Gasoline Price Pass-through

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The single most visible energy statistic to American consumers is the retail price of gasoline. While the average consumer probably has a general notion that gasoline prices are related to those for crude oil, he or she likely has little idea that gasoline, like most other goods, is priced at many different levels in the marketing chain, and that changes ripple through the system as prices rise and fall. When substantial price changes occur, especially upward, there are often allegations of impropriety, even price gouging, on the part of petroleum refiners and/or marketers. In order to understand the movement of gasoline prices over time, it is necessary to examine the relationship between prices at retail and various wholesale levels.

Over the past several years, the Energy Information Administration (EIA) has extensively studied the relationships between wholesale and retail markets for transportation fuels. Beginning with gasoline, then with diesel fuel, we looked at the two ends of the pricing structure in U.S. markets: daily spot prices, which capture sales of large quantities of product between refiners, importers/exporters, and traders; and weekly retail prices, measured at local gasoline outlets nationwide. In the course of this analysis, EIA has found that the relationships between spot and retail prices are consistent and predictable, to such an extent that changes in spot prices can be used to forecast subsequent changes in retail prices for the appropriate regions. This article represents a return to gasoline markets, where EIA first performed this type of analysis and modeling in 1997. The current effort takes advantage of improvements and enhancements to our approach over the intervening years, resulting in more detailed and accurate results.

What is price pass-through?

In the petroleum industry, like most others, the majority of all products sold changes hands a number of times on its way from the point of production (a refinery) to the point of ultimate consumption. Since each participant in this supply/marketing chain incurs some cost and wishes to make a profit, the price normally increases with each sale. As such, any change in price at the refinery, or any intermediate point of sale downstream, should be expected to affect prices at each successive sale. Petroleum products may be sold at any of the following levels:

• Spot market – refers to the one-time sale of a quantity of product "on the spot," in practice typically involving quantities in thousands of barrels at a convenient transfer point, such as a refinery, port, or pipeline junction. Spot prices are commonly collected and published by a number of price reporting services.

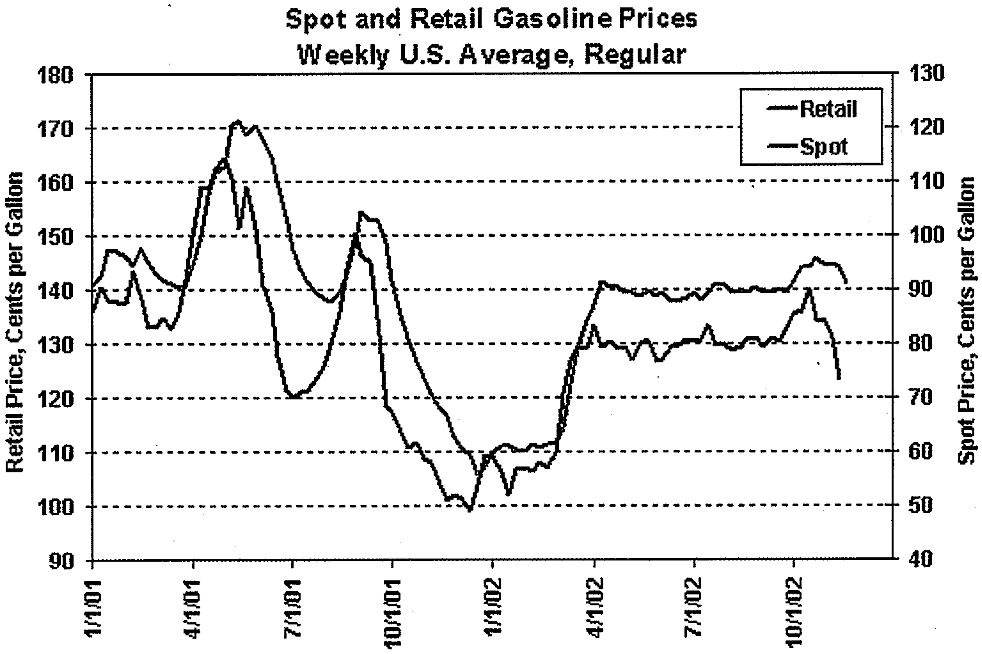
• Terminal, or "rack" – sales of product by the truckload (typically about 8,000 gallons) at the loading rack of a product terminal, supplied from a refinery, pipeline, or port.

