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# Oil Price and Exchange Rate Relationship for ASEAN-5 Countries: A Panel Study Approach

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## Abstract
The goal of this paper is to estimate the long run effects of real oil price and real interest rate differential on real exchange rate for a monthly panel of ASEAN-5 countries from 1983 to 2012. The modeling exercise begins with the determination of the stationarity condition of the variables which are found to be integrated of order one. Using several panel cointegration tests, the paper finds evidence of cointegration among the three variables. Finally, using pooled mean group estimator, the paper finds a negative and statistically significant impact of real oil price on real exchange rate for ASEAN-5 countries, implying that increase in real oil price leads to real exchange rate appreciation.
**Keywords:** oil price, exchange rate, cointegration.

## 1. Introduction

The potential significance of the price of oil for exchange rate movements has been noted by, *inter alios*, Golub (1983) and Krugman (1983a, b). There is a strong consensus among researchers who have examined the contribution of real oil price behaviour to the non-stationary behaviour of real exchange rates over the post-Bretton Woods period. Evidence shows that real exchange rates and real oil prices are cointegrated and that oil prices may have been the dominant source of persistent shocks and the non-stationary behaviour of US dollar real exchange rates over the post-Bretton Woods period (Amano and van Norden, 1998; and Chaudhuri and Daniel, 1998). Despite growing interest on the oil price-exchange rate nexus among OECD and Middle East economies (see, e.g., Chaudhuri and Daniel, 1998; Korhonen and Juurikkala, 2009), the study on emerging Asian economies is still lacking. This study attempts to address this issue for five core economies of South East Asia, namely Indonesia, Malaysia, the Philippines, Singapore and Thailand (henceforth denoted as ASEAN-5) during the period of 1983 to 2012.

In comparing a country that is self-sufficient in oil with one that needs to import oil, the former, other things being equal, would exhibit an appreciation as the price of oil rose in terms of the other country. More generally, countries that have at least some oil resources could find their currencies appreciating relative to countries that do not have oil resources (MacDonald, 1998). The paper expects to find a negative impact of oil price on exchange rate (i.e. real oil price increase leads to real appreciation of exchange rate) for the panel of ASEAN-5 countries. This is because among the ASEAN-5 countries, Malaysia and Indonesia are net oil exporters. Oil exports contribute around 6 percent and 9 percent respectively for Malaysia's and Indonesia's annual domestic revenue. Singapore although without any oil resource has a booming oil refinery industry that accounts for 6 percent of the city-state's economy. The Philippines despite being a net oil-importing country consumes oil only a third of that of Thailand (International Energy Agency, 2011), thus making the former's economy less exposed to oil price increases.

This paper is organized as follows: Section 2 provides a brief discussion on the theoretical framework and Section 3 discusses data and method employed in this study. This is followed by the presentation of empirical results as well as the analysis of the findings. Finally, concluding remarks are given at the end of the paper.

## 2. Theoretical Framework

This paper applies structural monetary model of Meese and Rogoff (1988) by considering the role of the real oil price as a determinant of the long-run equilibrium real exchange rate. The monetary model is regarded to be appropriate for this study due to the inclusion of the real interest rate differential as a determinant of the real exchange rate. Meese and Rogoff (1988) examined the co-movements of major currency real exchange rates and long-term real interest rates over the modern (post-March 1973) flexible exchange rate experience. The real exchange rate, $q_t$ (in log), can be defined as:

$$q_t \equiv e_t - p_t + p_t^* \qquad (1)$$

where $e_t$ is logarithm of nominal exchange rate (domestic currency per foreign currency unit) and $p_t$ and $p_t^*$ are the logarithms of domestic and foreign prices. Three assumptions are made: first, that when a shock occurs, the real exchange rate returns to its equilibrium value at a constant rate; second, that the long-run real exchange rate, $\hat{q}$, is a non-stationary variable; finally, that uncovered real interest rate parity is fulfilled:

$$E_t(q_{t+k} - q_t) = R_t - R_t^* \qquad (2)$$

where $R_t^*$ and $R_t$ are respectively, the real foreign and domestic interest rates for an asset of maturity $k$. Combining the three assumptions above, the real exchange rate can be expressed in the following form:

$$q_t = -\delta(R_t - R_t^*) + \hat{q}_t \qquad (3)$$

where $\delta$ is a positive parameter larger than unity. This leaves relatively open the question of which are the determinants of $\hat{q}_t$ that is non-stationary variable.

