the 25% of stores with the highest E85 volume percent, while the bottom quartile represents the lowest volume percent.

The spread in performance is pronounced (see Figure 22), with top quartile stores averaging E85 sales that approach 10% of unleaded sales, compared to stores in the bottom quartile whose E85 sales fall short of 2% of unleaded sales. The average E85 price for top quartile stores was nearly 20% below that for unleaded, whereas stores in the bottom quartile priced E85 on average 16% below unleaded. It is worth noting that not even top quartile stores averaged E85 prices that matched the 23% estimated threshold for energy parity. (Figure 22)

Interestingly, the stores that comprised the top quartile in terms of E85 sales recorded the lowest volume of unleaded sales. To determine if this relationship could be attributed to the average of stores across quartiles, Figure 23 shows the relationship for every store in the sample set, plotting the average daily unleaded volume compared with the volume of E85 as a percent of unleaded. This chart demonstrates that E85 tends to represent a greater percentage of a store's business when unleaded volume at the location is low. (Figure 23)

Quartile	UL Volume (Gallons/ Day)	UL Price/ Gallon	UL Margin/ Gallon	E85 Volume (Gallons/ Day)	E85 Price/ Gallon	E85 Margin/ Gallon	E85 as % UL Volume	$ Diff (UL–E85)	% Price Diff
1	4,606	$2.650	$0.134	405	$2.129	$0.109	9.84%	$0.521	19.60%
2	5,780	$2.653	$0.148	252	$2.237	$0.070	4.48%	$0.416	15.54%
3	6,589	$2.625	$0.148	180	$2.216	$0.023	2.83%	$0.409	15.49%
4	6,872	$2.617	$0.170	108	$2.202	-$0.057	1.61%	$0.416	15.81%

Figure 22: *Average Store Performance (Source: Fuels Institute)*

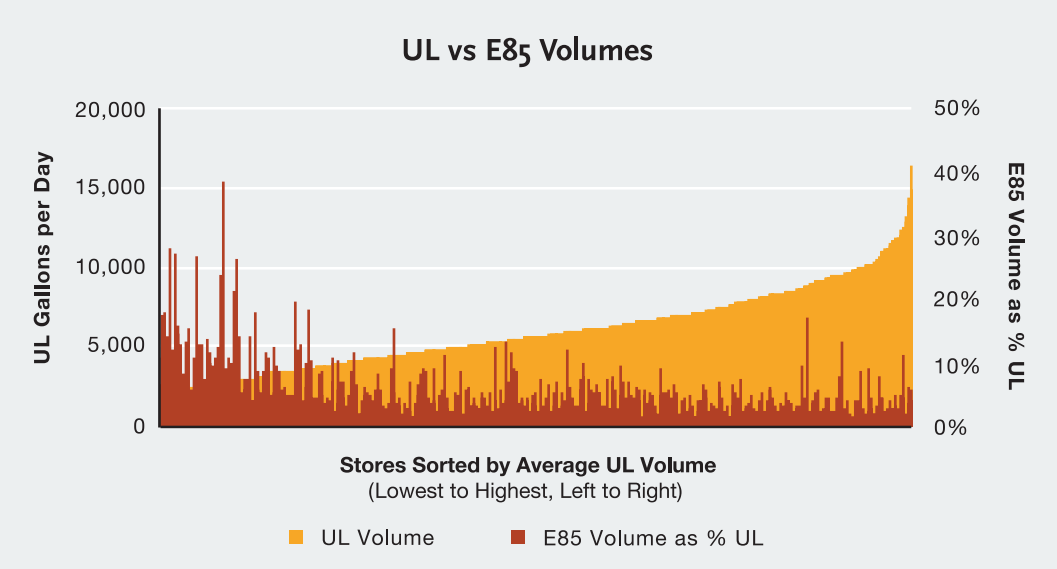


Figure 23: *UL vs E85 Volumes (Source: Fuels Institute)*

It is impossible to determine why this is the case because the store-level data was anonymized and store location information (when provided by the retailer) was stripped from the data. We could speculate that the stores with highest E85 volumes and lowest unleaded volumes may be located in more rural, agricultural areas where overall demand was lower than urban environments, and that customers have a closer affinity for biofuels due to their relationship with agriculture. If this is correct, another potential influence is the propensity of drivers in rural markets to drive light duty trucks. According to Navigant Research, 77% of registered flexible-fuel vehicles (FFVs) in 2016 were light-duty trucks, which could yield a higher potential demand for E85 in rural markets. In absence of geographical data for the stores represented in the sample or details on regional vehicle registrations, this is purely a speculative hypothesis. (Figure 24)

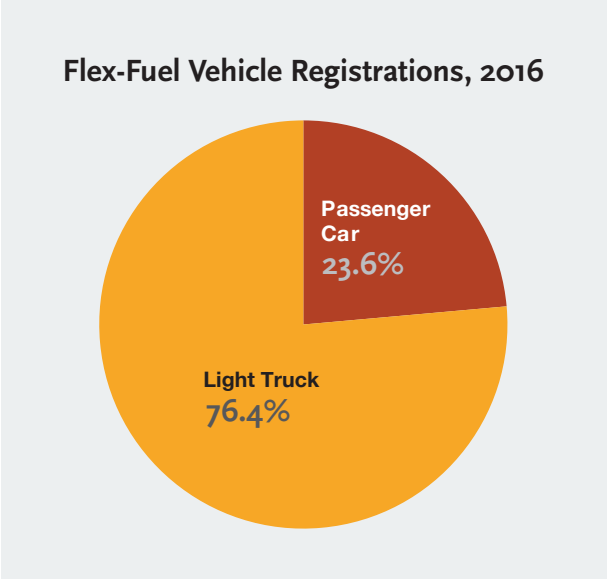


Figure 24: *Flex-Fuel Vehicle Registrations, 2016 (Source: Navigant Research)*

To evaluate the impact of E85 sales on overall store operations, consider daily refueling occasions for unleaded and E85 per store. According to NACS, the average fill-up is approximately eight gallons. Using this metric, top quartile E85 stores completed on average nearly 50 E85 transactions each day compared with 576 unleaded transactions. This is likely overstated, considering a significant market share of FFVs on the road are larger vehicles, like pickup trucks, which typically purchase more gallons per visit than the average car customer. In this scenario, if we assume the average refuel occasion was 15 gallons (we will not attempt to allocate size of fuel tank for unleaded customers for purposes of this analysis and assume all transactions average 15 gallons), E85 customer transactions would represent 27 customers each day for the top quartile stores compared with 307 unleaded transactions. Using the same refueling occasion statistics, bottom quartile stores would average between seven and 13 E85 customers per day, compared with 458 to 859 unleaded customers, respective to the 15- and 8-gallon refuel occasions. (Figure 25)

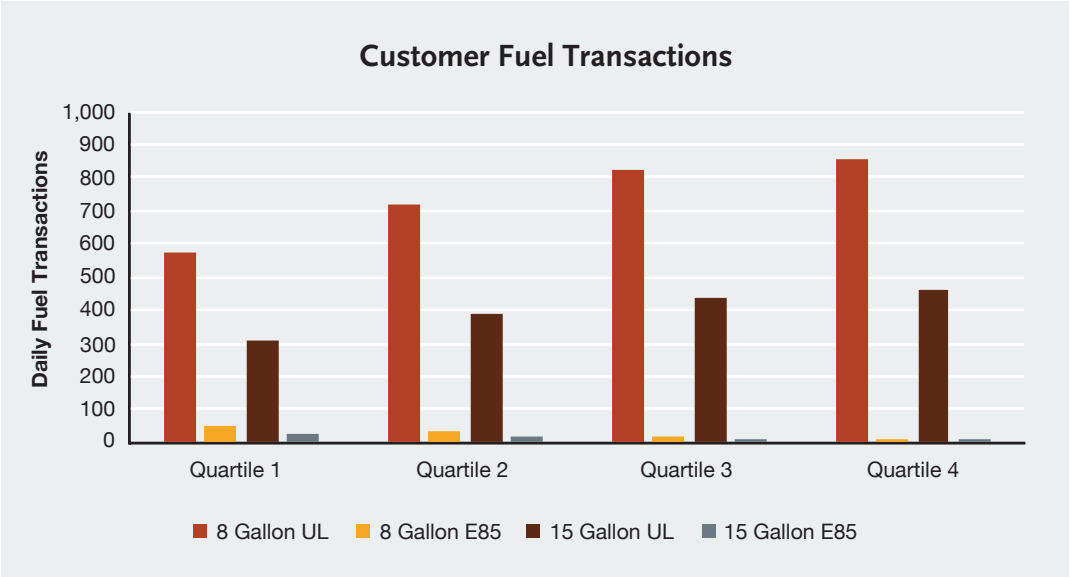


Figure 25: *Customer Fuel Transactions (Source: Fuels Institute)*

Figure 26 infers there are factors other than just price that influence how much E85 a store might sell. From this chart, we see that stores in the top quartile are much more aggressive in pricing E85 and that translated into E85 representing a greater share of their overall fuel business. However, the effect of pricing strategies on E85 volumes seems to vary among the remaining three quartiles. For example, stores in the second and fourth quartile seem to offer E85 at a similar discounted price compared with unleaded, but fourth quartile stores generated significantly lower E85 sales despite this similarity in pricing strategy. Hence, other factors must be playing an influential role. (Figure 26)

