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Exchange Rate Determination: Empirical Evidence from the Monetary Model in Malaysia

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This study examines the determination of exchange rate in Malaysia using the monetary model. The results of the autoregressive distributed lag (ARDL) approach shows that there is a long-run relationship between exchange rate and its determinants, namely relative money supply, relative demand, interest rate differential, and oil price. More specifically, an increase in relative money supply or interest rate differential will lead to a decrease in exchange rate in the long run. Conversely, an increase in oil price will lead to an increase in exchange rate in the long run. The results of the generalised forecast error variance decompositions show that oil price is relatively least important than relative money supply in the determination of exchange rate in Malaysia.

1. Introduction

The determination of exchange rate is an important issue in international finance. However, this issue remains open and little consensus exists on factors that influence exchange rate. One of the models used in the determination of exchange rate is the monetary model.[2] Many empirical studies show the monetary model to have a better power of out-of-sample prediction than the random walk model (Zhang, Lowinger, and Tang, 2007). Loria, Sanchez, and Salgado (2009) examine the Mexican peso against the United States (US) dollar using the monetary model. The results of the cointegrated structural vector autoregressive (SVAR) model show that there are robust short and long-run relationships between exchange rate and its determinants. Fundamental shocks influence changes in exchange rate. Husted and MacDonald (1999)

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[2] See Copeland (2008) for other models of exchange rate determination.

show that fundamentals influence changes in exchange rates of many Asian countries. Baharumshah and Masih (2005) examine the determination of Singaporean dollar and the Malaysian ringgit against Japanese yen, respectively using the monetary model augmented by current account balance. The results show that the model fits the data well. Moreover, the model produces good in-sample and out-of-sample forecasts. Baharumshah, Siti Hamizah, and Ahn (2009) examine the predictive power of the monetary model for the Malaysian ringgit against the US dollar. The out-of-sample forecasts show that the monetary model outperforms the random walk model. The monetary model does well at the four to eight quarters horizon.

Chen and Chen (2007) show that there is a link between real oil price and real exchange rate in the G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) using a monthly panel. Moreover, the panel predictive regression suggests real oil price has significant forecasting power. The out-of-sample prediction performances demonstrate greater predictability over longer horizons. Furthermore, the results show real interest rate differential and productivity differential to have important impact on real exchange rate. Bergvall (2004) shows amongst others that demand factor accounts for most of the long run variance in real effective exchange rate for Finland and Sweden whilst terms of trade and real oil price are found to be the most important determinant of long-run movement in real effective exchange rate for Norway and Denmark. On the other hand, Huang and Guo (2007) show amongst others that an increase in real oil price will lead to a minor appreciation of real effective exchange rate in the long run as China depends less on imported oil. The world oil price has been characterised by high volatility, high intensity jumps, and strong upward drift rather than to fall above the expected mean (Askari and Krichene, 2008: 2134; Dvir and Rogoff, 2009: 9). Askari and Krichene (2008: 2135) find that oil price volatility measured by implied volatility was excessively high, that is, in the range of 30 percent. This implies that oil price was facing uncertainty regarding future price development and sensitive to small shock and to news. Thus exchange rate may be volatile as well.

This study examines the determination of exchange rate in Malaysia using the monetary model augmented by oil price. Oil price is said to be volatile and to have a significant impact on exchange rate. Thus it is important to examine the impact of oil price on exchange rate. Malaysia is a net-oil exporting country. Oil price could have different impact on exchange rates of the net-oil exporting and importing countries. Generally, an increase in oil price could appreciate exchange rate of the net-oil exporting country whilst could depreciate exchange rate of the net-oil importing country (Bergvall, 2004: 327). Previous studies focus mostly on the impact of oil price on exchange rate in the net-oil importing country (Chen and Chen, 2007; Bagchi, Chortareas, and Miller, 2004). The Pesaran, Shin, and Smith (2001) (PSS) bounds testing approach is used to examine the long-run relationship of variables in the monetary model. The PSS bounds testing approach does not impose restrictive assumption that all the independent variables are to be integrated of the same order. The relative importance of oil price with other variables in the monetary model is examined using the generalised forecast error variance decomposition and generalised impulse response function (Koop, Pesaran, and Potter, 1996; Pesaran and Shin, 1998).