• Dealer tankwagon, or DTW – sales of a truckload or less of product, delivered into storage at a retail outlet.

• Retail – sales to the consumer, normally occurring at a service station, convenience store, or other retail outlet. (Larger consumers, such as commercial or government vehicle fleets, may buy directly from wholesalers in larger quantities.)

For purposes of this analysis, we have focused on only spot and retail prices (Figure 1). Daily spot prices for various petroleum products are readily available for a number of large supply points, including the Gulf Coast, New York Harbor, Los Angeles, and others, while retail gasoline and diesel fuel prices are collected and published weekly by EIA.

Figure 1

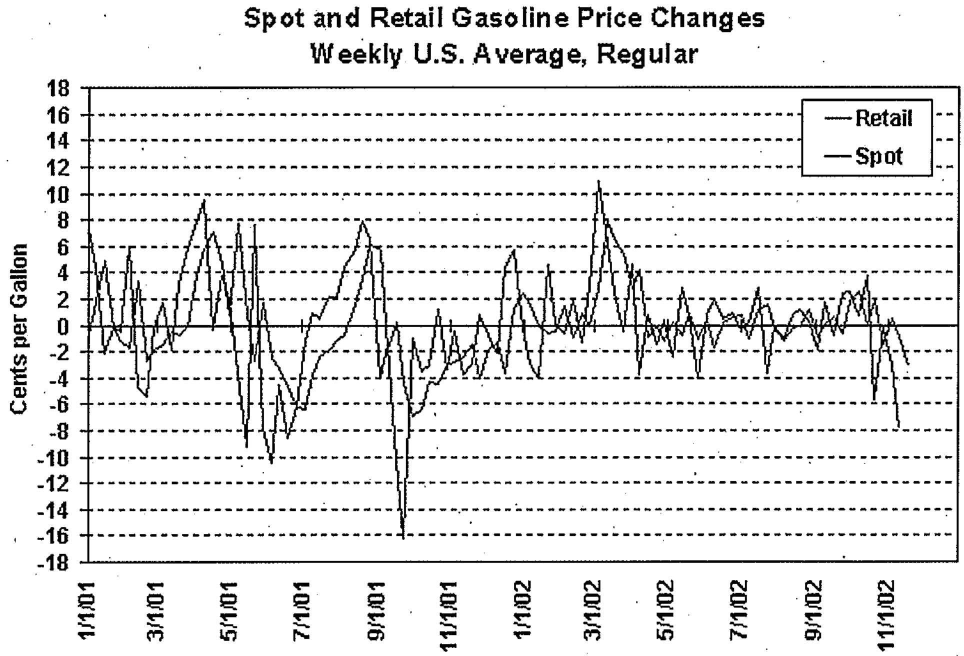


Sources: Spot prices – DRI/Platt's, Inc.; Retail prices – EIA.

The manner in which prices are passed through the various levels of petroleum markets is not uniform. While successive sellers of a product presumably act to cover their costs and make a profit, sellers vary greatly in their pricing behavior, such as reaction to competitors' price changes and attempts to protect or increase market share. Additionally, as prices rise and fall, some marketers reportedly reprice product for sale according to the cost of their most recent purchase, while others will anticipate the cost of their next purchase. A further complication is that not all product sold goes through the same levels of resale. Some product is sold directly by the refiner at its own company-operated retail outlets, while other fuels go through a succession of resales by any combination of traders, jobbers, lessee dealers, or independent marketers.

In any case, regardless of the differences in individual sales, the aggregate result of this combination of wholesale and retail activity is a recognizable pattern of price pass-through. As can be seen in Figure 2, significant changes in spot prices usually appear to show up in retail prices with some time delay, and somewhat dampened. EIA theorized that this phenomenon could be explained by a distributed lag: that the impact of a spot price change seen in a given week might be spread over several subsequent weeks at the retail level. We then set about analyzing this lag effect by looking at the week-to-week price changes at spot and retail levels for specific regions.