Figure 27 presents the quartiles pricing strategies compared with E85 sales volumes in terms of the real average price of E85 below unleaded. This chart provides further evidence that pricing is not the only factor relating to E85 sales. (Figure 27)

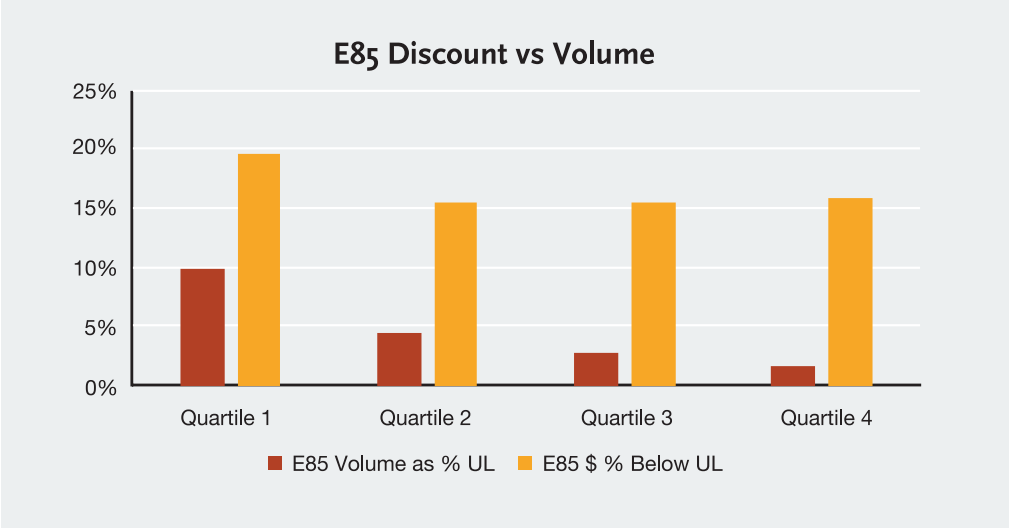


Figure 26: *E85 Discount vs Volume (Source: Fuels Institute)*

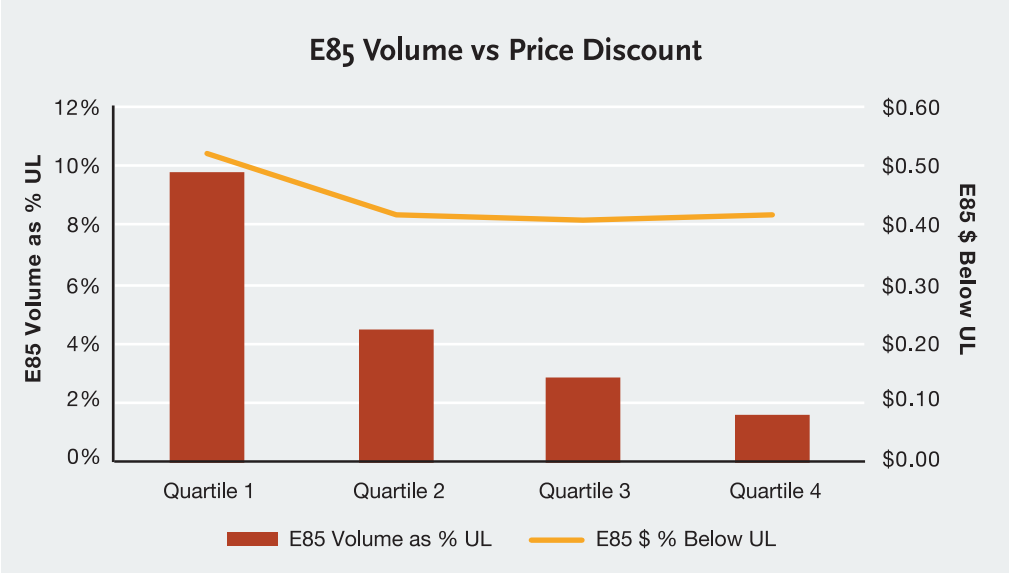


Figure 27: *E85 Volume vs Price Discount (Source: Fuels Institute)*

Individual Store Analysis: Top 5, Middle 5 and Bottom 5 Stores

In preparing this analysis, there was a desire to better understand the business of E85 on a store level basis. The robust quantity of data provided by retailers for this report is overwhelming to attempt an evaluation of every store, yet only comparing averages may disguise some information that could be relevant. Therefore, this section will look closely at the daily sales information from 15 individual stores.

In selecting the stores to profile, each store in the sample set was ranked in terms of E85 sales expressed as a percent of unleaded (same methodology used to segment the data into quartiles). The top five stores, the middle five and the bottom five stores were then selected for comparable analysis. In the event a store within these positions did not provide at least six months of sales data (some stores in the sample did not start selling E85 at the beginning of the sample period), the next viable option in the list was selected for analysis. Figure 28 presents the raw data for each of these stores. Note the return of a clear and consistent pattern—the stores that ranked higher in terms of E85 sales also tend to report the lower volumes of unleaded sales. (Figure 28)

	Store Number	UL Gallons/ Day	UL Price/ Gallon	E85 Gallons/ Day	E85 Price/ Gallon	E85 Volume as % UL	E85 $ Below UL	E85 $ % Below UL
Top 5 E85 Volume Stores	T-1	2,212	$2.640	595	$2.047	27.22%	$0.594	22.48%
	T-2	2,538	$2.640	658	$2.045	26.64%	$0.596	22.56%
	T-3	2,867	$2.639	748	$2.043	26.33%	$0.596	22.60%
	T-4	2,739	$2.641	640	$2.043	23.57%	$0.598	22.65%
	T-5	2,863	$2.640	602	$2.045	21.18%	$0.596	22.56%
Middle 5 E85 Volume Stores	M-1	6,078	$2.694	215	$2.392	3.63%	$0.302	11.22%
	M-2	4,799	$2.771	169	$2.299	3.62%	$0.472	17.02%
	M-3	8,324	$2.688	295	$2.170	3.60%	$0.518	19.27%
	M-4	3,980	$2.261	140	$2.110	3.59%	$0.151	6.69%
	M-5	9,017	$2.509	309	$2.276	3.59%	$0.234	9.31%
Bottom 5 E85 Volume Stores	B-1	6,634	$2.349	60	$1.933	0.88%	$0.416	17.70%
	B-2	4,737	$2.716	39	$2.303	0.82%	$0.412	15.19%
	B-3	9,759	$2.499	80	$2.069	0.81%	$0.430	17.20%
	B-4	7,559	$2.843	61	$2.314	0.81%	$0.528	18.58%
	B-5	9,521	$2.473	59	$2.014	0.63%	$0.459	18.58%

Figure 28: *Daily Sales Performance (Source: Fuels Institute)*

The sales of E85, expressed both in terms of total daily gallons and as a percent of unleaded for each of the stores profiled in this section, is presented in Figure 29. There is a significant and unmistakable drop in E85 volumes between the top five stores and the rest of the profiled stores. (Figure 29)

Average retail prices for each profiled store throughout the sample period are presented in Figure 30. The top five E85 stores seemed to maintain a similar pricing strategy with E85 relative to unleaded, whereas the others were less consistent. (Figure 30)