The rest of this study is structured as follows. The next section describes the monetary model to exchange rate determination. This is followed by explaining the data and methodology used in this study and then empirical results and discussions. The last section includes some concluding remarks.

2. The Monetary Model to Exchange Rate Determination

The monetary model shows how exchange rate and monetary factor interact in the long run. The model is based on amongst others purchasing power parity (PPP) and a stable money demand function.

Purchasing Power Parity (PPP)

Purchasing power parity (PPP) states that exchange rate between two counties is the ratio of prices between the two counties:

$$E_{H/F} = \frac{P_H}{P_F} \tag{1}$$

where $E_{H/F}$ is exchange rate of home currency for foreign currency, P_H is home price, and P_F is foreign price.

Equation (1) can be rearranged to obtain:

$$P_H = E_{H/F} P_F \tag{2}$$

PPP implies that home price and foreign price are equal when measured in terms of the same currency.

The Monetary Model to Exchange Rate

Money market is in equilibrium when model demand is equal to money supply:

$$M_d = M_s \tag{3}$$

where M_d is money demand and M_s is money supply. Real money demand can be expressed in the following function:

$$\frac{M_d}{P} = L(Y, R) \tag{4}$$

where P is price level, Y is income, and R is interest rate. Money demand theory predicts that an increase income will lead to an increase in real money demand whilst an increase interest rate will lead to a decrease in real money demand.

Price level can be expressed in terms of money demand and money supply. In home country, domestic price can be expressed by assuming money market is in equilibrium and money demand function is given in equation (4) as:

$$P_H = \frac{M_{s,H}}{L(R_H, Y_H)} \tag{5}$$

where the subscript H denotes home country. In foreign country, foreign price can be expressed in a similar way as in home country as:

$$P_F = \frac{M_{s,F}}{L(R_F, Y_F)} \tag{6}$$

where the subscript F denotes foreign country.

Under PPP, exchange rate can be expressed as:

$$E_{H/F} = \frac{\dfrac{M_{s,H}}{M_{s,F}}}{\dfrac{L(R_H, Y_H)}{L(R_F, Y_F)}} \tag{7}$$

The monetary model makes a number of specific predictions about the long-run impacts of changes in money market on exchange rate changes. An increase in home (foreign) money supply will lead to an increase in exchange rate or home (foreign) currency is said to be depreciated (appreciated) as more money supply will lead to higher price in the economy. An increase in interest rate in home (foreign) country will lead to an increase in exchange rate or home (foreign) currency is said to be depreciated (appreciated). An increase in home (foreign) output will lead to a decrease in exchange rate or home (foreign) currency is said to be appreciated (depreciated) (Copeland, 2008: 149-173).

3. Methodology

A vector of variables, namely exchange rate, relative money supply, relative demand, relative interest rate, and oil price is examined. Moreover, a dummy variable, that is, one for the period of 1997, quarter II to 1998, quarter IV and the rest are zero to capture the influence of the Asian financial crisis, 1997-1998 is included in the estimation. An increase in relative money supply, relative demand, and interest rate differential will lead to an increase in exchange rate in the long run. An increase in oil price will lead to a transfer of wealth from the net-oil importing country to the net-oil exporting country. Moreover, a change in oil price will lead to a change in relative price of the commodities. More specifically, an increase in oil price will lead to an increase in relative price of the commodities in the net-oil exporting country more than an increase in the net-oil importing country. Thus exchange rate will appreciate in the net-oil exporting country. Nonetheless, the impact of oil price on exchange rates depends on the composition of imports of the net-oil importing country and also on preferences of portfolio of both the net-oil-importing and net-oil-exporting countries (Huang and Guo, 2007: 405).

