# The Relationship between Crude and Refined Product Market: The Case of Singapore Gasoline Market using MOPS Data

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# The Relationship between Crude and Refined Product Market: The Case of Singapore Gasoline Market using MOPS Data[1]

by

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Abstract

Economic theory suggests that refined and crude oil prices should be interrelated as the refined products are a derivative of the crude product and hence the prices of the two categories must have a long run relationship. However any short term feedbacks between the two markets are also of interest. Any feedbacks which are significant between the markets will greatly improve our understanding of how the complex oil markets work and that the workings of both the markets are not as independent as some would want to believe.

The Johansen and Julius VCEM technique and Granger causality tests using co-integrating methodology show there is a basis to conclude that there is a uni-directional causality running from crude market to the refined product market, confirming a long run relationship between the markets.

[1] The author wishes to acknowledge the guidance of Professor Bill B Rao. His suggestions helped him to improve this paper in its various aspects.

## 1.0 **Introduction**

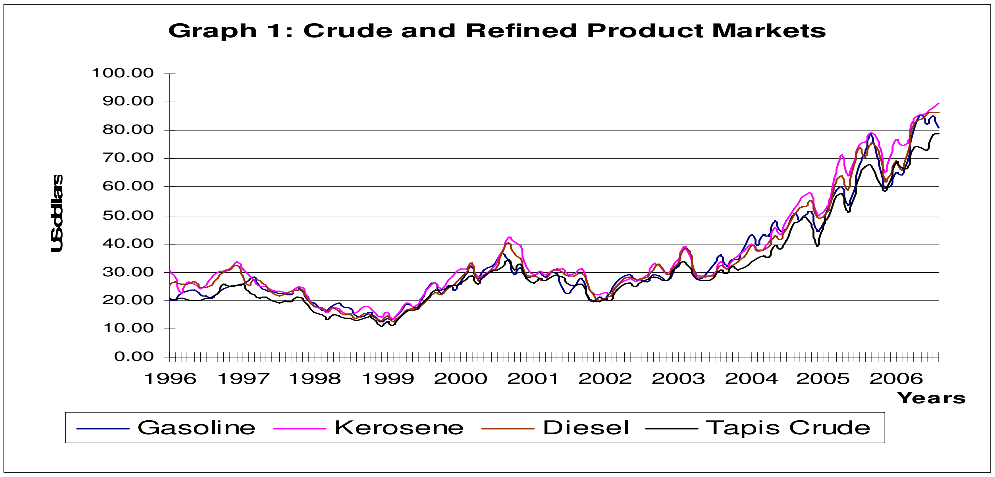
The spike in petroleum prices recently fueled intense public debate on the possible causes of price rises. Arguments that were put forward in the popular press focused on the price rises of refined product ex-refinery prices when the crude prices have been falling. Another argument popularly labeled as 'rockets and feathers' hypothesis of Bacon (1991) is also invoked. According to this hypothesis the prices of refined product prices respond asymmetrically to changes in crude prices. That is gasoline prices shoot up like rockets with rises in crude prices but float down like feathers when crude oil prices decrease.

Bacon (1991) found evidence of asymmetry in the UK market. Borenstein, Cameron and Gilbert (1997), BCG henceforth, tested, with weekly data, for asymmetry in the speed of retail price responses for the US gasoline market and found strong and pervasive evidence of asymmetry. Kaufmann and Laskowski (2005) revisited the issue of asymmetries in US gasoline market using monthly crude and gasoline data and concluded that the asymmetries can be attributed to refinery utilization rates and inventory behaviour. Their analysis implied that price asymmetries can be generated by efficient markets and do not require policy intervention by governments. Asche, Gjolberg and Volker (2003) investigated the crude and refined product markets in a multivariate framework and find that crude oil price is weakly exogenous and the link between several refined product prices implied market integration of these refined products and that producers will change output mix in response to price changes. Similarly, Rao and Rao (2005) demonstrated using quarterly gasoline prices that price asymmetry exists in the Fiji oil market and that upward adjustment in prices occur twice faster than any downward adjustments. Boreinstein, Cameron and Gilbert (1997) found asymmetric responses in US market but Bachmeier and Griffn (2003) showed that this was possibly due to the misspecification of the adjustment equations, inappropriate estimation methods and use of weekly instead of daily data. Rao and Rao (2006) point out some weaknesses in Bachmeier and Griffn and show that if the adjustment equations are properly specified and estimated, alternative specifications and temporal aggregation of data do not seem to affect the results. They used monthly US data to show that alternative specifications give equally good results and imply no asymmetry in the US gasoline price adjustments.

