Behavior of Retail Gas Prices to Changes in Crude Oil Prices: Symmetric or Asymmetric?

by

Jaewook Kim*

* PhD Student, UP College of Business Administration
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ABSTRACT

This study examines if the behavior of retail gasoline prices is indeed asymmetric or possibly symmetric in the Philippines. The researcher used data from US Energy Information Administration and One Alternative Energy Blog in Philippines for the statistics on retail gasoline prices weekly for 5 years in the period of October 2005 to September 2010 for analysis. The test results revealed that the behavior of retail gas price is not completely symmetric to changes of crude oil although there is a symmetric responsiveness of unleaded retail gas prices to changes of crude oil prices in amount.

Key Words: Crude Oil, Retail Gasoline, Asymmetry, Symmetry
INTRODUCTION

Many people have criticized the retail gasoline price movements, alleging that they do not respond symmetrically to price changes of crude oil. In particular, they believe that retail gasoline prices do not reflect decreases in crude oil prices as rapidly and fully as they do price increases; i.e., gasoline prices respond more quickly when oil prices are rising than falling. The perceived asymmetry in retail gas prices is of special concern especially to consumers who believe that they are being “gouged” by the oil companies.

This social sensitivity to any kind of price hike has driven a lot of studies devoted to the examination of pricing behavior of retail gasoline, especially that gasoline is considered a vital commodity for the movement of goods and of people.

In July 2008, the retail price of the gas increased tremendously up to 60 pesos per liter. Since that time, the retail price of the gas has decreased to 31 pesos per liter in December 2008. The price became lower because of the huge decrease of the price of the world crude oil. In July 2008, the West Texas Intermediate (WTI) crude oil was traded at the spot price of $145.31 per barrel, and on December 2008, WTI crude oil decreased until the spot price of 36.73 per barrel. If we compare the size of decreased retail price of the gas with the price of the world crude oil, we can easily find that the retail price of the gas declined just 50%, although the price of WTI crude oil fell 75%.

On the other hand, John Felmy, chief economist for the American Petroleum Institute, said, “While crude oil prices were rising, demand for gasoline was falling, so gas didn't go up as much as crude," meaning that gas prices are slippery when crude prices are increasing. Interestingly, from April to July 2008, Dubai crude oil prices increased 42% but retail gas prices in Philippines increased 27% only.

What is Symmetry?

It is defined as symmetric if the retail gas price is not affected differently when the crude oil price increases or decreases. There are three types of symmetry: (1) timing symmetry which
checks if the changes of the crude oil price pass along in an equal speed to the retail prices in increases and decreases; (2) amount symmetry which compares the changes of the retail price affected by the crude oil price in increases and decreases and; (3) pattern symmetry which checks if the retail gas price adjusts to the crude oil price by an equal amount in the equal length of time, so the pattern symmetry can be viewed as the combination of timing symmetry and amount symmetry.

The importance of examining the response of retail gas price to changes in oil price as symmetric or asymmetric could serve the public a great benefit by understanding the pattern of the gasoline responses. In this way, they can optimize the gasoline consumption using the right knowledge of the relation between the crude oil price and the retail gas price. In this study, an attempt is made to show if there is really an asymmetric or a possible symmetric responsive behavior of retail gasoline prices to crude oil prices change in the Philippines based on the data availability.

**LITERATURE REVIEW**

There had been researches made before with supporting econometric model. For example, Bacon (1991) found an asymmetry in the U.K. gasoline market, and Karrenbrock (1991), French (1991), Borenstein, Cameron, & Gilbert (1997), and GAO report (1993) all found some evidence of an asymmetric response in U.S. gasoline markets. However, Norman & Shin (1991) and Balke, Brown, & Yucel, 1998) found a symmetric response in U.S. gasoline markets. Among the above studies, the most complex and convincing is the study of Borenstein, Cameron, and Gilbert (1997), also known as BCG. They presented a series of bivariate error correction models to test for the asymmetry in price and movements in each of the different stages in the production and distribution of gasoline from the crude oil through refinery to the retail pump using weekly and biweekly data from 1986 to 1992. All found a strong and pervasive evidence of asymmetry (Balke et al., 1998).

Peter (2008) confirmed crude oil price is one determinant in computing retail gasoline prices. He also suggested that in pricing gasoline to local market, one can compare with the international prices, a benchmark like crude oil price. Bahrens, C.E., and Glover, C. (2007) illustrated the
higher prices for crude oil translates directly into higher prices for gasoline. Crude oil accounts for about 54% of the cost of gasoline, 30% comes from refining, distributing and marketing account and the remaining 16% taxes account. Thus, these costs are passed to the retail gasoline prices.