The Elliot, Rothenberg, and Stock (1996) (ERS) and Phillips and Perron (1988) (PP) unit root test statistics are used to examine the stationarity of the series. The ERS unit root test statistic is shown to have a higher power for small sample size. The PSS bounds testing approach is used to examine the long-run relationship of the series. The PSS bounds testing approach does not impose restrictive assumption that all the independent variables are to be integrated of the same order. In other words, independent variable could be I(0), I(1) or mixture of I(0) and I(1) variables. More specifically, the bounds testing approach is conducted in the following way. The unrestricted error correction model is specified as:

$$\begin{aligned}\Delta \log ER_t &= \beta_{10} + \beta_{11} Trend + \beta_{12} D_t + \sum_{i=1}^{p} \beta_{13i} \Delta \log ER_{t-1} + \sum_{i=0}^{p} \beta_{14i} \Delta \log M_{t-1} \\ &+ \sum_{i=0}^{p} \beta_{15i} \Delta \log Y_{t-i} + \sum_{i=0}^{p} \beta_{16i} \Delta R_{t-i} + \sum_{i=0}^{p} \beta_{17i} \Delta \log O_{t-i} \\ &+ \beta_{18} \log ER_{t-i} + \beta_{19} \log M_{t-i} + \beta_{110} Y_{t-i} + \beta_{111} \log R_{t-i} \\ &+ \beta_{112} \log O_{t-i} + u_{1,t} \qquad (8)\end{aligned}$$

where Δ is the first difference operator, log is the natural logarithm, *Trend* is a time trend, ER_t is exchange rate, D_t is the dummy variable to capture the influence of the Asian financial crisis, 1997-1998, M_t is relative money supply, Y_t is relative demand, R_t is interest rate differential, O_t is oil price, and $u_{1,t}$ is a disturbance term. The Wald or F-statistic is computed to test the null hypothesis, H_0: $\beta_{18} = \beta_{19} = \beta_{110} = \beta_{111} = \beta_{112} = 0$ against the alternative hypothesis, H_a: $\beta_{18} \neq \beta_{19} \neq \beta_{110} \neq \beta_{111} \neq \beta_{112} \neq 0$. The critical bounds values can be obtained from Pesaran, Shin, and Smith (2001). If the Wald or F-statistic falls outside the upper bound, the null hypothesis of no cointegration is rejected. In other words, log ER_t, log M_t, log Y_t, R_t, and log O_t are said to be cointegrated. However, no conclusive inference could be made for the Wald or F-statistic falls inside the critical bounds, unless the order of integration of the independent variables is known. If the Wald or F-statistic falls below the lower bound, the null hypothesis of no cointegration cannot be rejected.

If there is evidence of cointegration of the variables examined, the long-run model of the autoregressive distributed lag (ARDL) approach can be estimated as:

$$\log ER_t = \beta_{20} Trend + \sum_{i=1}^{q} \beta_{21i} \log ER_{t-1} + \sum_{i=0}^{q} \beta_{22i} \log M_{t-1} + \sum_{i=0}^{q} \beta_{23i} \log Y_{t-i}$$

$$+ \sum_{i=0}^{q} \beta_{24i} R_{t-i} + \sum_{i=0}^{q} \beta_{25i} \log O_{t-i} + u_{2,t} \qquad (9)$$

where $u_{2,t}$ is a disturbance term. The model is estimated by using the ordinary least squares (OLS) estimator.