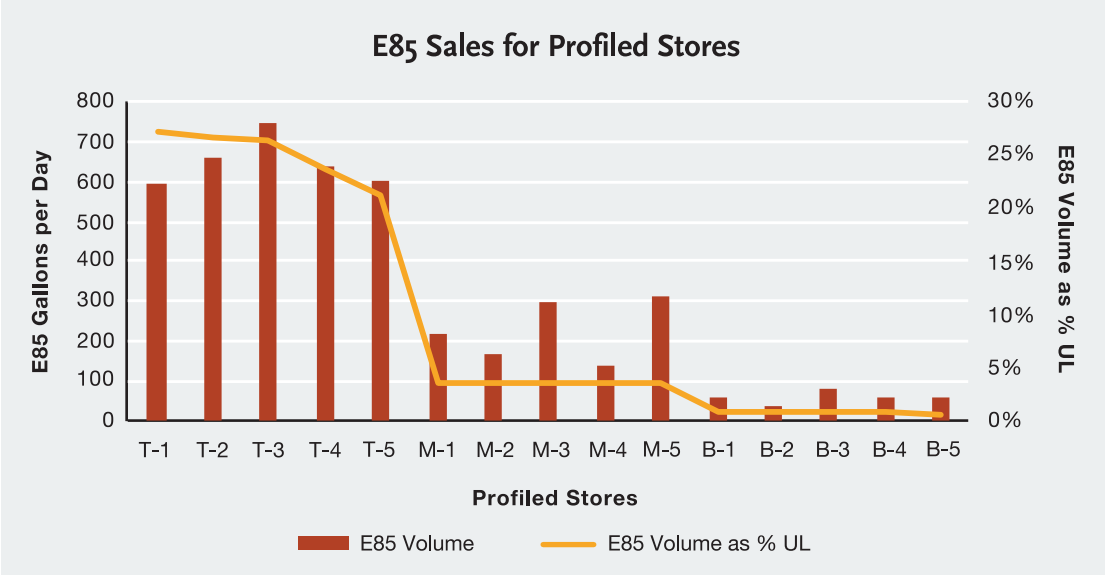


Figure 29: *E85 Sales for Profiled Stores (Source: Fuels Institute)*

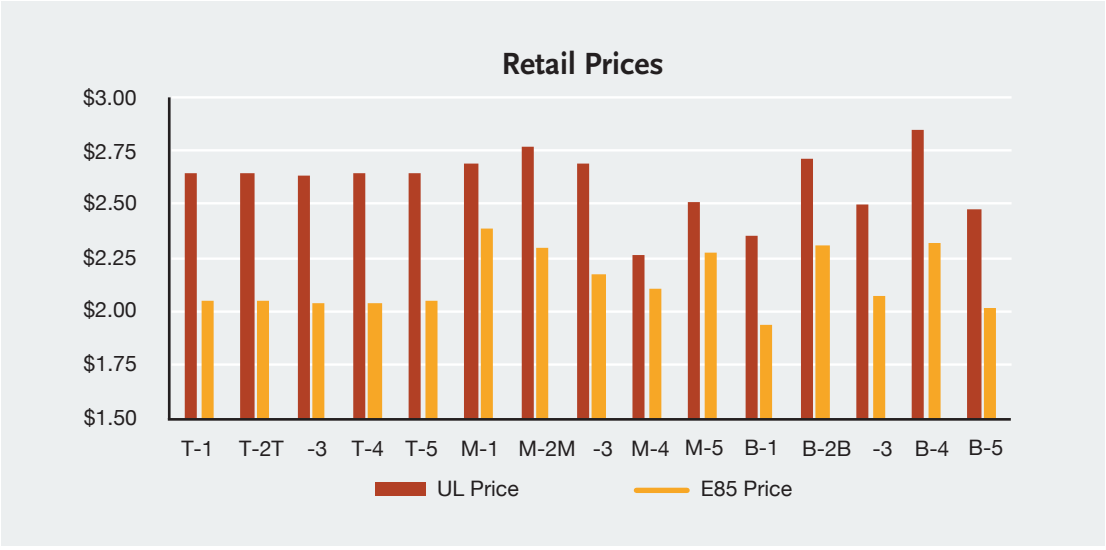


Figure 30: *Retail Prices (Source: Fuels Institute)*

This observation is further demonstrated in Figure 31, which shows the price E85 was sold below unleaded in both real dollars and as a percent. The average discounted price was higher for the top five stores in both real and percentage terms. (Figure 31)

As previously noted, there is a clear relationship in the sample set between the importance of E85 sales to a store's business and the volume of unleaded. Figure 32 reveals that the top five stores profiled had the lowest volume of unleaded sales, resulting in E85 representing a much more significant share of the store's fueling business. Again, the causal factors generating this relationship are unknown, but the relationship is unmistakable. (Figure 32)

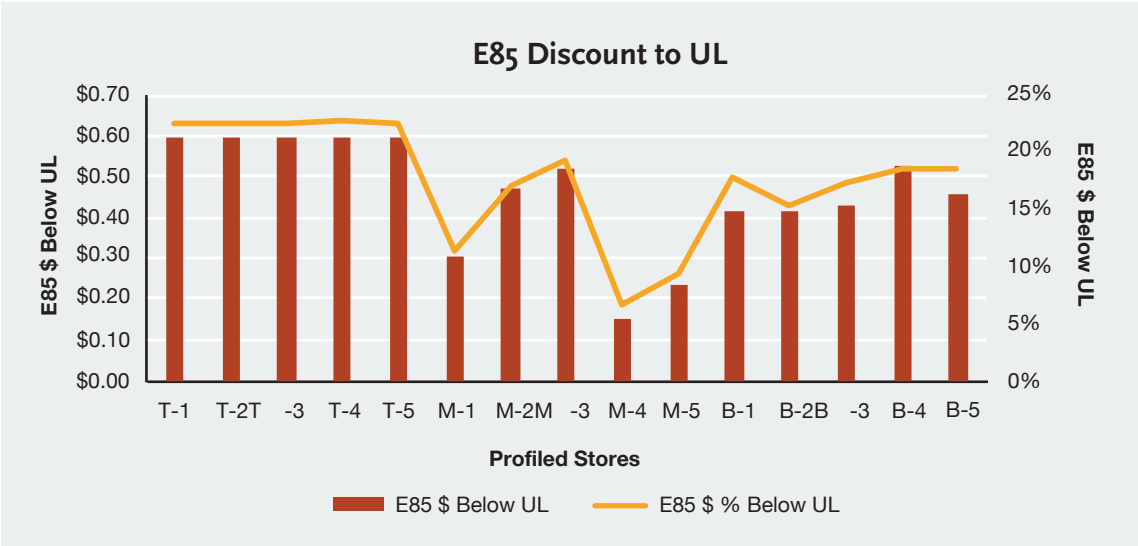


Figure 31: *E85 Discount to UL (Source: Fuels Institute)*

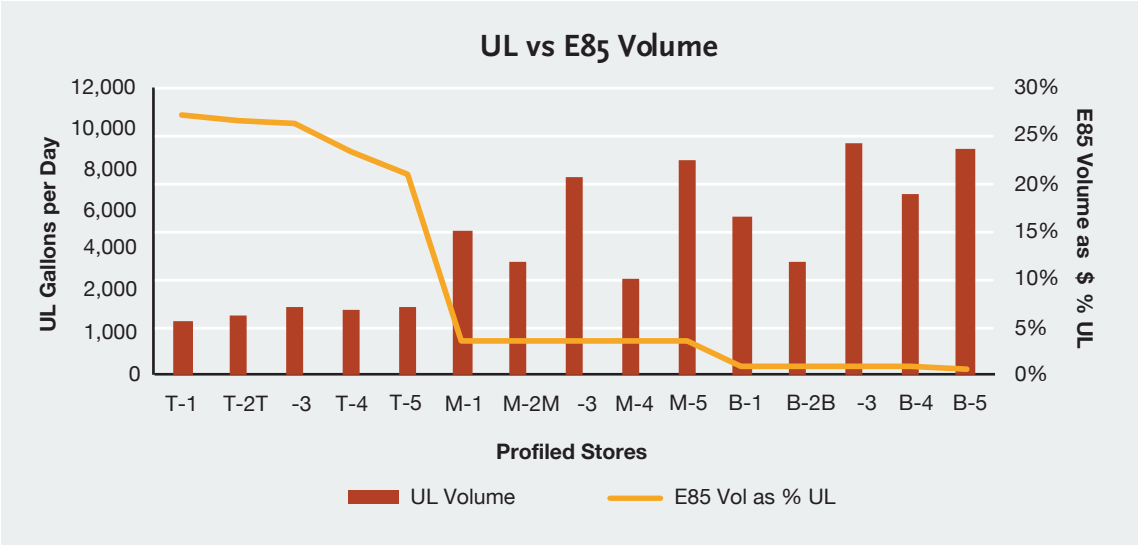


Figure 32: *UL vs E85 Volume (Source: Fuels Institute)*

Individual Store Profiles

The remainder of this section presents charts specific to the daily and monthly performance of each store. As noted above, the stores are grouped by top five, middle five and bottom five. For each grouping, axes values are consistent. However, it is important to note that performance values for each group greatly varied. Therefore, to show all the data effectively for each group, axes between groupings have been adjusted. Consequently, comparisons on appearances alone cannot be made between charts in one group with those in another group –the values of the respective axes must be taken into consideration.

Figure 33 summarizes the R and R^2 values calculated for each store, which are presented in the following charts for each group. It is important to note that correlation does not reflect causation. From this table, we see that the R^2 value for each store remains at a level that renders it improbable that a linear model would provide an accurate forecast of sales based on a variation in price.

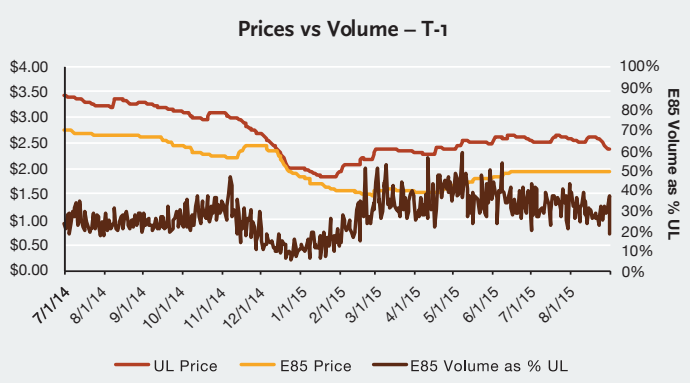
R and R^2 Values for Profiled Stores

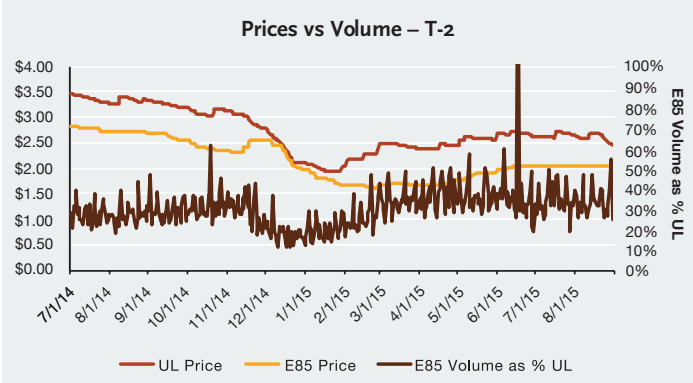
Data Set	R Value (E85 $ % Below UL vs E85 Volume as % UL)	R^2 Value (E85 $ % Below UL vs E85 Volume as % UL)	R Value (% Change in E85 – UL $ Diff vs % Change in E85 Volume as % UL)
Full Data	0.3979	0.1583	
T-1	0.7654	0.5858	0.9141
T-2	0.6037	0.3644	0.7665
T-3	0.7229	0.5225	0.6881
T-4	0.6182	0.3822	0.7797
T-5	0.5688	0.3235	0.8132
M-1	0.7574	0.4294	0.9629
M-2	0.5369	0.2739	0.6802
M-3	0.7748	0.5173	0.6969
M-4	0.4573	0.1848	0.5460
M-5	0.7836	0.5527	0.9898
B-1	0.4709	0.1726	0.9699
B-2	0.2997	0.0790	0.7419
B-3	0.3295	0.1086	0.1824
B-4	0.2494	0.0622	0.4895
B-5	0.3890	0.1201	0.7231