## 3. Method and Empirical Analysis

### 3.1 Data

The paper uses monthly data of oil price, exchange rate and interest rate for panel of 5 ASEAN countries from January 1983 to August 2012. Data are sourced from the International Financial Statistics (IFS), published by the IMF. Real exchange rates are constructed by using domestic price level and price level in a foreign country. Real exchange rate is equal to Nominal Exchange Rate * (Foreign Price Level / Domestic Price Level). Real oil price are defined as the price of monthly average crude oil expressed in US dollars, deflated by domestic CPI. Real oil price and real exchange rate are expressed in natural logarithm form. Real interest rate differentials (RDR) is calculated as $RDR_{it} = r_{it} - r_t^*$, where $r_{it}$ is the real interest rate of country $i$ and $r_t^*$ is the real foreign interest rate. Real interest rate is derived using Fisher equation. The real interest rate solved from the Fisher equation is (1 + Interest) / (1+Inflation) -1. The Hodrick Prescott filter is applied to RDR monthly series. US is chosen to be the numeraire country. The model to estimate is given as:

$$q_{it} = \alpha_i + \beta_{1i} rdr_{it} + \beta_{2i} roil_t \qquad (4)$$

where the real exchange rate ($q_{it}$) is defined as the cost of a unit of foreign currency in terms of the domestic currency, $rdr_{it}$ is the real interest rate differential and $roil_{it}$ is the real price of oil.

### 3.2. Panel unit root tests

The methods applied to the estimation of the real exchange rate model are based on the combination of panel techniques and cointegration tests. The first step to take, as in the time series context, is to analyze the order of integration of the variables, as a pre-requisite. Therefore, the paper employs the panel unit root tests proposed by Levin et al. (2002), and Hadri (2000). Table 1 reports on panel unit root tests for ASEAN-5countries. The results indicate that all the variables are stationarity in first difference and thus are integrated at level one,

**Table-1.** Panel Unit Root Tests

| | Null Hypothesis | Exchange Rate | Oil Price | Interest Rate Differential |
|---|---|---|---|---|
| **Series in level** | | | | |
| Levin, Lin, and Chu t-stat | Unit Root[a] | 1.97<br>(0.98) | 0.086<br>(0.53) | 1.69<br>(0.99) |
| Hadri Z-stat | Stationary[b] | 11.85<br>(0.00***) | 22.77<br>(0.00***) | -2.21<br>(0.01**) |
| **Series in first differences** | | | | |
| Levin, Lin, and Chu t-stat | Unit Root[a] | -8.60<br>(0.00***) | -48.13<br>(0.00***) | -58.58<br>(0.00***) |
| Hadri Z-stat | Stationary[b] | -0.97<br>(0.83) | -2.30<br>(0.99) | -2.28<br>(0.98) |

**Notes :** An intercept and trend are included in the test equation. The lag length was selected using the Modified Akaike Information Criteria.
The numbers in the bracket are the p-values of the corresponding test statistics.
* (**) *** denote statistical significance at the 10%,5% and 1% levels.
[a] Signifies that the null hypothesis is the unit root (with the assumption that the cross-sectional units share a common unit root process).
[b]Signifies that the null hypothesis of no unit root (but assumes a common unit root process for all cross-sectional units).