The error correction model of the ARDL approach can be estimated as:

$$\Delta \log ER_t = \beta_{30} + \beta_{31} D_t + \sum_{i=1}^{q} \beta_{32i} \Delta \log ER_{t-1} + \sum_{i=0}^{q} \beta_{33i} \Delta \log M_{t-1} + \sum_{i=0}^{q} \beta_{34i} \Delta \log Y_{t-i}$$

$$+ \sum_{i=0}^{q} \beta_{35i} \Delta R_{t-i} + \sum_{i=0}^{q} \beta_{36i} \Delta \log O_{t-i} + \beta_{37} EC_{t-1} + u_{3,t} \qquad (10)$$

where EC_{t-1} is one period lag of the error correction term and $u_{3,t}$ is a disturbance term. The error correction term is derived from the error term of equation (9). The coefficient of the error correction term is expected to be negative and measures the speed of adjustment towards the equilibrium in the long run.

The generalised forecast error variance decomposition and generalised impulse response function (Koop, Pesaran, and Potter, 1996; Pesaran and Shin, 1998) are used to examine the relationship of variables in a system. The generalised forecast error variance decomposition identifies the proportion of forecast error variance in one variable caused by the innovations in other variables in a system. Thus the relative importance of a set of variables that affect a variance of another variable is identified. The generalised impulse response function traces the dynamic responses of a variable to innovations in other variables in a system. A key feature of the generalised forecast error variance decomposition and generalised impulse response function (Koop, Pesaran, and Potter, 1996; Pesaran and Shin, 1998) is that they are invariant to the ordering of the variables in the vector autoregressive (VAR) system. Thus they provide robust results than the orthogonalised method of Sims (1980). Moreover, they allow for meaningful interpretation of the initial impact response of each variable to shocks to any of the other variables because they do not impose orthogonality (Wang and Dunne, 2003).

Let x_t is an $m \times 1$ vector of jointly determined dependent variables, which are assumed to be I(1) series, respectively. The infinite moving average representation of Δx_t can be written as:

$$\Delta x_t = \sum_{i=0}^{\infty} C_i \varepsilon_{t-i} + \sum_{i=0}^{\infty} C_i \Pi \Lambda w_{t-i}\ ,\ t = 1, 2, \ldots, \mathrm{T} \tag{11}$$

where C_i is $m \times m$ coefficient matrices, $\prod = \alpha'\beta$ (α and β are $m \times m$ matrices of full rank r, that is, rank ($\prod$) = r), Λ is an $m \times g$ matrix of unknown coefficients and w_t is an $q \times 1$ vector of deterministic and or exogenous variables.

The generalised impulse response function, which measures the effect of the shock to the j-th equation in (11) on Δx_{t+n} can be written as:

$$\Psi_{\Delta x_j}(n) = \sigma_{jj}^{-1/2} C_n \Sigma e_j\ ,\ n = 0, 1, 2, \ldots \tag{12}$$

where σ is standard error, Σ is $m \times 1$ covariance matrix, and e_j is an $m \times 1$ selection vector with unity as its j-th element and zeros elsewhere.

The generalised forecast error variance decomposition is given by:

$$\theta_{ij}(n) = \frac{\sigma_{ii}^{-1} \Sigma_{l=0}^{n} (e_i' C_l \Sigma e_j)^2}{\Sigma_{l=0}^{n} (e_i' C_l \Sigma C_l' e_i)}\ ,\ i, j = 1, \ldots, m \tag{13}$$

Generally, the sum of the generalised forecast error variance decomposition is not one, that is, $\sum_{j=1}^{m} \theta_{ij}(n) \neq 1$ as the non-zero covariance between the original (non-orthogonalised) shocks.