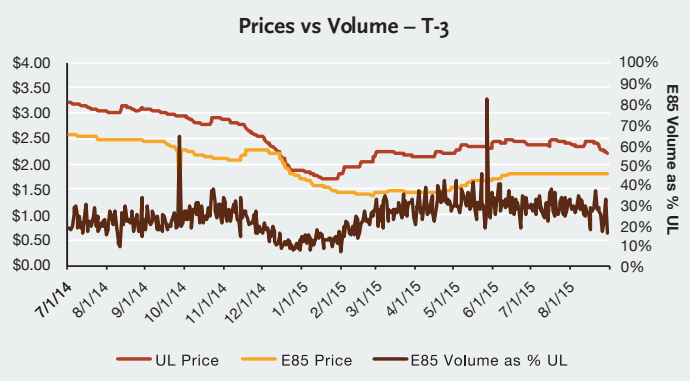
Figure 33: *R and R^2 Values for Profiled Stores (Source: Fuels Institute)*

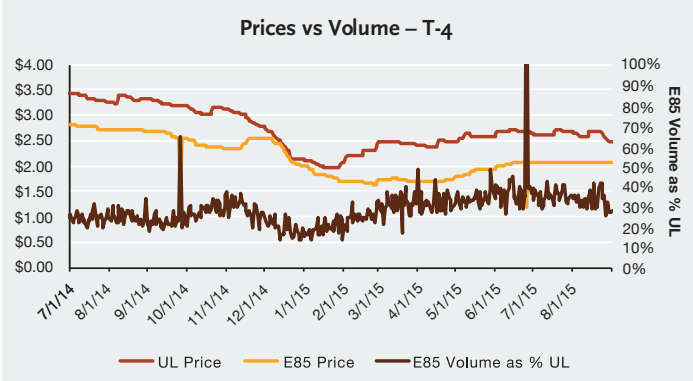
Top 5 Stores

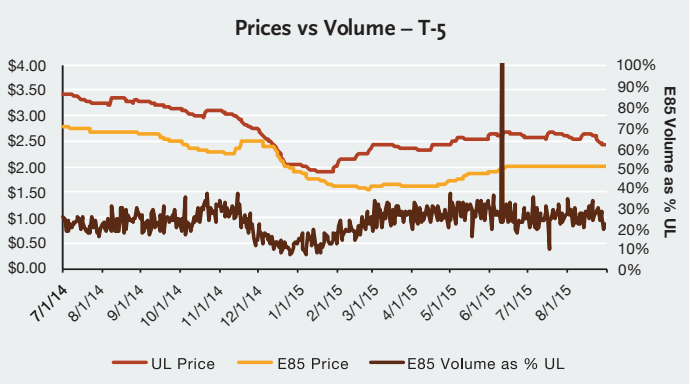
- **Chart Set: The daily prices of unleaded and E85 compared with the daily volume of E85 expressed as a percent of unleaded volume[7].**







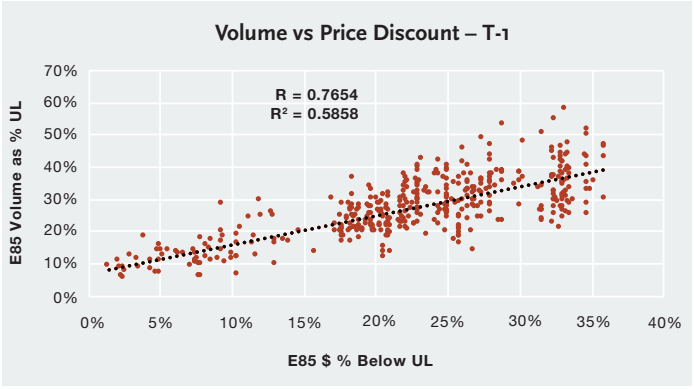


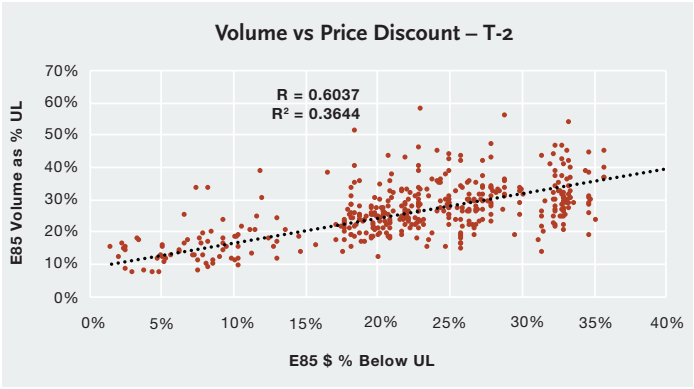


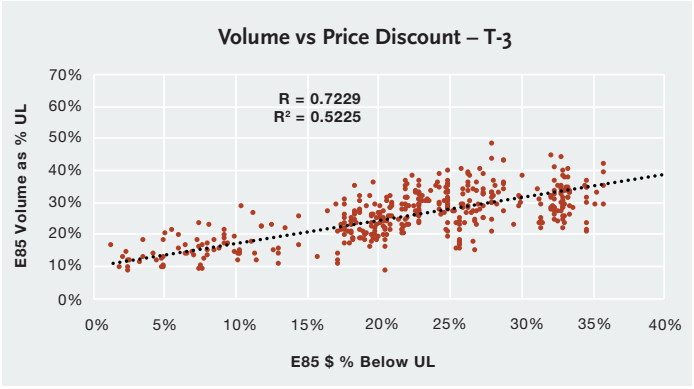
(Source: Fuels Institute)

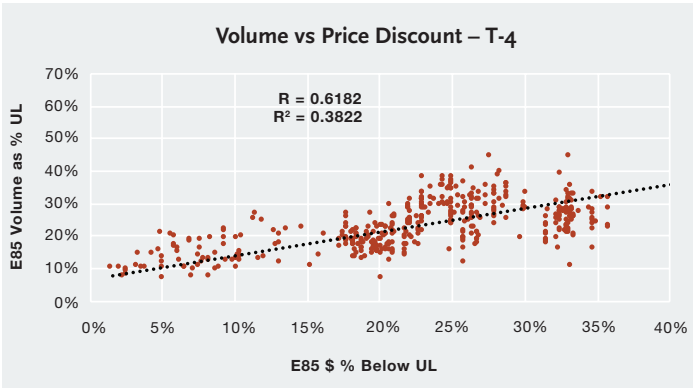
[7] The graphs for stores T-2, T-3, T-4 and T-5, show a spike in E85 sales in the early summer of 2015. A closer look at the data indicates that on a single day, each of these stores priced E85 below $1.00 per gallon, resulting in a dramatic increase in E85 volumes compared to other days within the provided data set. Unleaded prices did not experience a similar single-day drop. Why E85 prices were set at this level is unknown, but the data shows a direct relationship between this dramatic drop in prices (in each case approximately $1.00 per gallon below the day before and the day after) and the single day increase in E85 sales.