A number of these papers analyzed how retail prices have responded to changes in crude prices. A major criticism of the earlier approaches is that asymmetries in retail prices can be attributed to normal fluctuations in the refined product prices as this market responds to world market conditions of demand and supply. While this is true, assertions that refined product markets behave independently from the crude market also needs to be investigated. The Oil Industry sources in Fiji and the relevant Government Agency, The Prices and Incomes Board, believe that refined and crude markets are different markets and assert that crude prices as an explanatory variable to explain retail prices inappropriate (Rao and Rao, 2006). Implicitly they argue that the crude and refined markets behave independently of each other.

Economic theory on the other hand suggests that refined and crude oil prices should be interrelated as the refined products are a derivative of the crude product and hence the prices of the two categories must have a long run relationship. However any short term feedbacks between the two markets are also of interest. Any significant feedbacks between the markets will greatly improve our understanding of the complex oil markets and that the workings of both the markets are not as independent as some would want to believe.

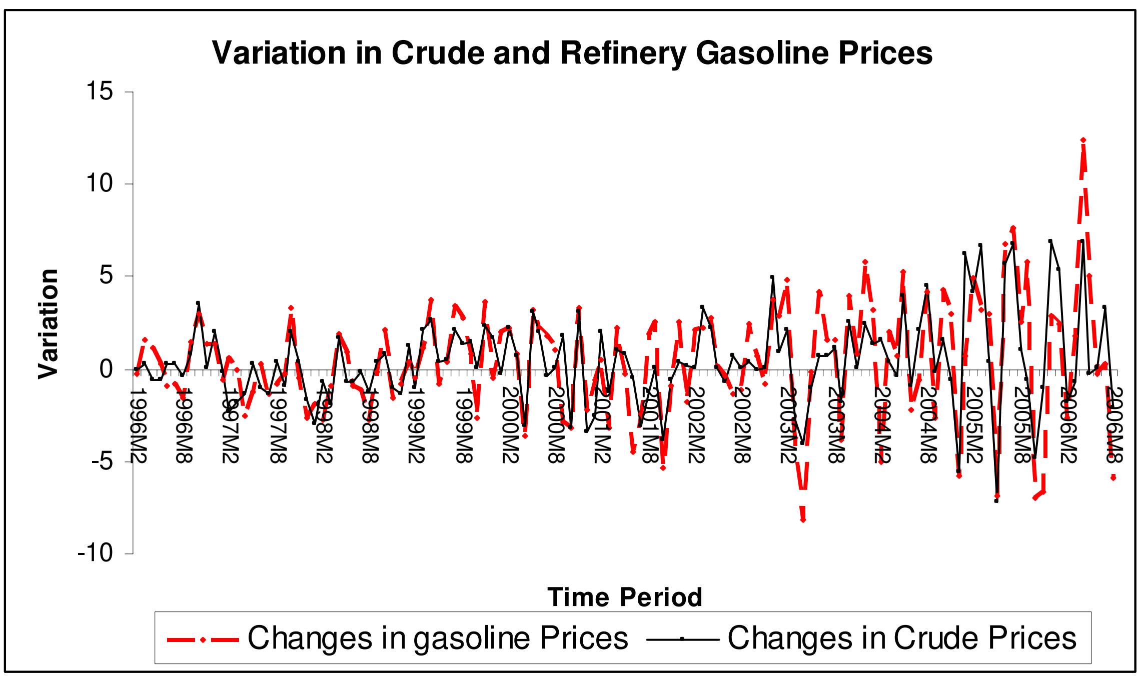
The previous studies on the relationship between crude and refined product market confirm a long term relationship between the two. In general, the observed pattern of crude oil and refined product prices tend to support this theory. Graph 1 shows this stable relationship for the years 1996 to 2005 using monthly data available from the Singapore markets.