4. Data

All the data were obtained from *International Financial Statistics*, the International Monetary Fund (IFS, IMF). Exchange rate is expressed by nominal effective exchange rate (2000 = 100). Relative money supply is expressed by ($M_{d,t}$ / $M_{w,t}$), where $M_{d,t}$ is the monetary aggregate M2 in Malaysia and $M_{w,t}$ is the monetary aggregate M2 in the world, which is expressed by the monetary aggregate M2 in the US. Relative demand is expressed by ($Y_{d,t}$ / $Y_{w,t}$), where $Y_{d,t}$ is the industrial production index (2000 = 100) in Malaysia and $Y_{w,t}$ is the industrial production index in the world, which is expressed by the industrial production index (2000 = 100) in the US.[3] Interest rate differential is expressed by the difference between the domestic interest rate and the world interest rate, that is, ($r_{d,t}$ - $r_{w,t}$), where $r_{d,t}$ is the money market rate in Malaysia and $r_{w,t}$ is the money market rate in the world, which is expressed by the money market rate in the US. Oil price is expressed by the world oil price (2000 = 100). The data are quarterly and the sample period is from 1975, quarter I to 2006, quarter IV. All data were seasonal adjusted and transformed into the natural logarithms before estimation, except interest rate differential.

Figure 1 shows the plots of the natural logarithms of exchange rate and oil price. Generally, these series, namely exchange rate and oil price moved in the same direction. Thus these series tended to be cointegrated. For the period of 1975, quarter I to 2006, quarter IV, the coefficient of correlation between nominal effective exchange rate and oil price was -0.1104. The standard deviations of those series were 17.1326 and 42.3702, respectively (IFS, IMF). They were closely related and oil price was more volatile than nominal effective exchange rate. Figure 2 shows the scatter plots of exchange rate against relative money supply, relative demand, interest rate differential, and oil price,

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[3] Baharumshah, Siti Hamizah, and Ahn (2009) also use the industrial production index as the proxy to measure the income in their study.

respectively. Generally, there is no clear pattern can be concluded from the figure about the relationship of exchange rate against relative money supply, relative demand, interest rate differential, and oil price, respectively.

Figure 1 The Plots of the Natural Logarithms of Exchange Rate (log ER_t) and Oil Price (log O_t)

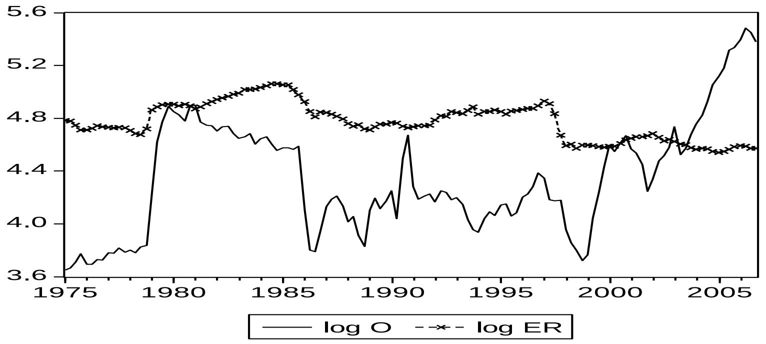
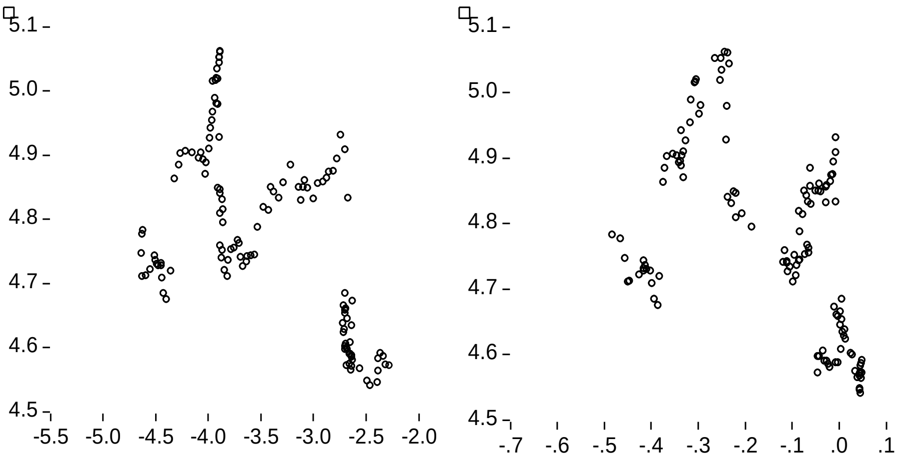
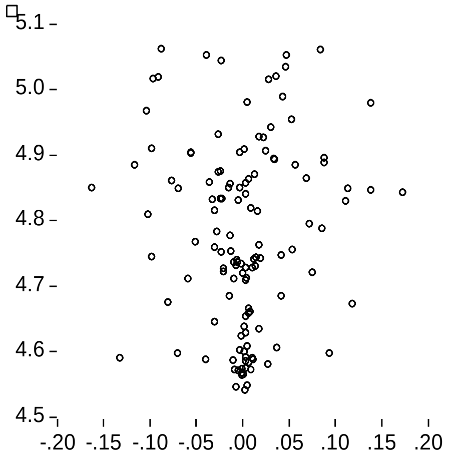


