

Gasoline and Crude Oil Prices: Why the Asymmetry?

Stephen P. A. Brown and Mine K. Yücel

The available evidence suggests that asymmetry is unlikely to be the result of monopoly power exercised by large, integrated oil companies.

The United States consumes 8.5 million barrels of gasoline daily—nearly half its daily consumption of all petroleum products. The average automobile tank is filled weekly, and gasoline prices are posted at every street corner where there is a gasoline station. Consequently, most U.S. consumers are very aware of movements in gasoline prices and closely observe the asymmetry when crude oil and gasoline prices fluctuate. Many consumers complain that gasoline prices rise more quickly when crude oil prices are rising than they fall when crude oil prices are falling, exhibiting an asymmetric relationship.¹ To the naked eye, movements in spot crude oil and retail gasoline prices may lend some credence to consumers' complaints (*Figure 1*).

Furthermore, in some instances when gasoline prices have risen sharply and swiftly following a rise in crude oil prices—such as occurred in 1999 and 2000 and during the Gulf War in 1990—consumers and politicians have called for policies to put a stop to what is seen as unfair pricing practices for petroleum products.² Such reactions seem to stem from a popular suspicion that large, integrated companies have monopolized the oil industry. The public seems to take the asymmetric relationship between gasoline and crude oil prices as evidence that the petroleum industry is monopolistic.

Most of the previous research on the subject confirms at least part of what consumers suspect: it provides econometric evidence of an asymmetric relationship between gasoline and crude oil prices. This article extends inquiry into the issue by considering competing explanations for the asymmetry. The available evidence

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Figure 1
Detrended Crude Oil and Retail Gasoline Prices



SOURCES: Department of Energy; Haver Analytics.

suggests that asymmetry is unlikely to be the result of monopoly power exercised by large, integrated oil companies. An examination of the possible explanations for the asymmetry also suggests that government intervention to prevent the asymmetry between gasoline and crude oil prices is likely to reduce economic efficiency.

THE EVIDENCE FOR ASYMMETRY

Most of the previous research provides econometric support for public claims that gasoline prices rise more quickly when crude oil prices are rising than they fall when crude prices are falling. Bacon (1991) finds asymmetry for the UK gasoline market. Karrenbock (1991); French (1991); Borenstein, Cameron, and Gilbert (1997); Balke, Brown, and Yücel (1998); and a GAO report (1993) all find some evidence for an asymmetric response in U.S. gasoline markets.³ In contrast with the other studies, Norman and Shin (1991) find a symmetric response in U.S. gasoline markets.

Of these studies, one of the most visible and comprehensive is that of Borenstein, Cameron, and Gilbert (1997), hereafter identified as BCG. They use weekly and biweekly data from 1986 to 1992 in a series of bivariate error-correction models to test for asymmetry in price movements between gasoline's various stages of production and distribution—from crude oil through the refinery to the retail pump. They find strong and pervasive evidence of asymmetry in all segments of the market.

Shin (1992) argues, however, that the periodicity of the data, the sample period of estimation, and the model specification may affect the results obtained in various studies. To examine the issues that Shin raises, Balke, Brown, and Yücel (1998), hereafter identified as BBY, extend the work of BCG by using several different model specifications and various subsamples of weekly data from 1987 through early 1996. BBY confirm BCG's supposition that most of the price volatility originates upstream (in or closer to markets for crude oil) rather than downstream (in or closer to final consumer markets). They also find that asymmetry is sensitive to model specification but not to sample period. With their most preferred specification, however, BBY find evidence that asymmetry is pervasive across the stages of gasoline production and distribution.

For example, BBY find retail gasoline prices initially rise sharply after the crude oil price rises and then increase more gradually, as

shown in Panel 1 of Figure 2. In contrast, retail gasoline prices respond only gradually to a falling crude oil price (Panel 2). The net effect is an asymmetric response in gasoline prices (Panel 3). Retail gasoline prices respond more quickly when crude oil prices are rising than when they are falling.

EXPLANATIONS OF ASYMMETRY

With a number of studies showing that gasoline prices respond more quickly when crude oil prices rise than when they fall, economists have offered numerous explanations for the phenomenon.⁴ Explanations include market power, search costs, consumer response to changing prices, inventory management, accounting practices, refinery adjustment costs, and the behavior of markups over the business cycle. For the gasoline markets, however, no one has posited a formal econometric test that would allow the testing of the various explanations—including market power—for price asymmetry against the available data. In the absence of such tests, judgment and economic theory must be used to sort through the explanations and determine whether the asymmetric response of gasoline prices to movements in crude oil prices is the result of market power or more benign forces.