### 3.3. Panel cointegration test

Next, the study proceeds with the test for the presence of cointegration between real exchange rate, real oil price, and real interest rate differential based on panel cointegration tests by Kao (1999) and Maddala and Wu (1999). Results are presented in Table 2 and Table 3 indicate the existence of long-run equilibrium relationship between real exchange rate, real oil price, and real interest rate differential.

### 3.4 Long-Run Estimation

Finally, the long-run elasticities of the impact of real oil price and real interest rate differential on real exchange is estimated using Pesaran et al. (1999) pooled mean group (PMG) procedure. In practice, the PMG procedure involves first estimating autoregressive distributed lag (ARDL) models separately for each country *i*.

$$q_{it} = \mu_i + \xi_{i,1} roil_{it} + \xi_{i,2} roil_{i,t-1} + \psi_{i,1} rdr_{it} + \psi_{i,2} rdr_{it-1} + \theta_i q_{it-1} + \epsilon_t \qquad (5)$$

where *i* refers to a country *i* (i.e. a cross-sectional unit), and *t* is the time period. The corresponding error correction equation can be written as

$$\Delta q_{it} = \varphi_i (q_{it-1} - \alpha_{i1} - \alpha_{i2} roil_{it} - \alpha_{i3} rdr_{it}) - \xi_{i,1} \Delta roil_{it} - \psi_{i,1} \Delta rdr_{it} + \nu_{it} \qquad (6)$$

where

$\alpha_{i1} = (\mu_i/1-\theta_i)$, $\alpha_{i2} = (\xi_{i,1} + \xi_{i,2}/1-\theta_i)$, and $\alpha_{i3} = (\psi_{i,1} + \psi_{i,2}/1-\theta_i)$

In Eq. 6, $\varphi_i$ is the coefficient that measures the speed of adjustment to short-run disequilibrium, $\alpha_{i2}roil_{it}$ and $\alpha_{i3}rdr_{it}$ are the long-run coefficients of real oil price and real interest rate differential, respectively, while $\xi_{i,1}\Delta roil_{it}$ and $\psi_{i,1}\Delta rdr_{it}$ are the short-run coefficients for real oil price and real interest rate differential, respectively. For robustness check, the paper also utilizes the mean group estimator (MG), and dynamic fixed effects estimator (DFE). The long-run slope homogeneity hypothesis of PMG is tested via the Hausman test. Under the null hypothesis, PMG estimators are consistent and more efficient than MG estimators, which impose no constraint on the regression.

**Table-2.** Kao (1999) Residual Cointegration Tests

| Null hypothesis: No Cointegration | Statistics | Probability |
|---|---|---|
| Panel of All Countries | -1.63 | 0.05* |

**Note:** The null hypothesis is that there is no cointegration.. An asterisk (*) indicates rejection at the 10% level or better

**Table-3.** Maddala & Wu (1999) Fisher Panel Cointegration Test

| Hypothesized No. of CE(s) | Fisher Stat.* (from trace test) | Prob. | Fisher Stat.* (from max-eigen test) | Prob. |
|---|---|---|---|---|
| None | 70.44 | 0.00* | 68.25 | 0.00* |
| At most 1 | 18.08 | 0.05* | 18.35 | 0.05* |
| At most 2 | 5.89 | 0.82 | 5.89 | 0.82 |

**Note:** The null hypothesis is that there is no cointegration. Linear deterministic trend is included in the test equation. An asterisk (*) indicates rejection at the 10% level or better