Figure 2



Source: Calculated by EIA from DRI/Platt's, Inc. spot and EIA retail prices.

This methodology was first applied to gasoline (see Motor Gasoline Assessment, Spring 1997 (DOE/EIA-0613, July 1997)). Later efforts refined the retail gasoline price model (Assessment of Summer 1997 Motor Gasoline Price Increase (DOE/EIA-0621, May 1998) and Price Changes in the Gasoline Market (DOE/EIA-0626, March 1999)), and then applied the same methodology to diesel fuel (Diesel Fuel Price Pass-through (July 2002)). The results of this work have been used by EIA in validating the results of our weekly retail price surveys, and by industry and government analysts wishing to forecast the movement of retail gasoline and diesel fuel prices over the near-term. Additionally, improved understanding of petroleum product pricing phenomena can aid policymakers and the public in evaluating market performance, and particularly the often-controversial question of whether any unusual manipulation of markets occurs.

Analytical Approach

In order to analyze the relationship between spot and retail gasoline prices, EIA first endeavored to match appropriate spot price data to each regional average retail price produced by the EIA-878 "Motor Gasoline Price Survey." (Throughout this analysis, prices for regular grade, representing about 80 percent of all sales, are used exclusively. Differential pricing for other grades is often influenced by marketing considerations outside the scope of this effort.) The ten retail prices used included all five Petroleum Administration for Defense Districts (PADDs), the three PADD 1 sub-districts, California, and the U.S. average. For each geographic area, we looked at the supply patterns, including refineries, ports, and pipelines, and determined the primary supply sources for the region. This information was then matched with available spot price data, and where necessary, a weighted average spot price was created according to the portion of the region served by each spot market.

The spot prices used for this paper, as listed in Table 1, were obtained from DRI/PLATTS, Inc. Table 2 demonstrates how the spot prices for each region (U.S., PADD, and sub-PADD) were generated. Weekly averages of the spot prices were calculated from the daily values. Derivation of the weighting factors for the U.S., PADDs, and sub-PADDs were based on resale volumes reported in Form EIA-782C, "Monthly Report of Prime Supplier Sales of Petroleum Products Sold for Local Consumption," with intra-State splits, where necessary, based on the population of the regions served by the relevant spot market.

Table 1. Platt's Oilgram Regular Gasoline Spot Price Series	
Spot Price	Definition
NYHconv	Conventional, Cargo, NY Harbor
NYHrfg	Reformulated, Barge, NY Harbor
LAconv	Conventional, Pipeline, Los Angeles
LArfg	Reformulated (CARB), Pipeline, Los Angeles
SFconv	Conventional 7.8 RVP, Pipeline, San Francisco
SFrfg	Reformulated (CARB), Pipeline, San Francisco
CHIconv	Conventional, Pipeline, Chicago
CHIrbob	Reformulated Blendstock, Pipeline, Chicago
GULFconv	Conventional, Cargo, US Gulf Coast
GULFrfg	Reformulated, Pipeline, US Gulf Coast
GRP3conv	Conventional, Oklahoma (Group 3)
PORTconv	Conventional, Pipeline, Portland OR
SEAconv	Conventional, Barge, Seattle

Table 2. Formulae used to calculate the PAD District spot prices
SPOTUS = 0.355*SPOTPAD1 + 0.288*SPOTPAD2 + 0.148*SPOTPAD3 + 0.034*SPOTPAD4 + 0.174*SPOTPAD5
SPOTPAD1 = 0.132*SPOTPAD1X + 0.376*SPOTPAD1Y + 0.492*SPOTPAD1Z
SPOTPAD1X = 0.199*NYHconv + 0.801*NYHrfg
SPOTPAD1Y = 0.358*NYHconv + 0.509*NYHrfg + 0.013*GULFconv + 0.120*GULFrfg
SPOTPAD1Z = 0.908*GULFconv + 0.092*GULFrfg
SPOTPAD2 = 0.100*CHIrbob + 0.428*CHIconv + 0.034*GULFrfg + 0.438*GRP3conv
SPOTPAD3 = 0.766*GULFconv + 0.234*GULFrfg
SPOTPAD4 = GRP3conv
SPOTPAD5 = 0.649*SPOTCA + 0.062*LArfg + 0.079*LAconv + 0.011*SFconv + 0.199*SPOTPNW
SPOTCA = 0.626*LArfg + 0.374*SFrfg
SPOTPNW= 0.360*PORTconv + 0.640*SEAconv