The International Crude Oil Market Handbook 2001-2002 published internationally different traded crude oils. These crude oils vary in terms of characteristics, quality, and market penetration. Generally, differences in the prices of these various crude oils are related to quality differences but other factors can also influence the price relationships between each other. From the handbook, two crude oils benchmark the gasoline prices in the market. West Texas Intermediate (WTI) crude oil is an ideal crude oil in United States, the largest consuming country in the world. Most WTI crude oils are refined in the Midwest region of the country. Brent Blend is ideal for making gasoline and middle distillates, both of which are consumed in large quantities in Northwest Europe. Dubai crude oil is included in the OPEC Basket Price marks Asia.

In 2006, DOE/EIA said that one of the components of the retail price of gasoline is the crude oil to refiners. To support the relationship between oil prices and retail gasoline prices, Government Accountability Office or GAO (2007) confirmed that crude oil prices are major determinant of gasoline prices.

Borenstein, Cameron, & Gilbert (1997) presented the relationship between the retail gasoline prices and oil prices by using a simple lag adjustment model. They estimated the rate at which gasoline prices adjust to crude oil price changes and assumed this simple linear long-run relationship between retail gasoline prices $R$ and crude oil prices $C$ as follows:

$$ R = \phi_0 + \phi_1 C + e $$

Borenstein et al. (1997) found a simple empirical model for the adjustment of retail gasoline prices to changes of crude oil prices, allowing for the possibility of asymmetric rates, and this model can be stated as:
\[ \Delta R_t = \sum_{i=0}^{n} \left( \beta_i^+ \Delta C_i^+ + \beta_i^- \Delta C_i^- \right) + \epsilon_t \]

Where:
- \( \Delta R_t \) = changes in retail price from the period \( t \) changes in crude oil
- \( n \) = number of periods it takes for retail prices to complete adjustment to the period \( t \) change in crude oil prices

Balke, Brown, & Yucel (1998) presented an econometric exercise that attempts whether asymmetry occurs and found that most of the price volatility originates upstream. So a new model of linear regression was presented with upstream and downstream prices, \( P_{Ut} \) and \( P_{Dt} \) respectively. In linear form:

\[ P_{Dt} = a + b P_{Ut} \]

Where: \( a \) and \( b \) = parameters indicating the relationship between the upstream and downstream prices.
- The markup, \( a \), represents the cost of refining, marketing, transportation, and/or distribution.
- The scalar, \( b \), allows for differences in units and heat content

The study of Balke, Brown, & Yucel suggested that the model that they used differs from BCG in their specification: Balke et al. yielded the same conclusion that an asymmetric relationship exists in response of gasoline prices to crude oil prices although their model indicated a few cases and small asymmetric relationship while BCG model said it’s pervasive.

Some analysts and politicians argued that the retail gasoline prices do not follow symmetrically on oil price (Rothschild, 1990). “When the oil prices fall, there is always stickiness in gasoline prices on the way down. You never see the stickiness on the way up. Much of the perception of the possible asymmetry focuses on the relationship between the price of oil and the retail price of gasoline.” This suggests that oil producers or refineries are principally responsible for the asymmetry (Karrenbrock, 1991).
Galeotti et al. (2003) tested the relationship between crude oil prices and retail gasoline prices in the European gasoline markets and found a little evidence of asymmetry. Thus, this indicates that a symmetric relationship may possibly exist. Some other studies also have shown that a symmetry exist in the Canadian retail gasoline market (Godby, et al., 2000). In Shin (1994), Bachmiere & Griffin (2003) found a symmetric response in U.S. gasoline market.

Karrenbrock (1991) suggested a relationship between wholesale prices and retail gasoline prices using an approach model developed by wolfram (1971) while following Heien (1980), and Boyd & Brasen (1988) by including intercept to avoid biasing the coefficient estimates. Karrenbrock showed the way to check if there is an asymmetric relationship between the wholesale prices of gasoline and the retail gasoline prices. In this article, the whole sale price implies the price charged for gasoline by the refiner or jobber to the retail gasoline station. His model showed a good model to test an asymmetric relationship between two prices and thus it is possible to test between the crude oil prices and gasoline retail prices.