Source: Platts Singapore Data

To show further relationship between the two markets the variation of crude prices over time can be related to similar variation in refined product prices. This spread is shown in graph 2

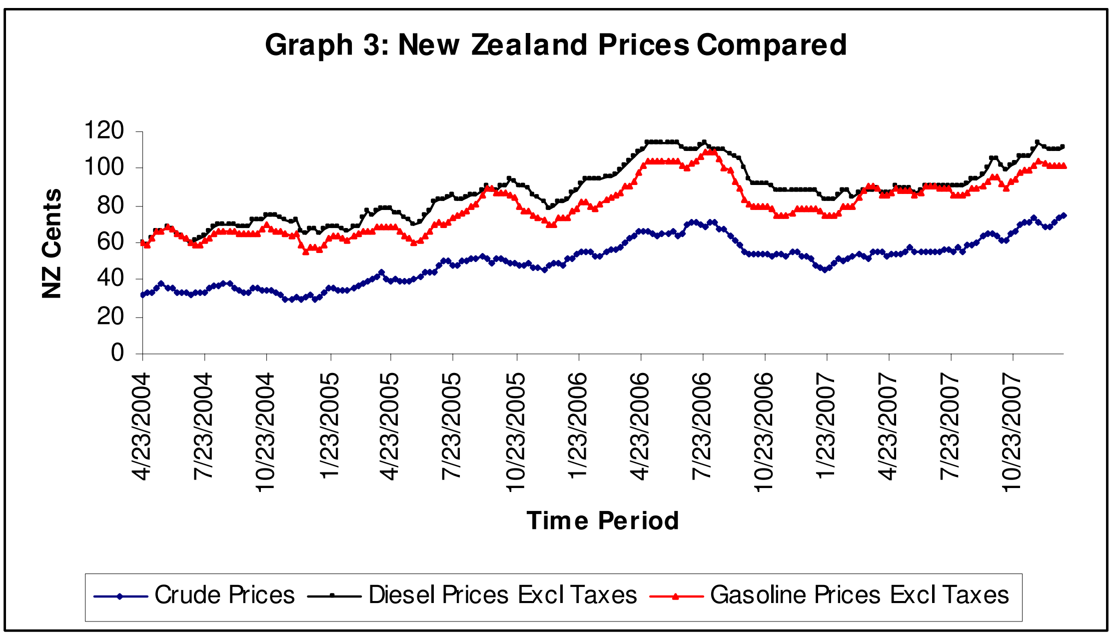
**Graph 2**: Variation in Crude and Product Prices from 1996 to 2006 using monthly data




Source: Singapore MOPS data

The variation in the refined gasoline prices shows a greater variation than the crude prices. This is consistent of the grain of the argument between crude and refined product markets that product markets are influenced much more by world market conditions than the crude markets.

Graph 3 compares monthly Dubai crude, gasoline and diesel retail prices (excluding taxes) in New Zealand from 2004 to 2007. The graph depicts a possible long run relationship between the crude and the retail prices. This further gives substance to the argument that crude prices can explain retail prices. Graph further display the 'margin' between the crude and retail prices excluding taxes. This margin on average is less than $NZ0.37 a litre and crude prices account for 58% of retail diesel prices excluding taxes. The similar percentage for gasoline is 63%.




Source: http://www.med.govt.nz/upload/35907/weekly%20table.csv

The objective of this paper is to establish the connection between crude and refined product markets and to indicate the direction of causality between the two markets. The refinery product price of gasoline and the prices of tapis crude have been used to detect causality. The outline of the paper is as follows: the next section discuses the Singapore refinery and the oil market in general. Section 3 states the methodology and presents the empirical results. Section 4 summarizes the paper and states its limitations.

## 2.0 Singapore Refinery Market

Singapore is the third largest oil refining centre in the world. The refinery started with a capacity of 70,000 barrels per day in 1973. Today, the capacity of the refinery has expanded to 285,000 barrels per day producing a wide range of high quality product including liquefied petroleum gas, motor gasoline, unleaded reformates, napnthas, jet fuel, kerosene, diesel oil and gas oil.

It exports a major portion of its refined products in tanker cargo to the world markets. Some of its major markets include Australia, China, Hong Kong, India, Indonesia, Japan, Malaysia, Middle East, Thailand, the United States and Vietnam.

### 2.1 Crude Characteristics and World Supply

The physical characteristics of crude oils differ. They are classified by their density and sulfur content. The higher value products can be recovered with simple distillation from less dense or lighter crudes that have a higher share of light hydrocarbons. The denser or heavier crude oils produce a greater share of lower-valued products with simple distillation and require additional processing to produce the desired range of products. The quality of the crude oil determines the level of processing and re-processing necessary to achieve the most advantageous mix of product output. Thus, the price and price differentials between crude oils also reflect the relative ease of refining.