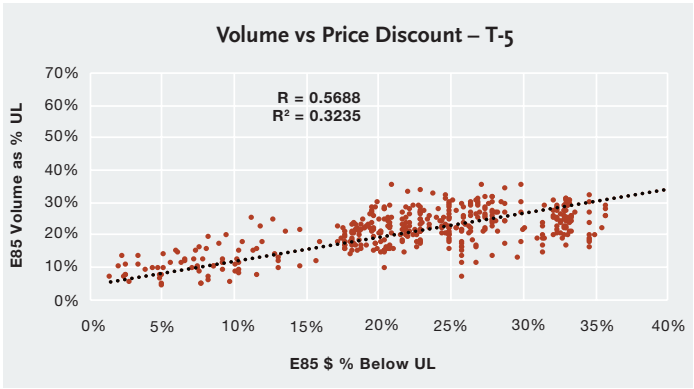
- **Chart Set: The daily volume of E85 as percent of unleaded related to the daily price of E85 expressed as a percent below the price of unleaded. R and R² values are provided for each.**





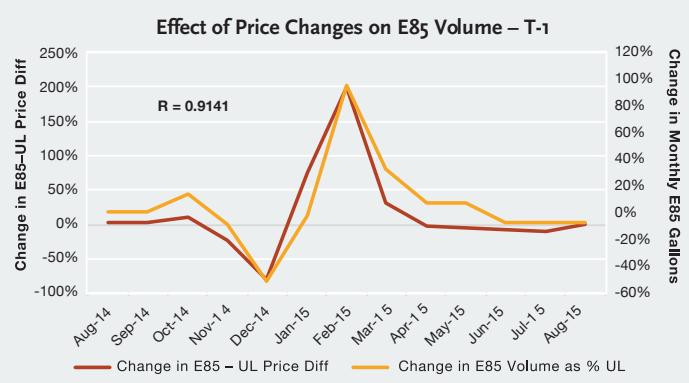


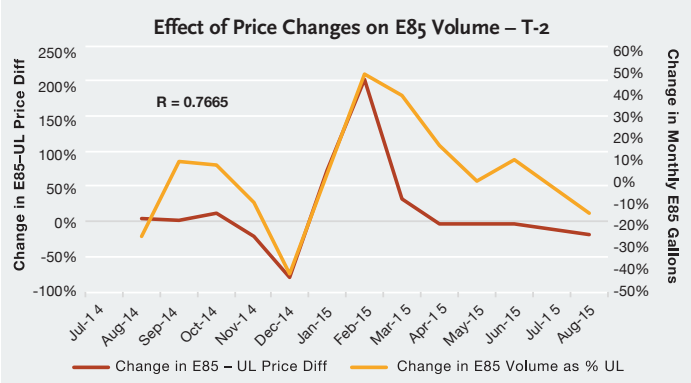


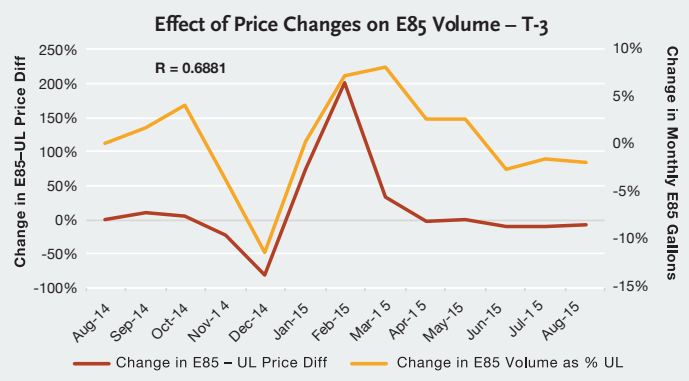


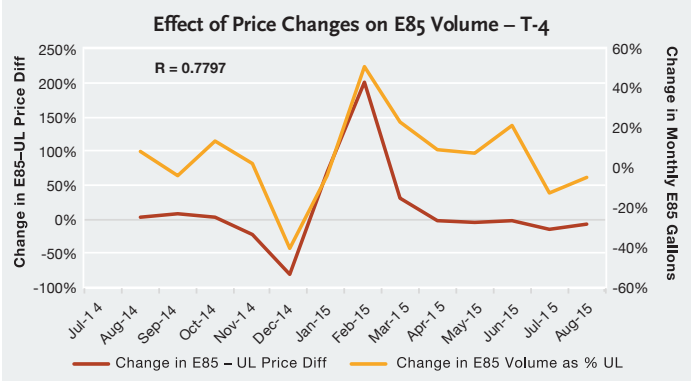
(Source: Fuels Institute)

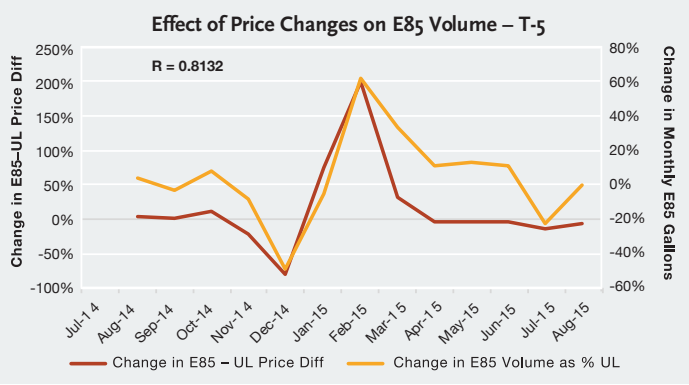
- **Chart Set: The change in the monthly average price delta between E85 and unleaded (UL) compared with the change in the monthly average volume of E85 gallons sold. The R value indicates the correlation between a change in the price delta and the volume of E85 sold.**







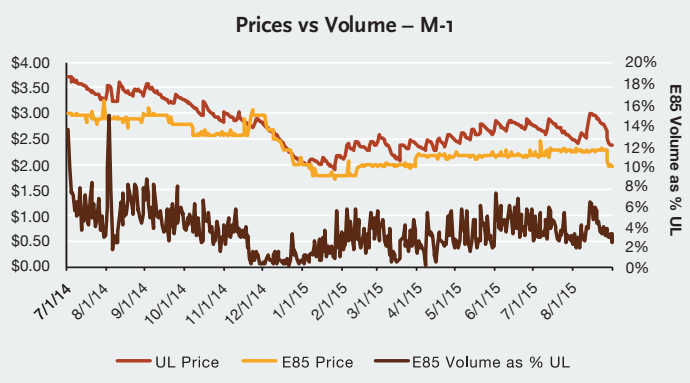


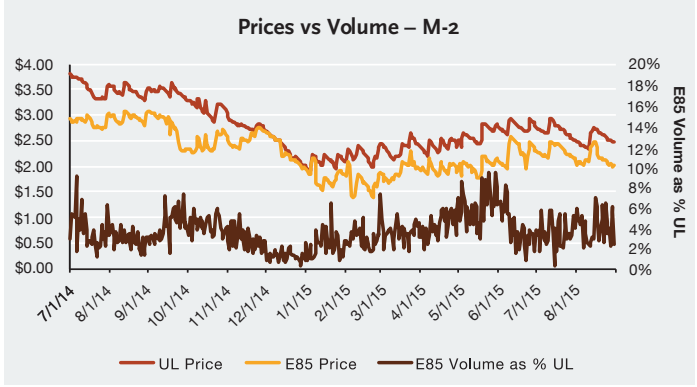


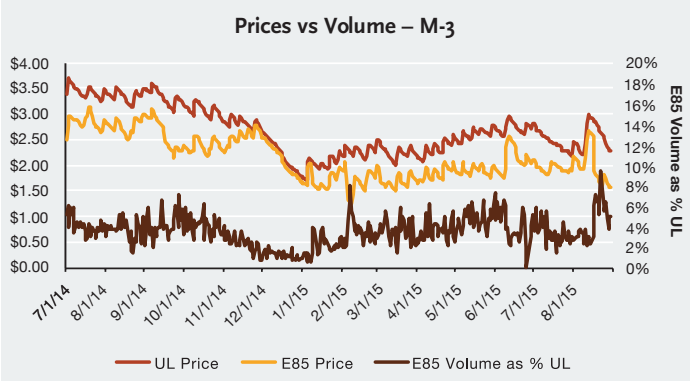
(Source: Fuels Institute)

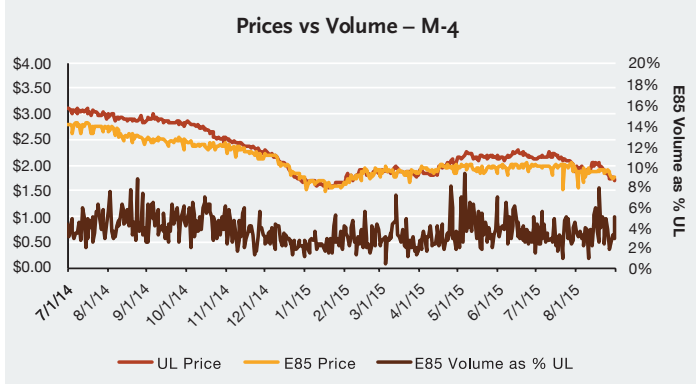
Middle 5 Stores

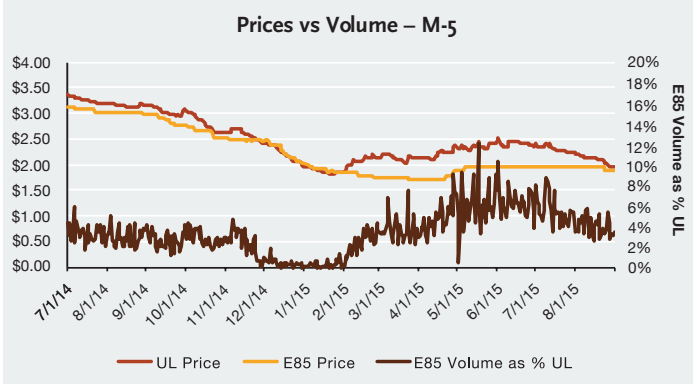
- **Chart Set: The daily prices of unleaded and E85 compared with the daily volume of E85 expressed as a percent of unleaded volume.**