DATA AND METHODOLOGY

This study used the data of crude oil price from the US Energy Information Administration and One Alternative Energy Blog in Philippines for the statistics of the weekly retail gasoline prices for 5 years from October, 2005 to September, 2010. As countries import the crude oil from different sources, the price of each country’s gas is also related with its depending crude oil according to the International Crude Oil Market Handbook, 2001-2002.¹ This study used Dubai crude oil as the Philippines imports it. For the representative retail gas, unleaded gasoline and diesel were used as they are common gasoline to consumers in the Philippines. There are 10 oil or gas suppliers in the Philippines such as Caltex, Petron, Shell, Sea Oil, Flying V, Unioil, Total, City Oil, Jetti, and Eastern but this study used only 9 companies’ 5 years historical prices except Eastern due to the data abailiability.² Price information was collected from well-known energy web sites.³ Since crude oil prices appeared in U.S dollars per barrel, the prices were converted to Philippine peso per liter using the right exchange rate of every week.⁴ Tests were done by STATA program with OLS estimates.
This research used Karrenbrock’s model which shows a good way to test a symmetric behavior of one price to changes of the other price although he used it for the relationship between the wholesale and retail gas prices.

To test for the symmetric movements in retail price, the test was based on a model in which the change in retail gasoline price ($\Delta R_t$) is the function of the change in crude oil price ($\Delta C_t$). This model shows the effect of a change in the crude oil price on the retail price.⁵ The relationship is summarized as:

$$\Delta R_t = a_0 + a_1 \Delta C_t$$

However, since the effect of a change in the crude oil price does not pass through only for the same period but it is accumulated, the test uses the distributed lag model which is:

$$\Delta R_t = a_0 + a_{1,0} \Delta C_t + a_{1,1} \Delta C_{t-1} + a_{1,2} \Delta C_{t-2} + \cdots = a_0 + \sum_{i=0}^{p} a_{1,i} \Delta C_{t-i} + e_t$$

In order to examine how the effect of a crude oil price increase differs from that of a decrease, periods of crude oil price increases and decreases must be separated. Since there can be the difference in the timing of price pass-through in increase and decrease, finding the optimal lag is the first job to be done for the whole symmetry tests. The following model is the final model to find the amount symmetry and pattern symmetry.

$$\Delta R_t = a_0 + \sum_{i=0}^{p} a_{1,i} \Delta C_{t-i} + \sum_{i=0}^{q} a_{2,i} \Delta C_{t-i} + e_t$$

where

$\Delta R_t = R_t - R_{t-1}$

$\Delta C_{t-i} = C_{t-i} - C_{t-i-1}$ if $(C_{t-i} - C_{t-i-1}) > 0$, and $= 0$

$\Delta C_{t-i} = C_{t-i} - C_{t-i-1}$ if $(C_{t-i} - C_{t-i-1}) < 0$, and $= 0$
That is, all $\Delta C_{t}$ are positive or zero and all $\Delta CD_{t}$ are negative or zero.

$e_{t}$ = a random error term

$p$ and $q$ = specified number of lags for the crude oil price increases and decreases

As mentioned in the introduction, symmetry tests are largely classified into three---timing symmetry, amount symmetry, and pattern symmetry. Amount symmetry was divided by 2 sub-amount tests.

Timing Symmetry

HYPOTHESIS 1. The number of lags for increases is equal to the number of lags for decreases.

Differences in the timing of price pass-through can be indicated by differences in the number of lags for increases ($p$) and decreases ($q$). The test of this hypothesis will show if the length of time in which retail prices completely respond to a wholesale price change is symmetric or not.6

Amount Symmetry

HYPOTHESIS 2. The cumulative effect of a crude oil price increase is equivalent to that of a crude oil price decrease, that is;

$$H_{0}: \sum_{i=0}^{p} a_{1,i} = \sum_{i=0}^{q} a_{2,i}$$

To support amount symmetry, one more hypothesis can be tested to check the full reflection of the crude oil price in the retail price.

HYPOTHESIS 3. The crude oil price changes are fully reflected in the retail price, that is;

$$H_{0}: \sum_{i=0}^{p} a_{1,i} = 1 \quad \text{and} \quad \sum_{i=0}^{q} a_{2,i} = 1$$
**Pattern Symmetry**

HYPOTHESIS 4. The pattern of the retail price increases is not significantly different from that of the retail price decreases, that is;

\[ H_0: p = q \text{ and } a_{1,i} = a_{2,i} \]

To support pattern symmetry, the first condition is that basically the optimal lag of increases should be equal to that of decreases and the estimated coefficient of each lag variable in increases should not be statistically different from that in decreases.