The price of oil, like those of other goods and services, reflect both the product's underlying cost as well as market conditions at all stages of production and distribution.

The pre-tax price of refined oil product reflect costs associated with the raw material, transportation to refinery, processing, transportation from the refinery to the consumer market, storage and distribution between the market distribution center and the retail outlet or consumer and market conditions at each stage of production and distribution and in the local market. The price of crude oil, the raw material from which petroleum products are made, is established by the supply and demand conditions in the global oil market. Speculations on product availability can also have a major influence on prices. The crude oil price forms the baseline for product prices.

The crude oil prices are the most important determinant of petroleum product prices, as shown in graph 2 and often the most important factor in price changes as well.

Consumers have found themselves facing higher prices for gasoline and other petroleum products. The policymakers and consumers know that a sustained increase in the prices for petroleum products are critical to their economic well-being and need to understand three important points. Firstly, the petroleum products are global commodities and their prices are determined by supply and demand conditions globally. Secondly, the price of crude oil is the most significant factor determining the price paid for petroleum products. As a result, the price of petroleum products is principally determined by the worldwide demand for and supply of crude oil. Thirdly, prices reflect the interactions of buyers and sellers, influenced by their respective knowledge of the market and hence their expectations of the demand for and supply of crude oil and petroleum products.

Thus, those countries that follow the prices and incomes policy of monitoring the oil price movements via price controls must ensure that prices set are a fair reflection of prices worldwide. This is important in the sense of information asymmetry that exists between the oil companies and the government regulatory agencies, with regulatory bodies relying on the oil companies to supply their cost information on which maximum prices are based. Without appropriate proxies to monitor oil company cost movements, it might be quite prudent for the governments to remove price controls and deregulate the oil market.

The current prices for petroleum products are sustained at high levels due to stronger than expected growth in a number of world economies, like in China and India as these products are a significant source of fuel for the growing world economy. With crude oil suppliers producing at near capacity and as well as the cartel strength in the petroleum market, the capability to increase production to mitigate price increases has been limited.

The largest sources of supply are Saudi Arabia, Russia, the United States, Iran, Mexico, China, and Europe's North Sea. The Organization of Petroleum Exporting Countries (OPEC), an international cartel of oil-producing countries, produces about 40 percent of the world's daily consumption of crude oil and together has 65% of world's oil reserves. OPEC can manage its collective supply to influence world oil prices but it must be noted that it would not be in the organization's interest to push for price rises that would harm world economic growth and hence its own detriment. The ability of the major private oil companies, in an oligopolistic market structure, for super-normal profits also cannot be discounted.

## 3.0 Methodology

To show the relationship between the crude and the refined product markets, several different methodologies have been used. Firstly, I employ the Johansen Maximum Likelihood (JML) technique to determine the long run relationship between the two markets with the direction of Granger causality determined by the co-integrating VAR methodology.

We show the relationship between the crude and the refined product market by the following formulations:

$$LPG_t = \alpha + \psi \, LPC_t + \xi_t \qquad (1)$$

where *LPG* and *LPC* respectively denote the natural logarithms of refined product prices and crude oil prices and $\xi_t$ is the error term with the usual classical properties.

**Data**

The crude and refined product price time series data from 1996 to 2006 is the Mean of Platts (MOPS) which is the mean of daily spot prices at the Singapore market, the main supplier of refined products in the Asia Pacific region. The monthly data used has been derived from the MOPS data.

## 4.0 Analysis and Results

The time series properties of the variables are examined using the Augmented Dicky-Fuller (ADF) tests. The variables need to be stationery for the appropriate tests to be applied in the co-integrating methodology. Table 2 reports the results for the unit root tests. The test statistics for the ADF test are based on the maximized value of the AIC.

Table 2. Unit Root Test

| Variables | ADF | 5% Critical Values* |
|---|---|---|
| Crude Prices (*LPC*) | 0.39316 | -2.8865 |
| Δ in Crude Prices ( *Δ LPC*) | -2.9538 | -2.8868 |
| Refined Product Prices (*LPG*) | 0.24221 | -2.8865 |
| Δ in Refined Product Prices ( *ΔLPG*) | -9.3486 | -2.8868 |

- Mackinnon (1996) one-sided p-values.