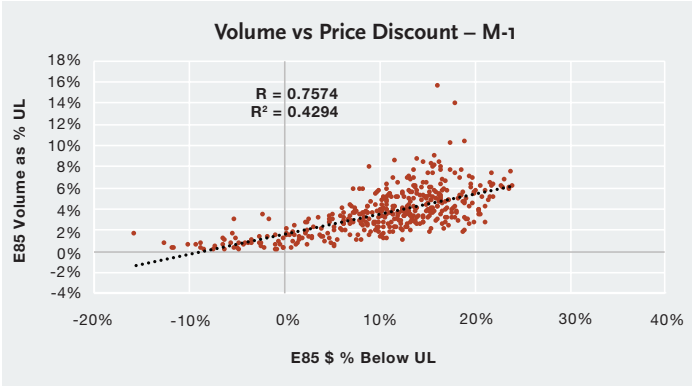


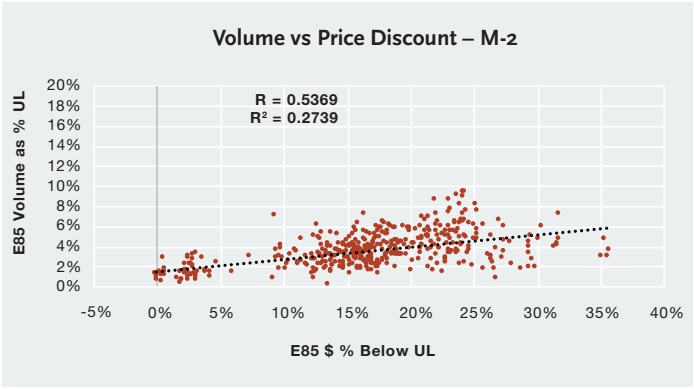


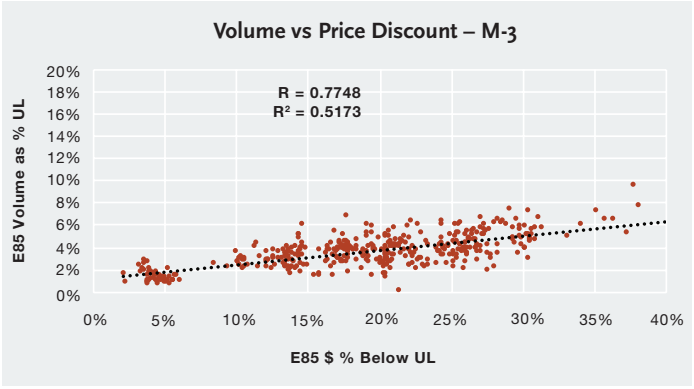


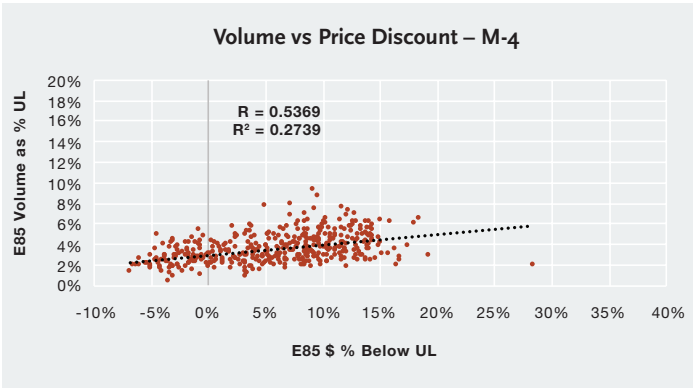
(Source: Fuels Institute)

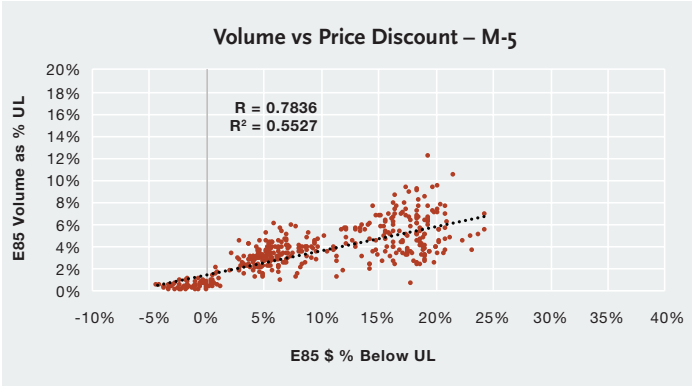
- **Chart Set: The daily volume of E85 as percent of unleaded related to the daily price of E85 expressed as a percent below the price of unleaded. R and R² values are provided for each.**





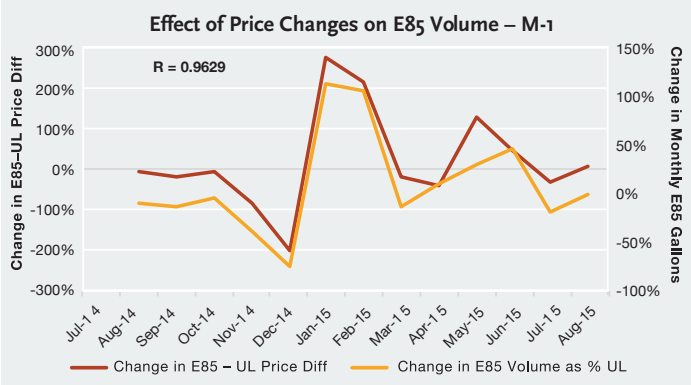


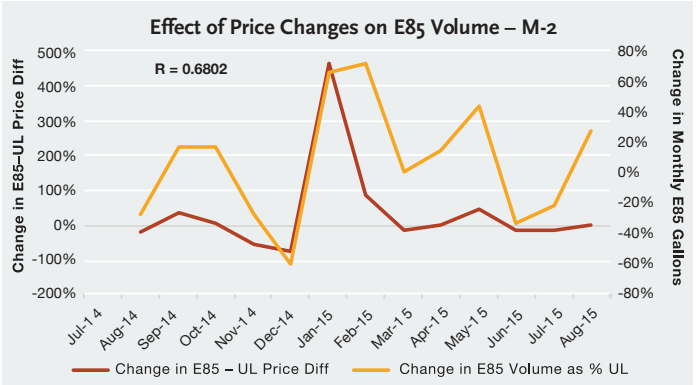


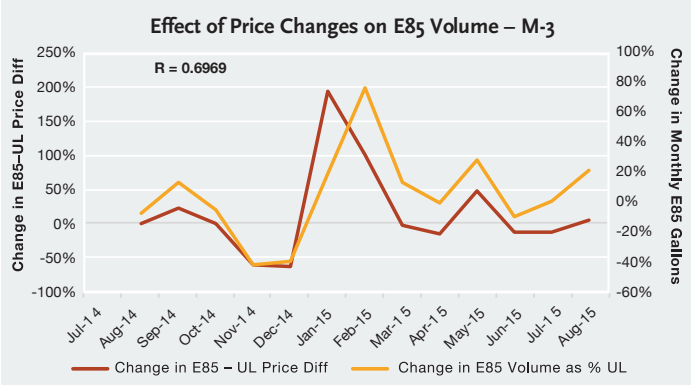


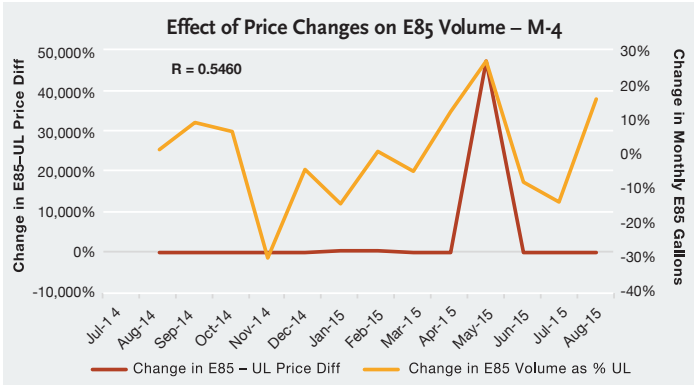
(Source: Fuels Institute)

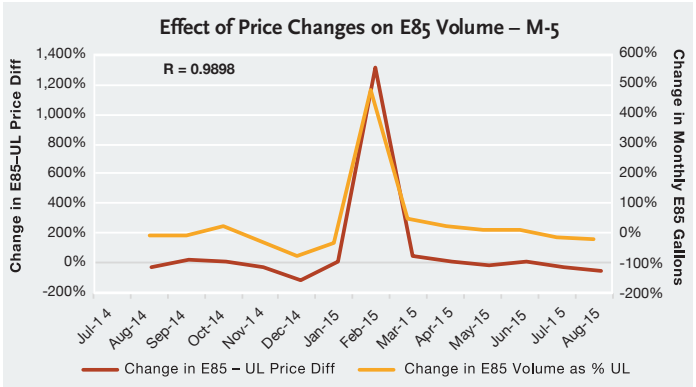
- **Chart Set: The change in the monthly average price delta between E85 and unleaded (UL) compared with the change in the monthly average volume of E85 gallons sold. The R value indicates the correlation between a change in the price delta and the volume of E85 sold.**