Investigation of the time series properties of the price data was performed in order to assist in specifying the form of the forecasting model; for example, data with unit root properties are best analyzed in first differences, whereas stationary series can be estimated in level form. The unit root test could not reject the hypothesis that the retail and spot gasoline price series have a unit root; thus first differences of all data series were used for the regression analysis. The retail prices and weekly averages of the spot prices were defined to correspond to the same week; since the retail data correspond to a Monday morning open of business price, the retail prices were estimated only as a function of lagged spot prices.

The price response models were estimated in the form:

Equation C1.

$$\Delta RETAIL_t = \sum_{i=1}^{k} \beta_i \, \Delta SPOT_{t-i} + \varepsilon_t$$

Where:

D is the week-to-week change

$RETAIL_t$ is the Monday gasoline retail price for week t

$SPOT_t$ is the average gasoline spot price for week t

e_t is the random error term at time t.

Table 3 and **Table 4** show the parameter estimates for the various regions using Ordinary Least Squares with unrestricted lags as the estimation method. The lag length was chosen by using the number of lags that minimized the Akaike and/or Schwartz-Bayes information criterion value and maximized the predictive values of the forecast; this also provided parameter estimates that showed little or no change when an additional lag was added to the estimation.

Results

Estimates showed that the price passthrough from the spot to the retail market is complete within two-and-one-half months, with about 50 percent of the change occurring within 2 weeks and 80 percent within 4 weeks. However, PADDs 4 and 5 displayed much slower changes, with slightly less than 40 percent spot price pass-through occurring within the first two weeks.

A priori, one would expect to see approximately 1:1 eventual pass-through of spot price changes and would also expect the influence of a spot price change to decrease monotonically over time after the first time period. Close examination of the estimation results show that, except for one or two isolated instances, the regression models for the various regions do display this expected behavior. The results show, depending on the regions, that anywhere between 92 and 114 percent of the spot price change is passed through to retail within two-and-one-half months and also that lag effects decrease over time.

Table 5. Cumulative Pass-Through to Retail for a 10-Cent Change in Spot Price

Area	Lag Length	Time Elapsed (weeks)										
		1	2	3	4	5	6	7	8	9	10	11
U.S. Average	7	4.4	6.6	7.7	8.3	9.2	9.8	10.3				
PADD 1	9	3.0	5.2	7.0	8.0	9.0	9.5	10.0	10.3	11.0		
PADD 1X	11	2.1	4.2	5.7	6.7	8.0	8.7	9.5	10.0	10.5	11.0	11.4
PADD 1Y	10	2.5	4.5	6.1	7.2	8.2	8.9	9.6	10.2	10.8	11.2	
PADD 1Z	8	3.5	6.0	7.9	8.9	9.9	10.3	11.0	11.2			
PADD 2	4	6.7	9.5	10.2	10.8							
PADD 3	7	3.3	5.9	7.4	8.5	9.6	10.2	10.8				
PADD 4	9	1.8	4.0	5.4	6.5	7.4	8.2	8.9	9.6	10.3		
PADD 5	10	1.8	3.3	4.6	5.6	6.7	7.5	8.4	8.7	8.9	9.2	
California	7	2.4	3.8	5.3	6.6	7.7	8.3	9.2				

The cumulative price pass-through results are shown in Table 5. This table shows the expected increase in retail price over time resulting from a sudden 10-cent-per-gallon increase in the spot price. Using PADD 3 as an example, if the (USGC) spot price increased by 10 cents per gallon during a particular week, this would result in the retail price increasing by 5.9 cents per gallon within two weeks, 8.5 cents per gallon within 4 weeks and 10.2 cents per gallon within 6 weeks. Note that most of the retail price change occurs within the first three weeks and that all subsequent changes are much smaller. Table 5 shows that in all regions, an initial 10-cent spot price change will have at least 3 cents passed through to retail within 2 weeks and at least 6 cents after 4 weeks. The reason for a complete pass-through within 4 weeks for PADD 2 is probably because the source of supply is relatively close to the main population centers.