Figure 2 The Scatter Plots of the Natural Logarithms of Exchange Rate (log ER_t) against Relative Money Supply (log M_t), Relative Demand (log Y_t), Interest Rate Differential (R_t), and Oil Price (log O_t)

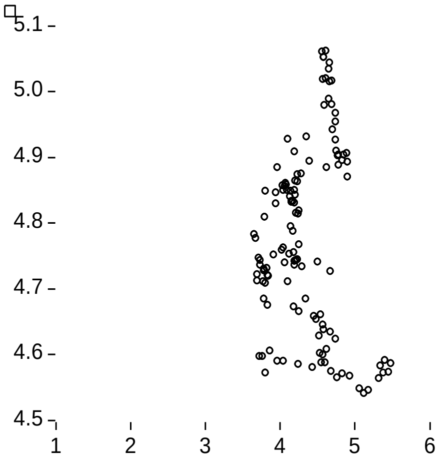


log ER_t and log M_t log ER_t and log Y_t

log ER_t and R_t



log ER_t and log O_t



5. Empirical Results and Discussions

The results of the ERS and PP unit root test statistics are reported in Table 1. The lag length used to estimate the ERS unit root test statistics is based on the Akaike Information Criterion (AIC). The lag length used to compute the PP unit root test statistics is based on the Newey-West Bandwidth, with the maximum lag length is set to eight. The results of the ERS and PP unit root test statistics show that all the variables are non-stationary in their levels but become stationary after taking the first difference, except relative money supply and interest rate differential. For relative money supply, the ERS unit root test statistic (Trend) shows no evidence of a unit root whilst the PP unit root test statistic (Trend) shows that it is a non-stationary series. For interest rate differential, the ERS unit root test statistics (No Trend, Trend) show that it is non-stationary series whilst the PP unit root test statistics (No Trend, Trend) show that it is a stationary series. Thus the variables examined could be the mixture of I(1) and I(0) variables.

Table 1 The Elliott, Rothenberg, and Stock (1996) (ERS) and Phillips and Perron (1988) (PP) Unit Root Test Statistics

	ERS (No Trend)	PP (No Trend)	ERS (Trend)	PP (Trend)
log ER_t	-1.6718(1)	-1.2670(3)	-2.1833(1)	-2.0980(3)
Δ log ER_t	-6.8360**(0)	-6.6518**(7)	-6.8708**(0)	-6.6329**(7)
log M_t	1.0628(6)	-0.3459(7)	-2.9466(6)	-1.7086(7)
Δ log M_t	-2.7870**(5)	-6.7505**(2)	-2.4108(5)	-6.7219**(2)
log Y_t	1.1641(8)	-2.0379(8)	-0.6770(8)	-1.4828(8)
Δ log Y_t	-2.5309*(8)	-9.7811**(8)	-4.0346**(8)	-9.9451**(8)
R_t	-1.1412(6)	-31.7904**(8)	-2.6350(6)	-32.1004**(8)
Δ R_t	-4.3323**(8)	-52.5835**(8)	-4.7081**(8)	-52.3255**(8)
log O_t	0.7930(8)	-1.4109(1)	-1.1138(8)	-1.7164(1)
Δ log O_t	-4.8281**(7)	-8.3830**(4)	-4.8891**(7)	-8.3512**(4)

The result of the PSS bounds testing approach is reported in Table 2. The choice of the lag used in the estimation of the test statistic is based on the AIC. The F-statistic is found to be outside the upper bound and statistically significant at the 1 percent level. Thus there is a long-run relationship among exchange rate, relative money supply, relative demand, interest rate differential, and oil price. In other words, these variables are moving together and would not move too far from each other in the long run.