According to the ADF test statistics it is found that both the refined product prices and the crude prices were *I(1)* in the levels but *I(0)* in the first differences. The ADF Test equations indicate that trend does not significantly explain changes in either crude or the product prices.

Johansen Maximum Likelihood method (JML) or the VECM technique is the most frequently used technique used in econometric work. This technique as suggested by Johansen (1998) and Johansen and Juselius (1990) can also be used to detect causality and provides more efficient and reliable estimates than the standard Granger causality tests and can be used to identify the JML long run equation.

The variables *LPG* and *LPC* must be I(0), a requirement of the *VECM* technique. This has been established using the appropriate ADF tests. The Akaike Information Criterion *(AIC)* and Schwarz Bayesian Criterion *(SBC)* both indicate that the optimal lag order is 1. The number of co-integrating vectors(s) using the JML procedure based on both maximum eigenvalue and trace of the stochastic matrix is reported in tables 3A and 3B. At 95% critical values, both the maximal eigenvalue and trace tests reject the null hypothesis that there is no cointegration but confirm that there is at least one cointegrating vector.

Table 3A: Johansen Maximum Likelihood Procedure of the co-integrating regression.

A. Test Based on Maximal Eigenvalue of the Stochastic Matrix

| Null | Alternative | Statistic | 95% Critical Value | 90% Critical Value |
|---|---|---|---|---|
| r = 0 | r = 1 | 30.6910 | 18.3300 | 16.2800 |
| r<= 1 | r = 2 | 2.8504 | 11.5400 | 9.7500 |

3B: Test Based on Trace of the Stochastic Matrix

| Null | Alternative | Statistic | 95% Critical Value | 90% Critical Value |
|---|---|---|---|---|
| r = 0 | r = 1 | 33.5414 | 23.8300 | 21.2300 |
| r<= 1 | r = 2 | 2.8504 | 11.5400 | 9.7500 |

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Estimated Cointegrated Vectors in Johansen Estimation (Normalized in Brackets)
 Cointegration with unrestricted intercepts and unrestricted trends in the VAR
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The implied cointegrating vector with unrestricted intercepts and unrestricted trends normalized on LPG is given by equation (3). Microfit is used for estimation. The order of VAR used is 1, selected using the VAR cointegrating methodology. The *t-statistic* is given in brackets.

$$LPG = 0.92691\ LPC \qquad (3)$$
$$(18.99)$$

The cointegrating *VAR* methodology can be used to confirm causality. The null hypothesis that the coefficients of the lagged values of *LPG* in the block of equations explaining the variable *LPC* are zero is accepted. The null hypothesis that the coefficients of the lagged values of *LPC* in the block of equations explaining the variable *LPG* are zero is rejected. The maximum order of the lag(s) is 1. This test confirms that the causality is uni-directional, going from crude market to refined market. The result is significant at 5% significance level and indicates that crude prices explain the refined product prices. It further confirms that the normalized equation reported in equation (3) is that of the refined product prices and therefore *LPG* appears on the left side of the equation.

In estimating the error correction model for the short run, a lag search procedure used in the General to Specific *(GETS)* approach was adopted. Using a 12 period lag structure, $\Delta LPG$ is regressed on the lagged error correction term (*ECM*), its lagged values and that of $\Delta LPC$. Using the standard variable deletion tests, we arrived at the following parsimonious short run equation. The *t*-statistics are given in brackets. The coefficient of the lagged error term has the correct sign and is significant.

$$\Delta LPG = \underset{(5.2535)}{0.12619} - \underset{(-5.3505)}{0.37627}\, ECM_{t-1} + \underset{(12.2072)}{0.88295}\, \Delta LPC_t - \underset{(2.0959)}{0.15405}\, \Delta LPC_{t-1} - \underset{(-2.4450)}{0.17926}\, \Delta LPC_{t-4} \qquad (4)$$

*R-Bar-Squared* =0 .60996 *SER* =0 .056515 $X^2_{scl}$ = 13.5369[.331] $X^2_{ff}$ = 3.1531[.076]

$X^2_{n}$ = 0 .13562[.934] $X^2_{hs}$ = 0.017687[.894] *DW-statistic* = 1.8469

The justification for including the current period change in LCP is based on our finding that *LGP* does not cause *LCP*. However, the above equation is re-estimated by excluding the current period change in *LCP*. The results are poor as shown below.