**ANALYSIS AND RESULTS**

After the Dubai crude oil prices were converted to pesos per liter, 5 years’ historical movement of retail gas prices in the Philippines are shown in the following figures.
When we see the whole trend, the movement of two prices between crude oil price and retail gas price looks symmetric, but the test showed the detailed differences.

**Timing Symmetry**

When the distributed lag model was run to find the optimal lag for unleaded gas and diesel in increasing and decreasing, different results were created. Lag lengths used for periods of crude oil price increases were the same for unleaded gas and diesel, and they are all 2. However, unleaded gas had a longer lag length for crude oil price decreases than diesel by one. That is, the lag length of unleaded is 3 but that of diesel is 2. This means that crude oil price increases affect both unleaded and diesel retail prices for 3 weeks (the first week and two lagged weeks), but crude oil price decreases affect unleaded gas for 4 weeks and diesel for 3 weeks. Thus, the hypothesis 1 that the length of time in which retail prices completely respond to a crude oil price change is symmetric can be rejected for unleaded gas but cannot be rejected for diesel.
Amount Symmetry

The ordinary least squares estimates for the final model are summarized in the following table 1.

<table>
<thead>
<tr>
<th>Types of gasoline</th>
<th>Timing</th>
<th>Amount</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of weeks lagged</td>
<td>t-value for test of</td>
<td>t-value for test of</td>
</tr>
<tr>
<td></td>
<td>CI</td>
<td>CD</td>
<td>∑a₁,i = ∑a₂,i</td>
</tr>
<tr>
<td>Unleaded</td>
<td>2</td>
<td>3</td>
<td>0.37</td>
</tr>
<tr>
<td>Diesel</td>
<td>2</td>
<td>2</td>
<td>1.53</td>
</tr>
</tbody>
</table>

In hypothesis 2, the test intends to check if the cumulative effect of a crude oil price increase is equivalent to that of a crude oil price decrease by testing $\sum_{i=0}^{p} a_{1,i} = \sum_{i=0}^{q} a_{2,i}$. As we can see in table 1, t-statistic for first amount symmetric test for unleaded is very low, which means it can’t reject the null hypothesis and even in case of diesel, t-statistic is 1.53 meaning that it also can’t reject the null hypothesis at 5% significance level.

In hypothesis 3, the test tried to see if the crude oil price changes are fully reflected in the retail price by checking $\sum_{i=0}^{p} a_{1,i} = 1$ and $\sum_{i=0}^{q} a_{2,i} = 1$. This hypothesis cannot be rejected for unleaded retail gas since t-statistics are both low in increases and decreases, but the hypothesis can be rejected for diesel because t-statistic in price decreases of diesel is 3.3. It means that crude oil price increases are fully passed along to consumers, but crude oil prices are not fully passed along in case of diesel. Even if the test increased one more lag for diesel in price decreases, the result of testing hypothesis 3 didn’t change.

Through testing hypothesis 2 & 3, we can see that there is amount symmetry of price pass-through in unleaded retail gas but it is not complete in diesel retail gas.
**Pattern Symmetry**

The test also tried to see if there is pattern symmetry of retail price responses in increases and decreases by checking the estimated coefficients. The following table 2 shows the estimated figures.

**Table 2**

<table>
<thead>
<tr>
<th>Types of gasoline</th>
<th>Crude oil increases</th>
<th>Crude oil decreases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$a_{1,0}$</td>
<td>$a_{1,1}$</td>
</tr>
<tr>
<td>Unleaded</td>
<td>0.17</td>
<td>0.42</td>
</tr>
<tr>
<td>Diesel</td>
<td>0.20</td>
<td>0.56</td>
</tr>
</tbody>
</table>

* Estimated coefficients indicate statistical significance at the 5 percent level.

As shown in table 2, for crude oil price increases, the largest retail response occurs in the second week for unleaded and diesel, but for crude oil price decreases, the largest retail response occurs in the third week. Figure 3 & 4 show this pattern graphically.
A direct interpretation of the coefficients, as reported in table 2, is as follows: a 1-peso increase in crude oil price leads to 17-centavo increase in the unleaded retail gas price during the initial week, while a 1-peso decrease in crude oil price leads to 16-centavo decrease, therefore there is only 1-centavo difference in unleaded during the initial week. For diesel, the difference is 13 centavos implying that diesel responses faster in price increases than in price decreases during the first week. Thus, during the first week the pattern in price increases is similar to that in decreases for unleaded, but it is different in case of diesel.