Table 2 The Result of the Pesaran, Shin, and Smith (2001) (PSS) Bounds Testing Approach for Cointegration

F-Statistic
4.6507**

Notes: The critical values for bounds testing approach are from Pesaran, Shin, and Smith (2001). The critical values for unrestrictive intercept and restricted trend case with six regressors at the 1% level are 3.27 for lower critical bound, I(0) and 4.39 for upper critical bound, I(1). ** denotes significance at the 1% level.

The long-run and short-run coefficients of the ARDL approach are reported in Table 3. The long-run coefficients are estimated using

ARDL (3, 2, 0, 3, 0) selected based on AIC. The order of the variables is exchange rate, relative money supply, relative demand, interest rate differential, and oil price. In the long run, an increase in relative money supply or interest rate differential will lead to a decrease in exchange rate whilst an increase in oil price will lead to an increase in exchange rate in the long run.[4] There is no significant impact of relative demand on exchange rate in the long run. The short-run coefficients are estimated using the error correction model.

Table 3 The Long-Run and Short-Run Coefficients of the Autoregressive Distributed Lag (ARDL) Approach

	Long Run	Short Run
log M_t	-0.6353*	0.1681
log Y_t	0.4598	-0.2593
R_t	-48.7612	8.0184$^{@@}$
log O_t	0.6104**	0.0298
D_t	-	-0.0323**

Notes: $^{@@}$ denotes significance of the Wald test at the 1% level. ** (*) denotes significance of the t-test at the 1% (5%) level.

The result of the error-correction model is reported in Table 4. The error correction model fulfils the condition of no-autocorrelation. The result of the OLS estimator with White's Heteroscedasticity adjusted standard error is discussed when the test of heteroscedasticity is found to be significant. Figure 3 shows the plots of cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ). The plot of CUSUM shows no evidence of instability of the error correction model whilst the plot of CUSUMSQ shows some evidence of instability of the error correction model. Nonetheless, the error correction model can be said to be stable. The adjusted r-squared (R^2) is high, that is, 0.3516. In the short run, interest rate differential and oil price are found to be important in the determination of exchange rate.[5] Moreover, the Asian financial crisis is found to have a significant impact on exchange rate.

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[4] The coefficient of interest rate differential is found to be statistically significant at the 10 percent level.

[5] The coefficient of oil price is found to be statistically significant at the 10 percent level.