## 3.5 Long Run Estimation Results

Table 4 examines the real oil price and real interest rate differential effects on real exchange rates for ASEAN-5 countries. It reports three alternative pooled estimates of PMG, MG, and DFE with a time trend. First, the long-run restriction imposed by PMG estimators cannot be rejected at the 5 percent level by the Hausman test statistics, suggesting that the PMG is the preferred estimator over MG. The coefficients corresponding to the speeds of convergence reported in Table 4 for PMG estimators are significantly different from zero. The PMG estimates, which impose homogeneity only on the long-run coefficients, provide strong evidence in support of a negative effect of real oil price on real exchange rate (i.e., higher real oil price leads to appreciation of real exchange rates). Our results are similar to the studies done for the oil exporting countries (see, e.g., Korhonen and Juurikkala, 2009; Koranchelian et al., 2005 and Zalduendo, 2006). This could be due to the fact that among the ASEAN-5, Indonesia, Malaysia and Singapore would benefit most from the oil price increases because of the significant contributions of oil revenue to these countries. The Philippines despite being an oil importing country consumes only a third of that of Thailand, thus making the former's economy less exposed to oil price increases. Since the analysis is based on the panel data of the ASEAN-5 countries, the results need to be treated with caution. The results do not represent the individual country but it only a general attribute to all member countries.

The PMG estimates also find evidence of a positive relationship between real interest rate differential and real exchange rate among the ASEAN-5 countries. The $rdr_{it}$ predicts that fluctuations in the real interest rate differential should be associated with temporary fluctuations in real exchange rates. More specifically, a widening interest rate differential in favour of the home country should be indicative of a future depreciation of the real exchange rate (Hoffmann and Ronald, 2009). Moving from PMG to MG and DFE estimates, the paper finds no statistically significant evidence in support of a long run effect of real oil price on real exchange rates, but finds strong evidence to support a positive effect of real interest differential on real exchange rate at 1% level of significance. Taking into account the whole set of regression results, the analysis shows a significant effect of real oil price and real interest rate differential on real exchange rate, only when using the PMG approach. The negatively significant real oil price coefficients obtained from PMG estimator suggest that higher real oil prices would result in an appreciation of real exchange rates for ASEAN-5 countries.

**Table-4.** Panel Long Run Estimation

| **Dependent Variable: Log Real Exchange Rate** | **With Time Trend. One lag (1,1,1,1)** | | | |
|---|---|---|---|---|
| | MG | PMG | Hausman | DFE |
| *Convergence Coefficient* | **-0.02***** | **-0.01***** | | **-0.02***** |
| | (-2.23) | (-2.64) | | (-3.64) |
| *Long Run Coefficient* | | | | |
| Log Oil Price | -0.15 | **-0.16*** | **0.98** | 0.0673 |
| | (-1.03) | (-1.67) | | (0.659) |
| Interest Rate Differential | **10.04***** | **8.77***** | | **10.02***** |
| | (2.76) | (3.31) | | (3.34) |
| Time Trend | 0.00 | -0.00 | | 0.00 |
| | (0.07) | (-0.66) | | (0.85) |
| *Short Run Coefficient* | | | | |
| ΔLog Oil Price | **-0.19***** | **-0.02***** | | **-0.02**** |
| | (-2.21) | (-2.4) | | (-2.36) |
| Δ Interest Rate Differential | 0.15 | 0.16 | | 0.02 |
| | (1.42) | (1.47) | | (0.64) |
| No. of Countries | 5 | 5 | | 5 |
| No. of Observations | 1775 | 1775 | | 1775 |
| Log likelihood | | 4087 | | |

**Note :** t-statistics calculated using heteroskedasticity consistent standard errors.
All equations include a constant country-specific term. t-statistics are in parentheses.
*Significant at 10% or better; Significant coefficients in **bold** letters.

## 4. Summary and conclusion

The paper investigates the existence of relationship link exists between the price of oil and real exchange rates for five ASEAN countries. All variables are determined as non-stationary at level but stationary at first difference or I(1) for all countries in the. Second, it shows existence of a long-term relation (i.e. cointegration relation) between the variables. Third, as for the impacts of real oil price on real exchange rate, the paper conducted a dynamic panel data study which allows for considerable heterogeneity across countries for eight countries over 1983–2012 using the PMG, MG and DFE panel estimators. Of the three estimators used, the paper finds a significant impact of real oil price on real exchange rates when using the PMG estimator which indicates that oil price increases would cause a real appreciation of exchange rates.

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