An important issue in price pass-through is that of symmetry, i.e. whether changes up or down in spot prices are fully and consistently reflected in retail prices. Price symmetry (or asymmetry) can be broken into two types: amount symmetry, in which the magnitude of changes at the wholesale and retail level are compared, and pattern symmetry, which is concerned with the speed of pass-through from wholesale to retail. Only amount symmetry was evaluated in the current effort. In essence, this was a test as to whether the passthrough model regression coefficients sum to 1.00 (see Price Changes in the Gasoline Market for further details). The results of the testing for amount symmetry are summarized in Table 6. A passthrough value of 100.0 would indicate exactly 100 percent pass-through of the spot price change to the retail price. The statistical tests indicate that amount symmetry is prevalent throughout the gasoline distribution system; only PADD 1 (and its sub-districts) show evidence of possible asymmetry.

Table 6. Statistical Tests Show Amount Symmetry of Price Changes

Area	Passthrough	p-Value
National	102.9	(0.571)
PADD 1	110.4*	(0.094)
PADD 1A	113.7*	(0.064)
PADD 1B	112.0*	(0.087)
PADD 1C	111.5*	(0.072)
PADD 2	108.0	(0.111)
PADD 3	108.4	(0.145)
PADD 4	102.6	(0.951)
PADD 5	92.0	(0.215)
California	91.6	(0.295)

Notes:

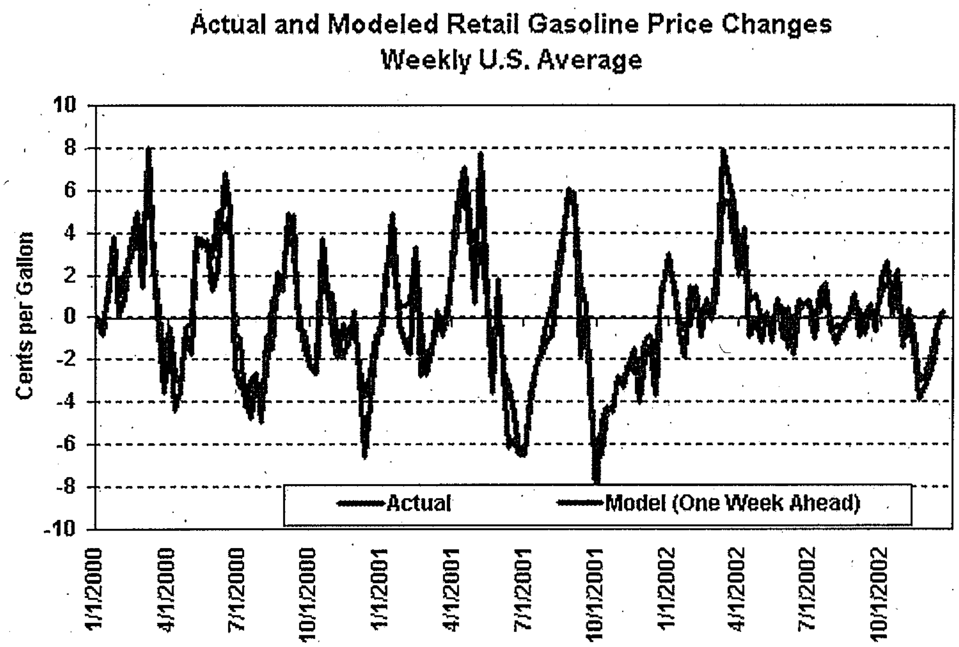
Numbers in the table are cumulative passthrough percentages of spot price changes passed through to retail.
The p-values for the Wald test F-Statistic of the cumulative percentage being equal to 100.0 are shown in parentheses.