But during the second week the pattern is really different in price increases and decreases for both retail gas. Retail gas prices both responses faster in price increases than in decreases. The difference between increases and decreases leads to 27 centavos and 46 centavos respectively for unleaded and diesel. In the third week the pattern shows reversely implying that the largest retail response occurs in decreases rather than in increases. Thus, hypothesis that $a_{1,i} = a_{2,i}$ can be rejected for both unleaded and diesel, indicating that each week there is a different price pattern in price increases and decreases. In the first and second week, all estimated coefficients are bigger in increases than in decreases but in the third week, there are opposite results. Through this test of pattern symmetry, we can get the idea that retail gas prices respond faster to crude oil price increases than decreases.
CONCLUSION

This paper has tested for symmetric retail gasoline price responses to changes in crude oil prices. The results show very different results in three kinds of symmetry tests. In timing symmetry, there is a symmetric responsiveness of retail diesel prices to changes of crude oil, but there is none in unleaded. In amount symmetry, there is a symmetric responsiveness of retail gas prices to changes of crude oil prices only for retail unleaded, but not for retail diesel. In pattern symmetry test, however, both retail gas showed asymmetric responses to crude oil price increases and decreases. Some people believe that retail gas price is sticky only when the crude oil decreases. If we consider the test result of the pattern symmetry test, we can see that retail gas prices respond slower in decreases than in increases. Contrary to the popular belief that consumers do not benefit from crude oil price decreases, crude oil price decreases are finally passed along to consumers as fully as are crude oil prices increases in case of unleaded retail gasoline. Although diesel retail gas price behavior does show complete amount symmetry, at least it shows that the cumulative effect of a crude oil price increase is equivalent to that of a crude oil price decrease. As the test results show in pattern symmetry, there might be the time gap in retail gas responses but eventually retail gasoline prices can move symmetrically in increases and decreases.

From regular vehicle drivers who consume the gas up to the business sectors that use the retail gas as the main cost factor, it became a social issue or interest to know how the retail gas price is affected by changes of the crude oil price. They are curious about how long and how much the retail gas price is affected by the changes of the crude oil price. Besides, they wish to know the stream or the trend of the retail gas price when the crude oil price is changing because knowing the price pattern will help them economize on the gas or maximize the benefit of using it. However, it is not easy to get the correct information and sometimes the public even tend to miss the correct information. For example, the benchmark crude oil of Philippines’ retail gasoline is Dubai crude oil but not WTI, but people usually see the prices’ high changes of WTI in the mass media. In the peak month of 2008, Dubai crude oil did not increase as high as WTI crude oil.7
There should be errors or disturbances that should be controlled for us to have more accurate results, and there could be business transactions that can hardly be quantified to be adopted in the model. Also, it is possible that this study can be tested using more sophisticated symmetry model by adding more control variables. Some other studies have shown before that symmetry existed but no one mentioned how strong, weak, or pervasive the relationship. Nevertheless, through this test, the behavior of the retail gas prices in the Philippines to changes of crude oil prices can be shown in different kinds of symmetry. Although the retail gas price can’t be completely predicted by knowing the changes of the crude oil, if the final consumers who are from the individual to the business sectors can figure out the pattern of the movements of the retail gas price depending on the changes of the crude oil price, the public might be able to get the benefit or advantage of optimizing the expenses of the retail gas by having the knowledge of the relationship of two prices.
ENDNOTES

1. The Philippines and New Zealand import the Dubai crude oil, US does the WTI crude oil and other many European countries do the Brent crude oil.

2. The weekly retail gas prices were obtained by computing the average of 9 companies’ prices. In case of missing weeks, prices were gotten by getting the average of the previous month and the next month.

3. For the crude oil, it is U.S. EIA (http://www.eia.doe.gov) and for the retail gas, it is One Alternative Energy Blog (http://www.alternat1ve.com). The crude oil price is weekly Asia Dubai Fateh Spot Price FOB (Dollars per Barrel).

4. Dubai crude oil price for Philippines: (US$ per barrel * exchange rate) / 159 = peso per liter. Historical weekly currency exchange rates were used from the interbank rate of OANDA Information company (http://www.oanda.com).

5. Retail gasoline prices include federal and state tax

6. To find the optimal lag for increases and decrease, the test used the distributed lag model and checked the significance level of increasing lag.

7. The highest spot price for Dubai crude oil was US$ 136.7 per barrel and US$ 145.16 for WTI crude oil in July, 2008.

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