Market Power

Market power is probably the greatest concern to those who observe that gasoline prices respond more quickly when crude oil prices rise than when they fall. For the banking industry, Neumark and Sharpe (1992) show that market concentration is an explanatory variable for the asymmetry found in interest rate movements. In a comprehensive study of U.S. industry, however, Peltzman (2000) finds no evidence that market power is related to price asymmetry. In addition, neither we nor Peltzman could find a theoretical model that relates market power to an asymmetric response of downstream prices to changes in upstream prices.⁵ Were such a model to exist, it might involve consumer search costs or firms concerned with maintaining a tacit collusion or both.

Consider an industry with a few dominant firms that are engaged in an unspoken collusion to maintain higher profit margins. Reputation can be important to maintaining such a tacit agreement (Tirole 1990). If the firms value the agreement and have imperfect knowledge of the upstream prices their competitors are paying, each firm would face an asymmetric loss

function where it would be more reluctant to lower its selling price than to raise it. When upstream prices rise, each firm is quick to raise its selling price because it wants to signal its competitors that it is adhering to the tacit agreement by not cutting its margin. When the upstream price falls, each firm is slow to lower its selling price because doing so runs the risk of sending a signal to its competitors that it is cutting its margin and no longer adhering to the tacit agreement. In the gasoline markets, such an explanation could be applied to each upstream price and its adjacent downstream price.

Despite popular wisdom and an explanation linking concentration to the asymmetry between movements in crude oil and gasoline prices, there does not appear to be much evidence of monopolization in any segment of the gasoline market. The United States consumed 123 billion gallons of gasoline in 1996. The market share claimed by the four largest gasoline refiner/marketers (37.7 percent), as well as a relatively low Herfindahl–Hirschman Index of 650, suggests that U.S. gasoline production is competitive when viewed at the national level.⁶

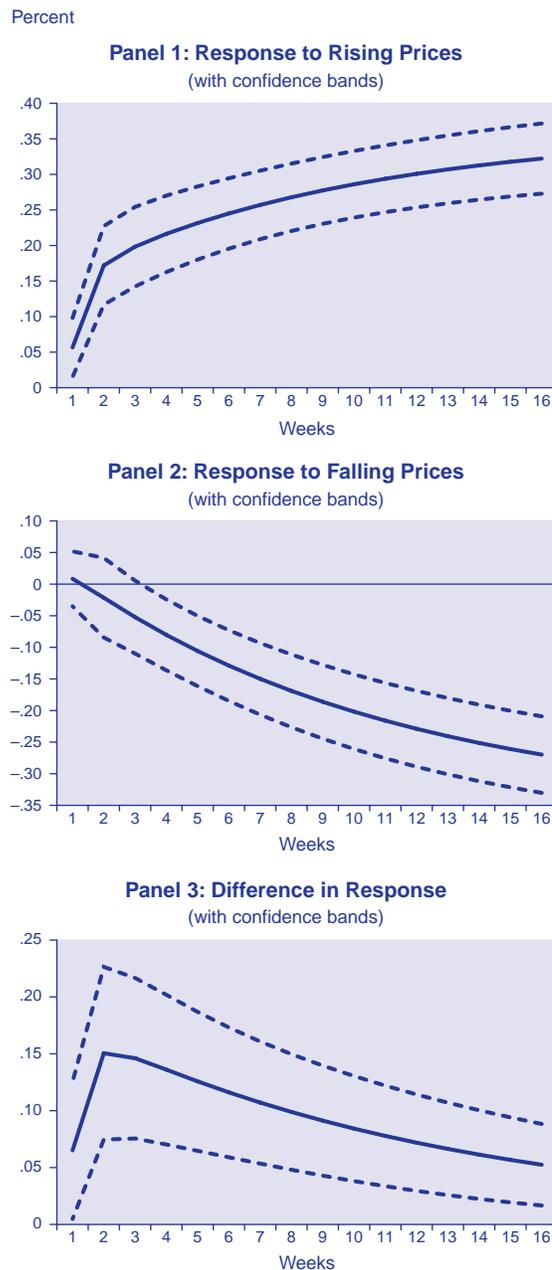
Because refined products are harder and more expensive to ship than crude oil, however, gasoline markets tend to be regionalized. In addition, regional variation in the environmental regulation of gasoline formulation may be increasing the regionalization of gasoline markets. Furthermore, changes in technology and environmental regulation have caused some smaller refiners to go out of business and increased the market share of the remaining refiners—most notably in California, where the clean air rules are more stringent than the national average and the number of refiners has decreased (from 31 in 1990 to 23 in 1996).