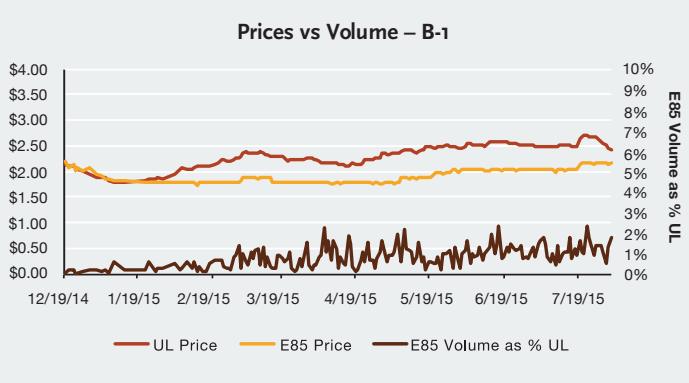


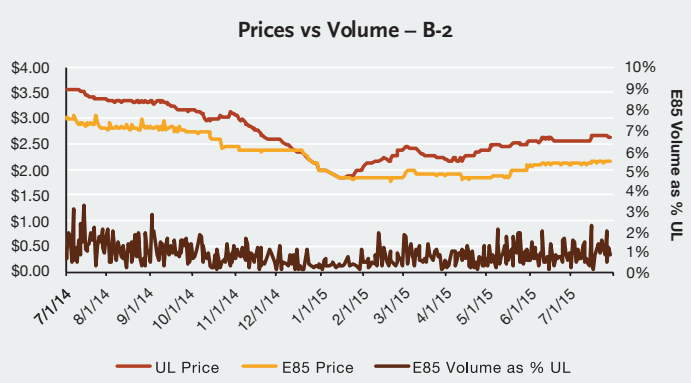


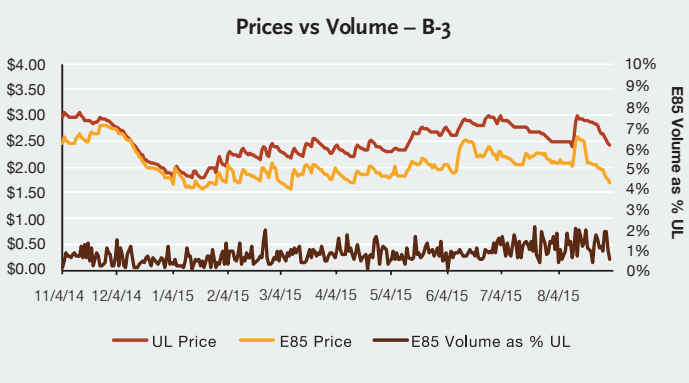
(Source: Fuels Institute)

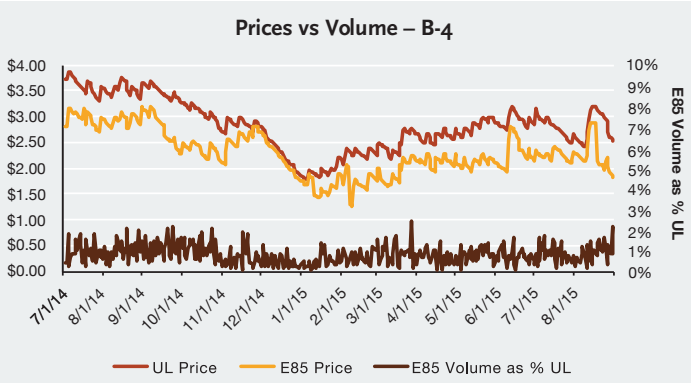
Bottom 5 Stores

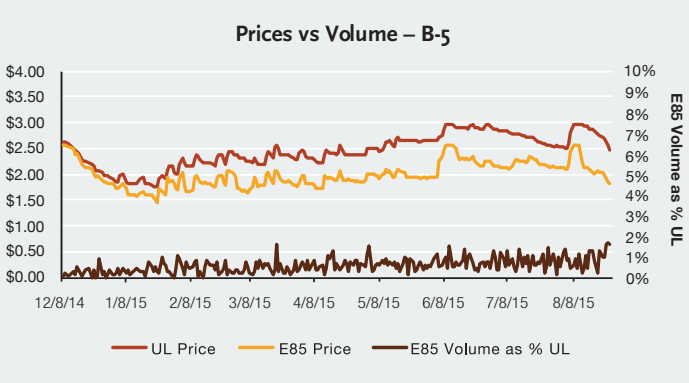
- **Chart Set: The daily prices of unleaded and E85 compared with the daily volume of E85 expressed as a percent of unleaded volume.**





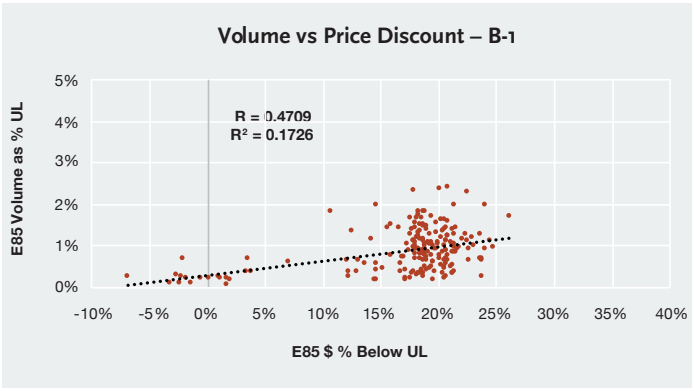


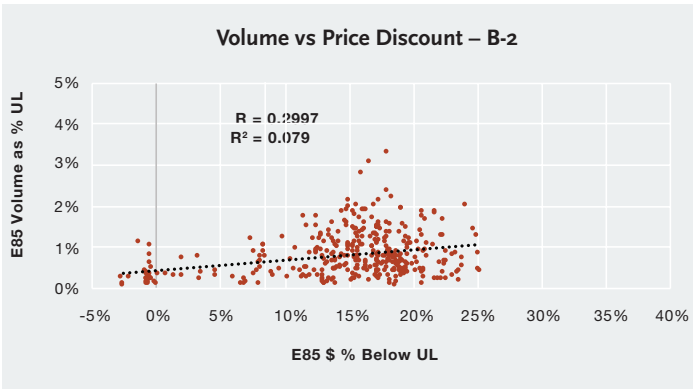


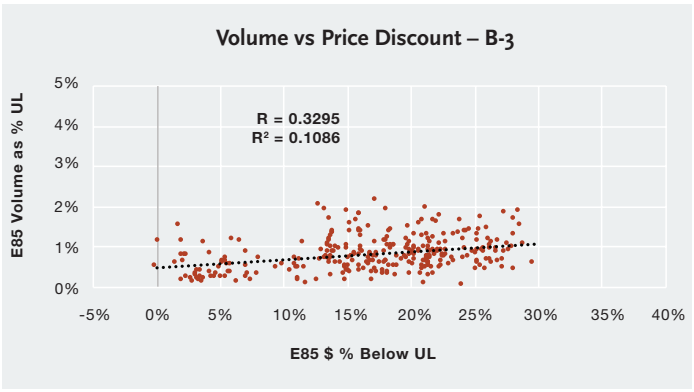


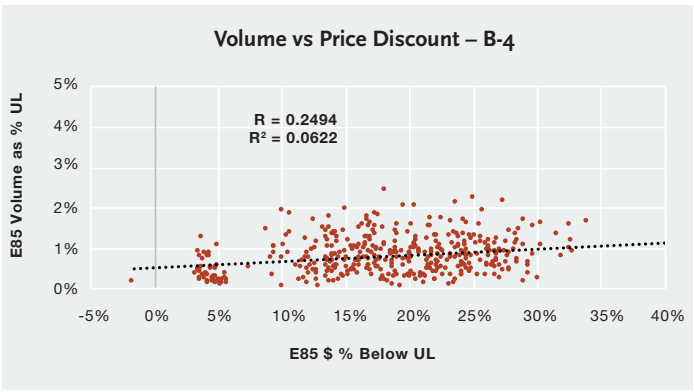
(Source: Fuels Institute)

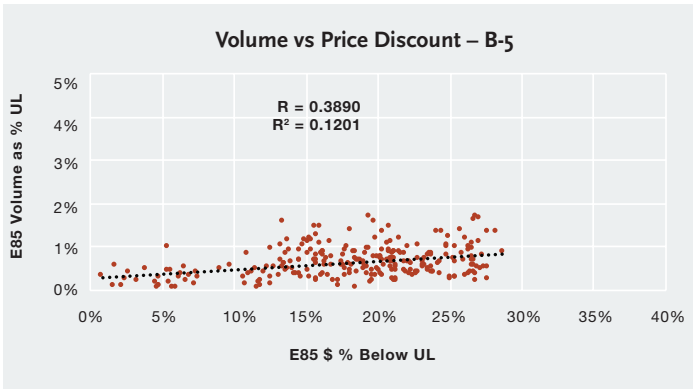
- **Chart Set: The daily volume of E85 as percent of unleaded related to the daily price of E85 expressed as a percent below the price of unleaded. R and R² values are provided for each.**