$$\Delta LPG = \underset{(3.8728)}{0.13921} - \underset{(-3.6751)}{0.38711}\, ECM_{t-1} + \underset{(1.6382)^{**}}{0.18029}\, \Delta LPC_{t-1} - \underset{(-2.0369)}{0.22342}\, \Delta LPC_{t-4} \qquad (5)$$

*R-Bar-Squared* = 0.12481 *SER* = 0.084656 $X^2_{scl}$ =21.6391[.042] $X^2_{ff}$ = 3.5185[.061]

$X^2_{n}$ = 1.6080[.448] $X^2_{hs}$ = 0.37365[.541] *DW-statistic* = 1.8635

**** significant at 10%**

The re-estimated model (5) shows a marked change in r-bar squared, having declined from 0.61 to 0.12 and fails the diagnostic tests for equation estimation. This indicates that the current period change in *LPC* significantly explains the change in *LPG*.

Having obtained the long run equilibrium estimates and the dynamic counterpart, it is important to test for the stability of the refinery price function. When we subjected our preferred equation (4) to CUSUM and CUSUSQ stability tests, neither the CUSUM nor the CUSUM SQUARES showed any instability. The plots of these tests are given in Figure 1 and 2 below.

Figure 1

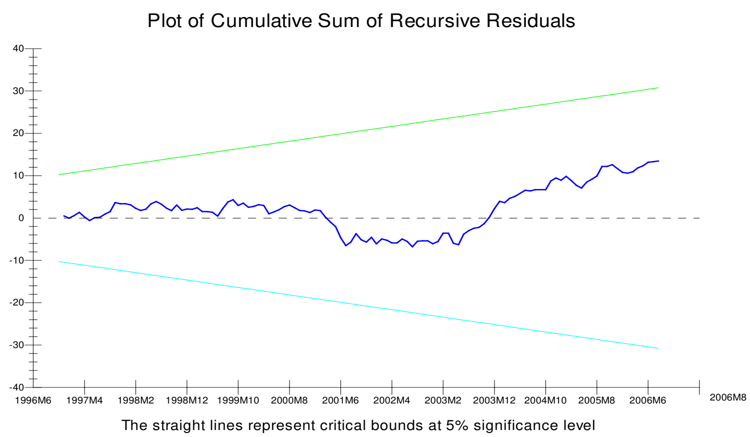
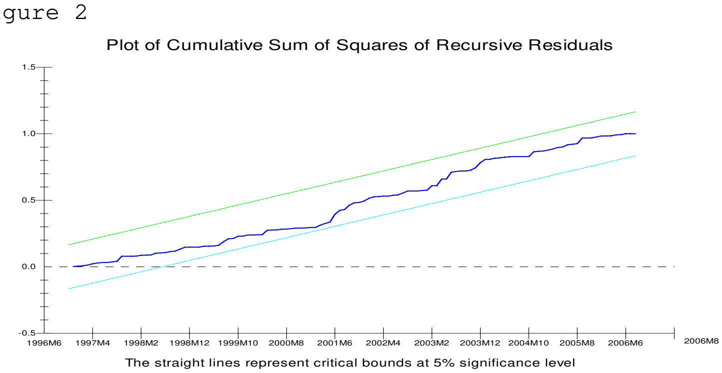



Figure 2




## 5.0 **Conclusions**

The results of this paper suggest that crude oil and refined gasoline markets are related and have a long run relationship. Using the *VCEM* technique and Granger-Causality tests in the co-integrating methodology, the causality is uni-directional, going from crude markets to the refined markets. This further indicates that in explaining the two markets the refined market variable should be on the left side of the equation and therefore can also convincingly explain fluctuations prices at the retail end. The equilibrium long run relationship implies that a 1% increase in the price of crude oil will eventually raise the price of refined fuel by 0.93%. Furthermore, recent large increases in the crude oil prices do not seem to have caused any temporal instability in this relationship.

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## Appendix

Data Source: Mean of Platts Singapore (MOPS), Singapore Refineries. Crude prices and Refine Product prices are both available from Platts.

Data Intervals: Monthly data converted from MOPS.

LPG = log of refined product ex–refinery prices of gasoline.

LPC = log of crude oil prices.

ECMRP = Error Correction Mechanism for the refined price variable.

ECMCP = Error Correction Mechanism for the crude prices.

Unit of measurement: prices quoted are US$ per barrel.