If gasoline markets were strictly regional, the number of refiners serving a region would be limited by the size of the regional market and economies of scale. In those regions with a few refiners, market power would be a possibility. Nonetheless, gasoline shipments between regions seem sufficient to establish workable competition in most areas, and in most regions of the country one can find a number of competing brands of gasoline.

The case for market power also seems difficult to make for the retail sector. In rural areas and small towns, regional monopolies could exist, and gasoline stations have often been cited as examples of monopolistic competition. But, the sheer number of retail gasoline stations makes complete monopolization unlikely. The United States had 190,246 retail

gasoline outlets in 1996. Of these, 114,452 were branded outlets (that is, they sold brand-name gasoline) belonging to 21 companies with at least 1,000 outlets each. Citgo, a subsidiary of the Venezuelan PDVSA, had the most retail outlets, with 14,529 in 48 states; Texaco came in second with 13,785 outlets in 25 states. The top six companies had 55 percent of the branded market and 33 percent of the total retail market, none of which provides strong evidence of

Figure 2
Asymmetric Response of Retail Gasoline Prices to Movements in Crude Oil Prices



SOURCE: Balke, Brown, and Yücel (1998).

Components of the Retail Gasoline Price

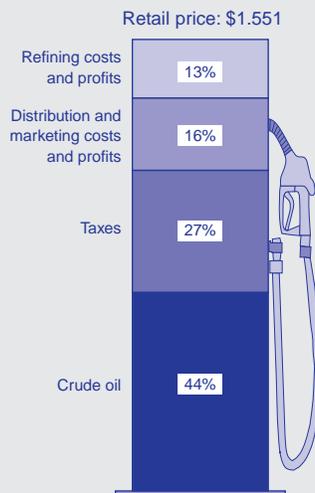
The cost to produce and deliver gasoline to consumers includes the cost of crude oil to refiners, refinery processing costs, marketing and distribution costs, and retail station costs and taxes. In July 2000 crude oil costs made up 44 percent of the total cost of gasoline. Refining costs and profits were 13 percent, and distribution, marketing, and retail costs were 16 percent.

Federal and state taxes (not including county and local taxes) were 27 percent of the total price, on average. Both federal and state taxes have been increasing in the past two decades. After staying constant at 4 cents per gallon until 1983, federal taxes rose gradually to 18.4 cents per gallon by 1994, where they have remained. State taxes have increased steadily from the 1920s to the current rate of 19.96 cents.

SOURCE: Energy Information Administration, Office of Oil and Gas, online publication "A Primer on Gasoline Prices."

What Do We Pay For in a Gallon of Regular Grade Gas?

(July 2000)



car consumes 504 gallons of gasoline per year. For a person filling up the tank every week, that comes to 9.7 gallons per week. The price differential between gasoline stations is usually not more than a couple of cents. If the difference were 10 cents (which is much higher than average), it would amount to 97 cents per week, about the price of a cup of coffee, which is likely to be less than the value of the time used in an aggressive search for lower-priced gasoline.⁸

More Benign Explanations

Beyond market power and search costs, economists have offered a number of explanations for the asymmetric response of gasoline prices to movements in crude oil prices. Alternative explanations include markups that vary over the business cycle, consumer response to changing prices, inventory management, accounting practices, and refinery adjustment costs. Other than the variation in markups over the business cycle, none of the explanations can be ruled out on either theoretical or empirical grounds.

If markups vary over the business cycle, the difference between the crude oil and retail gasoline price could increase as overall prices rise. Reagan (1982) and Reagan and Weitzman (1982) offer a theoretical explanation for such a relationship based upon the variation in demand over the business cycle. Haltiwanger and Harrington (1991) further suggest that the fluctuations in margins may result from variations in the degree of collusive behavior. However, BBY find that the shocks to crude oil and gasoline prices originate with supply rather than demand, which renders the explanation inapplicable.

The consumer response to changing gasoline prices may contribute to the asymmetry between movements in crude oil and gasoline prices at the retail level. If consumers accelerate their gasoline purchases to beat further increases when its price is rising, they will increase inventories held in automobiles and quicken the pace at which the price rises. If drivers fear running out of gasoline and do not slow their purchases when its price is falling by as much as they accelerated their purchases when prices rose, the price of gasoline will fall more slowly than it rose.

Similarly, firms in the oil industry may view the short-run costs of unexpected changes in their inventories as asymmetric (see BCG). If operation costs rise sharply when inventories are reduced below normal operating levels, a reduction of upstream supply could lead a firm to raise its output prices aggressively to prevent a

market concentration or market power. Nonetheless, Borenstein and Shepard (1993) find some evidence of coordinated pricing in a study using data from 1986–91 for 59 U.S. cities.