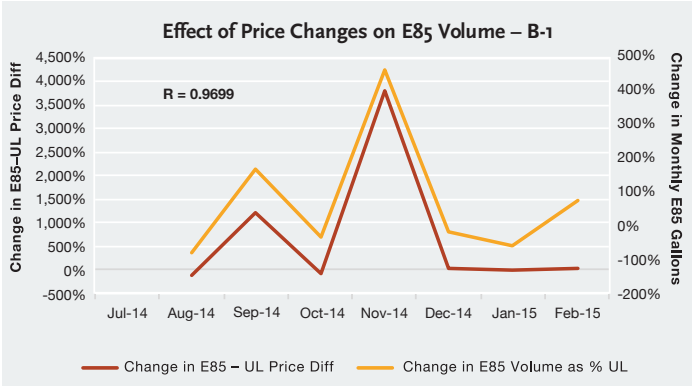


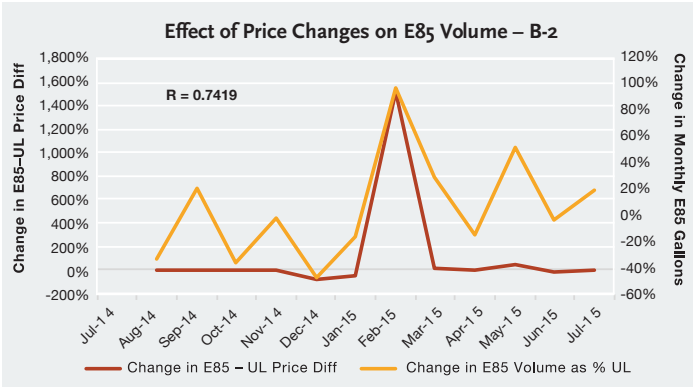


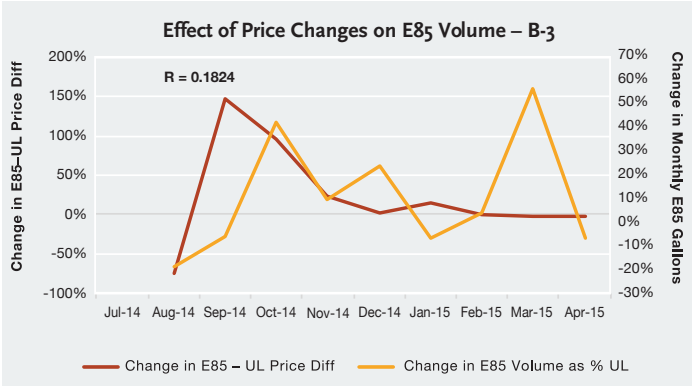


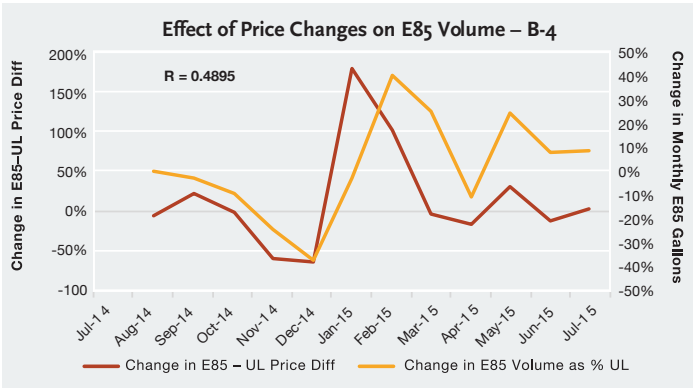
(Source: Fuels Institute)

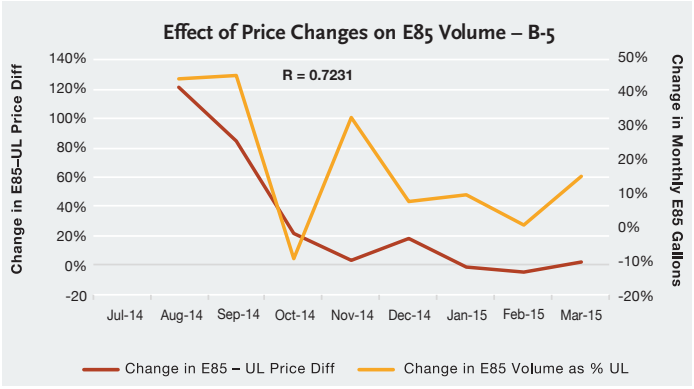
- **Chart Set: The change in the monthly average price delta between E85 and unleaded (UL) compared with the change in the monthly average volume of E85 gallons sold. The R value indicates the correlation between a change in the price delta and the volume of E85 sold.**











(Source: Fuels Institute)

Observations

Analyzing the real-world sales data from 620 retail facilities provides insight into how E85 performs in the market, especially as it relates to unleaded. The relationship between the two fuels is critical because FFV drivers can purchase either fuel without limitation. From this analysis, here are some key observations:

- **Price of unleaded seems to have little effect on E85 sales.** The original question that spurred this analysis was to determine if the decline in retail unleaded prices over the past three years had a diminishing effect on E85 demand. The two sample sets analyzed (this report and the 2014 Fuels Institute report) indicate that E85 continued to be priced at a level close to $0.50 below unleaded and E85 sales volume increased in the second time-period to reflect an average store volume of 4.77% of unleaded sales compared with 2.79% in the prior report. It is important to recognize that these sample sets do not represent same store or same firm performance, so it is impossible to draw a direct comparison. But the trend of the sample sets indicates that the price of unleaded has limited influence on the sale of E85.

- **Factors other than price affect E85 sales.** The analysis of the entire sample set, and of the profiled 15 stores, indicate that while there is a correlation between price discount and E85 sales volume, it is far from exact or even consistent from store-to-store. In fact, the correlation between the E85 price discount (expressed as a percent at which E85 is priced below unleaded) compared with the volume of E85 sold (expressed as a percent of the volume of unleaded) for the entire sample set was 0.1583 (a 1.0 indicates a perfect correlation) and, for the 15 profiled stores, it ranges from a low of 0.2494 to a high of 0.7836. To improve upon these correlations, future studies should track and control for other factors influencing the consumer's purchase decision.

- **Stores with greater E85 sales did not necessarily yield more compelling correlations between price and volume.** When evaluating the 15 profiled stores to understand the relationship between the monthly E85 price discount change compared with the monthly volume of E85 expressed in real gallons, the range of the correlation is significant: from a low of 0.1824 to a high of .9898 (almost a perfect correlation). It would be tempting to claim that correlation should be stronger in those stores that generated greater E85 sales; however, the distribution of correlation coefficients across the three tiers analyzed doesn't fit this pattern, with some of the higher correlation coefficients being found in stores that were not among the top five in the sample set.

- **Lower volume stores reported stronger E85 sales in both gallons and percent volume.** In this report, all analyses support this finding, but the analysis of the sample stores when organized into performance quartiles is especially illuminating. More clearly than elsewhere in the analysis it is shown that stores with lower throughput volumes of unleaded tend to report higher E85 volumes, both in terms of real gallons and as a percent of unleaded volume. We cannot definitively explain why this may be the case, but the relationship between the two is unmistakable. Additional research into specific store locations might yield additional insight.

- **Energy parity does not seem to factor significantly in E85 pricing decisions.** The data shows that very few retail stations post E85 prices that averaged near 23% below unleaded prices. The most successful stores (top quartile) averaged 19.6% below unleaded and generated E85 sales that matched 9.8% of the store's unleaded volume. The E85 price for this quartile was $0.521 per gallon below unleaded. If stations were to price E85 at or greater than 23% below unleaded, it is unclear whether they would generate greater volumes. There is evidence, however, that when E85 prices drop significantly below unleaded, even for one day, E85 volumes have the potential to spike. But sustained, average prices at the 23% or greater level presented inconsistent results across the data set.

- **Linear predictions that seek to forecast E85 sales volumes based on price relative to unleaded are not reliable.** The data indicates that the conditions that affect a store's overall sales of E85 may not be related directly to the pricing strategy of the facility. While volume and price are correlated, as evidenced in the sample set, the correlation is far from consistent. Furthermore, the data set does not yield evidence that a linear trend line could effectively predict sales performance in relation to certain pricing strategies. The R^2 value (which predicts how well a data set fits a model) for this data set is 0.1583, far below the 1.0 value which would indicate the data fits a predictive model.

Ultimately, consumers are influenced by numerous factors when deciding to purchase E85. Finding the right conditions to attract the 20 million FFV drivers on the road to opt for E85 instead of unleaded requires careful study of prevailing market conditions, consumer behavior and localized strategies to maximize the return on investment for the fuel. Relying upon price experience alone will not necessarily yield predictable results.

The data presented in this report indicates that retail facility analysis is necessary to fully understand why consumers choose to purchase or not purchase E85, and dispels the assumption that price alone will determine the success of an E85 retail fuel offer.

About the Fuels Institute

The Fuels Institute, founded by NACS in 2013, is a 501(c)(4) non-profit research-oriented think tank dedicated to evaluating the market issues related to vehicles and the fuels that power them. By bringing together diverse stakeholders of the transportation and fuels markets, the Institute helps to identify opportunities and challenges associated with new technologies and to facilitate industry coordination to help ensure that consumers derive the greatest benefit.

The Fuels Institute commissions and publishes comprehensive, fact-based research projects that address the interests of the affected stakeholders. Such publications will help to inform both business owners considering long-term investment decisions and policymakers considering legislation and regulations affecting the market. Our research is independent and unbiased, designed to answer questions, not advocate a specific outcome. Participants in the Fuels Institute are dedicated to promoting facts and providing decision makers with the most credible information possible, so that the market can deliver the best in vehicle and fueling options to the consumer. For more about the Fuels Institute, visit www.fuelsinstitute.org.

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