Tests are for weekly data from January 2000 through June 2002, except for California (approx. June 2000 to June 2002) and PADD 4 (June 1998 to June 2002).
* = Statistically significant at the .10 level.

Once the appropriate lags were determined, using the regression procedure described above, a spreadsheet model was created using these lags and available spot price data to forecast retail price changes by week. Data were available to model most of the regional prices as far back as 1995. The results of this model, for the U.S. average retail regular gasoline price, are shown in Figure 3. (For clarity, only the period from January 2001 to date is shown. The complete series for the U.S. average, as well as each region modeled, are shown in **Figures 4-13** .) The effectiveness of this model was then measured in two ways: the percentage of weeks in which the model correctly forecast the direction of the price change, and the mean absolute error of the forecast weekly retail price change from that actually experienced. These results are shown in Table 7. As can be seen in

Figure 3 and Table 7, the model provides a relatively accurate forecast of retail price changes one week ahead. For nearly 80 percent of the forecast weeks at the national level (disregarding changes rounded to zero, i.e., less than 0.05 cent), the model correctly predicts the direction of the retail price change. The mean absolute error of the U.S. average retail price change forecast during the forecasted time period is only 0.76 cent per gallon.

Figure 3



Source: EIA.

Table 7. Accuracy of Retail Gasoline Model Results		
November 4, 1996 to November 11, 2002		
	Direction of Price Change	Mean Absolute Error
U.S. Average	78.5%	0.76
PADD 1	83.9%	0.61
PADD 1a	80.7%	0.65
PADD 1b	81.0%	0.63
PADD 1c	82.3%	0.74
PADD 2	76.3%	1.44
PADD 3	79.4%	0.74
PADD 4*	76.6%	0.98
PADD 5	79.4%	1.00
California**	78.5%	1.55
* time period begins June 15, 1998		
** time period begins November 8, 1999		

Aside from the accuracy of the model, what do these results indicate about retail gasoline pricing? Perhaps one of the most revealing aspects of this analysis is what the results do not show: there is so little difference between actual retail gasoline prices and the forecast created from spot prices and observed lag patterns that there is no evidence of significant influence on aggregate retail prices beyond the spot price level. In other words, despite allegations of competitive irregularities in retail markets, it appears that most of the movement in retail prices (on a national and regional basis) is predetermined by previous movements in spot prices. This also suggests that there may be no significant pattern asymmetry in retail gasoline price movements (different pass-through behavior when prices are rising than when they are falling), because pattern asymmetry would result in a difference in the model's performance depending on the direction of price movements. It should be noted, however, that no formal testing for pattern asymmetry was performed; this could be explored in future follow-up efforts.

It is also useful to note some apparent differences between price pass-through for gasoline and that for diesel fuel. It appears from comparing the results of the present study with previous work on diesel fuel that the results for diesel fuel are somewhat more consistent, producing a more accurate model. If this is in fact the case, a reasonable explanation could be that the U.S. market structure for on-highway diesel fuel is simpler than that for gasoline, with essentially only one grade or formulation of fuel sold. Additionally, the average speed of pass-through is significantly more rapid for diesel fuel, possibly reflecting fewer middlemen, on average, transacting for each gallon of diesel fuel as opposed to gasoline.

Further Work

Although the results of EIA's price pass-through modeling efforts to date are useful, there remains a significant amount of further work that could be done in this area. Potential additional efforts on this subject include:

- Evaluate price pass-through for each region for pattern asymmetry. (This has previously been performed only for the Midwest region.)
- Attempt to drive the model with daily spot prices. The current model uses weekly average spot prices; this could lead to inferior results when there is a significant price shift during the week, masked by the weekly average.
- Adjust model for one-time changes, such as changes in tax rates, during the period covered.
- Calculate pass-through including intermediate price levels (rack and dealer tankwagon).
- Analyze price pass-through for additional products, including heating oil and propane.

EIA may pursue any or all of these suggestions in future analysis according to customer interest and available resources.

* Also contributing to this article was Robert Hubbard III.

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