Limited Market Power and Search Costs

In the retail gasoline market, consumer search costs could lead to temporary market power for gasoline stations and an asymmetric response to changes in the wholesale price of gasoline. (See BCG, Norman and Shin 1991, Borenstein 1991, Deltas 1997, and Peltzman 2000.) Each gasoline station has a locational monopoly that is limited by consumer search. After consumers have searched, the profit margins at each gasoline station are pushed down to a roughly competitive level. When wholesale prices rise, the owner of each station acts to maintain profit margins and quickly passes the increase on to customers.⁷ When wholesale prices fall, however, each station temporarily boosts its profit margins by slowly passing the decrease on to customers. Only after the customers engage in a costly and time-consuming search to find the lowest prices are the stations forced to lower prices to a competitive level.

A factor slowing the search process is that the costs of an intensive search are likely to be much higher for most consumers than the corresponding gains from finding a cheaper price for gasoline. The money saved is a very small part of the consumer's budget, so that consumers will not search unless the price differential is very high. How large is this differential for the average consumer? The average passenger

loss of inventories. If an increase in inventories above normal operating levels has a relatively small effect on costs, the firm could be less aggressive in reducing its selling prices when it experiences an increase in upstream supply. Hence, inventories would buffer downstream price movements less when prices are rising than when they are falling.

If oil supply shocks cause asymmetric movements in inventories—with higher inventories when oil supply is plentiful and lower inventories when oil supply is reduced—the asymmetry of price movements could be enhanced by FIFO (first in, first out) accounting. If inventories are lower when upstream supply is reduced, the firm will sell the products incorporating the higher upstream price sooner. If inventories are higher when upstream supply is increased, the firm will sell the products incorporating the lower upstream price later. These actions help foster asymmetric pricing.

Refiners also face adjustment costs to changing their output or their product mix and, consequently, adjust their output slowly when possible. When crude oil supplies are reduced, refiners as a group have little choice but to reduce output quickly, which would lead to fairly quick increases in gasoline prices. When crude oil supplies are increased, however, refiners don't necessarily have to increase output quickly. They can increase output slowly and delay the decreases in gasoline prices.

THE POLICY RESPONSE

If we adhere to the traditional view that economic policy should be directed only at market failures or imperfections, policy probably should not be directed at eliminating the asymmetry between crude oil and retail gasoline prices. The evidence of monopolization in refining and wholesale markets for gasoline is weak at best. Peltzman (2000) finds that asymmetry itself is not indicative of a monopolized market. Any market power that might exist at the retail level appears to be related to the costs of product differentiation—most likely in the form of locational differences.

Furthermore, Peltzman finds that an asymmetric relationship between an upstream and a downstream price is as likely in competitive markets as in markets thought to be monopolized. If competitive market forces and asymmetry coexist, steps to suppress or eliminate the asymmetry are likely to prove costly because government interference in natural market processes typically reduces economic efficiency.⁹

If the monopolization of gasoline markets is a concern, policies will be more effectively directed at monopolization than at market phenomena that can be the result of either competitive or monopolized markets.

Refining and Wholesale Markets

Because there is little evidence of monopolization in the refinery and wholesale markets for gasoline, the observed asymmetry between wholesale gasoline and crude prices is most likely the result of competitive market forces. Calculations based on the BBY estimates also suggest the degree of asymmetry of response in wholesale gasoline prices to changes in crude oil prices is quite small and of short duration. Given a 1 percent increase and a 1 percent decrease in the crude oil price, the difference in response of wholesale gasoline to these changes is only 0.35 percent and persists only for two weeks. The asymmetry of response in wholesale gasoline prices starts around the third week and becomes insignificant around the fifth week. If competitive market forces account for the asymmetry between wholesale gasoline and crude oil prices, any policies to eliminate it are quite likely to involve higher costs than living with the asymmetry.

Even if it is the result of market power, the asymmetry is so fleeting that the likely costs of the unintended consequences of a policy to prevent price asymmetries probably would outweigh the benefits. If policymakers are concerned about the monopolization of refinery or wholesale markets for gasoline, the most prudent policy is to watch for mergers that increase market concentration without providing gains in the economies of scale, rather than to take direct steps to suppress asymmetry.

Retail Markets

Compared with the upstream markets, price asymmetries in the retail market are longer in duration and smaller in magnitude. Locational differentiation and consumer search costs could contribute to market power, and Borenstein and Shepard (1993) find evidence of coordinated pricing in the retail gasoline market. But, asymmetric pricing can arise whether or not there is market power. Consequently, the benefits of policies to eliminate asymmetry in the retail gasoline market are likely to be small, while the costs could be high.

Calculations made with the BBY estimates suggest that a 1 percent increase and a 1 percent decrease in the price of oil lead to a peak differential of only 0.2 percent in the response

of the retail gasoline price. To illustrate, suppose the current prices for oil and gasoline are \$30 per barrel and \$1.50 per gallon, respectively. The peak difference in the response of the retail gasoline price to a \$6 increase and decrease in the per barrel price of crude oil would be only 6 cents per gallon.¹⁰ For the average driver, this differential would amount to about 60 cents in the peak week. Because the differential is so small and search costs are high, it is not surprising that the price asymmetry persists longer than 16 weeks.

Since there is no evidence or theory suggesting that asymmetry necessarily arises from market power in the retail market, policies aimed at eradicating asymmetry are likely to reduce efficiency. Even a simple policy of requiring retail margins to remain constant over time could have unintended consequences for inventories and lead to shortages when prices are rising. More complicated policies would be more difficult to administer. Again, the best policy seems to be to watch for mergers that increase market concentration, rather than to take direct steps to suppress the asymmetry.

CONCLUSIONS

A number of econometric studies confirm casual observations that gasoline prices respond asymmetrically to crude oil price movements by rising more quickly when crude oil prices are rising than falling when crude oil prices are falling. Although popular opinion seems to attribute the asymmetry to market power, Peltzman (2000) shows that price asymmetries arise independently of market structure. In addition, no formal theory relating market power to asymmetry has been tested (to our knowledge), nor is there much evidence of concentration in U.S. markets for gasoline. Consumer search costs and locational advantages may provide market power to some retailers, but such market power might be viewed as the costs of product differentiation under monopolistic competition.

With the evidence pointing away from market power as an explanation, asymmetry is likely to be the consequence of other market factors. As such, policies to suppress asymmetric price movements are likely to lead to undesirable outcomes. If one is concerned about market power in the production, distribution, and marketing of gasoline, the best policy seems to be watching for mergers that increase market concentration without increasing economies of scale, rather than taking direct steps to suppress asymmetry.

NOTES

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- ¹ Previous research does not find this type of asymmetry. Increased environmental regulation of refinery operations and increased taxation of gasoline appear to have been offset by productivity gains. See Borenstein, Cameron, and Gilbert (1997) and Balke, Brown, and Yücel (1998).
- ² For examples, see Ferguson (2000) and Ivanovich (2000).
- ³ Peltzman (2000) finds that the fuel component of the consumer price index responds asymmetrically to the fuel component of the producer price index.
- ⁴ Pricing asymmetries have been observed in many industries, including banking (Neumark and Sharpe 1992) and agriculture (Mohanty et al. 1995). Peltzman (2000) finds pricing asymmetry exists in about two-thirds of U.S. industry.
- ⁵ Variations of the kinked-demand model of oligopoly do not suggest an asymmetrical movement in the output price of an industry in the response to common shocks to the input prices of the firms in that industry. The model explains why prices are less likely to change in either direction. See Scherer (1980) and Neumark and Sharpe (1992).
- ⁶ The Herfindahl–Hirschman Index (HHI) is a summary measure of market concentration.

$$HHI = \sum_{i=1}^n S_i^2,$$

where S_i is the market share of the i th firm. A monopolistic industry with one firm would have an *HHI* of 10,000 (where market shares are measured in percentage terms).

- ⁷ Given that retail margins are very small (see Deltas 1997 and BCG), a large increase in input prices could quickly turn margins negative. Hence, retailers hasten to pass on input price increases.
- ⁸ The low individual costs associated with limited market power should not be taken as an argument that asymmetry has little aggregate cost. We are simply pointing out that the individual benefit–cost calculations made by rational individuals are likely to result in a relatively slow search. When multiplied by the tens of millions of people who drive on a daily basis, the aggregate costs of asymmetry are significant, but these costs are presumably lower than the aggregate search costs that would be necessary to eliminate asymmetry.
- ⁹ Such policies might include government manipulation of inventories or a requirement that oil companies, distributors, and retailers use LIFO (last in, first out)

pricing for gasoline with constant markups over time. To the extent that either policy interfered with free market outcomes, implementation would reduce economic efficiency. A policy of varying taxes inversely with oil prices would be ineffective in eliminating asymmetry because it would not produce additional gasoline when prices are rising.

¹⁰ Six dollars per barrel is equal to the variance of oil prices in the past 10 years.

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