Table 4 The Result of the Error Correction Model

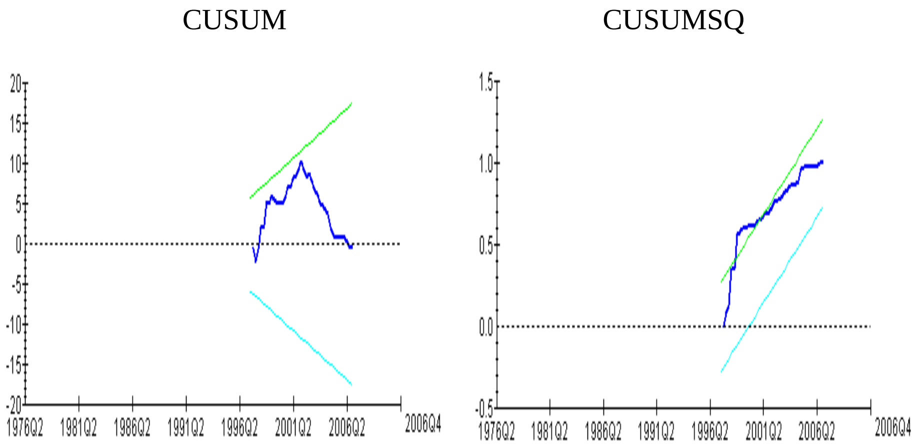
	OLS	OLS – White
constant	0.0003	0.0003
	(0.0051)	(0.0057)
Δ log M_{t-1}	0.1681	0.1681
	(1.6982)	(1.4669)
Δ log Y_{t-3}	-0.2593	-0.2593
	(-1.4011)	(-1.6347)
ΔR_t	-0.2601	-0.2601
	(-3.0502)**	(-2.3679)*
ΔR_{t-1}	0.2372	0.2372
	(3.1418)**	(2.5406)**
ΔR_{t-3}	-0.1660	-0.1660
	(-3.0201)**	(-2.9680)**
ΔR_{t-4}	-0.1254	-0.1254
	(-2.2265)*	(-2.0963)*
Δ log O_{t-2}	0.0298	0.0298
	(1.6392)	(1.9173)
Δ log ER_{t-1}	0.3925	0.3925
	(4.4603)**	(3.3682)**
Δ log ER_{t-2}	-0.1840	-0.1840
	(-2.0551)*	(-1.6365)
Δ log ER_{t-4}	-0.2016	-0.2016
	(-2.5880)*	(-1.9624)
EC_{t-1}	-0.0174	-0.0174
	(-3.6648)**	(-3.0698)**
D_t	-0.0323	-0.0323
	(-2.9957)**	(-2.2060)*
Trend	-0.0001	-0.0001
	(-0.1816)	(-0.2119)

Diagnostic tests:

Adj. R^2	0.3516	-
LM	1.4863	-
Reset	5.6483*	-
Normal	45.0249**	-
Hetero	15.5115**	-

Notes: Adj. R^2 is the adjusted R^2. LM is the Lagrange multiplier test of disturbance term serial correlation. Reset is the test of functional form. Normal is the test of the normality of disturbance term. Hetero is the test of heteroscedasticity. OLS denotes the results of the OLS estimator. OLS – White denotes the result of the OLS estimator with White's Heteroscedasticity adjusted standard error. Values in parentheses are the t-statistic. ** (*) denotes significance at the 1% (5%) level.

Figure 3 Plot of Cumulative Sum of Recursive Residuals (CUSUM) and Plot of Cumulative Sum of Recursive Residuals (CUSUMSQ)



Note: The straight lines represent critical bounds at the 5% level.

The coefficient of the error correction term, that is, the speed of the adjustment is found to be negative and statistically significant at the 1 percent level. Thus the condition for a long-term stable equilibrium is satisfied. The coefficient is -0.0174. The half-life period of shock is -40.1816. Thus the difference between the actual exchange rate and the equilibrium exchange rate is reduced by half, about 40 quarters or about 10 years after an exogenous shock.[6]

The generalised forecast error variance decomposition identifies the proportion of forecast error variance in one variable caused by the innovations in other variables in a system. Therefore the relative importance of a set of variables that affects a variance of another variable is identified. The results of the generalised forecast error variance decomposition are reported in Table 5. The results of the generalised forecast error variance decomposition, which are reported, are based on the 1-5, 10, 15, and 20 horizon periods. The result shows that relative money supply is the most important contributor to the forecast error variance of exchange rate. This is followed by interest rate

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[6] The half-life period is calculated as log (0.5) / log (1 - α), where α is the coefficient of the error correction term (Bergvall, 2004: 329).

differential, oil price, and relative demand. Productivity differential accounts for about 3.5 percent of the forecast error variance of exchange rate whilst interest rate differential, oil price, and relative demand account for about 2.7, 0.9, and 0.6 percent, respectively.

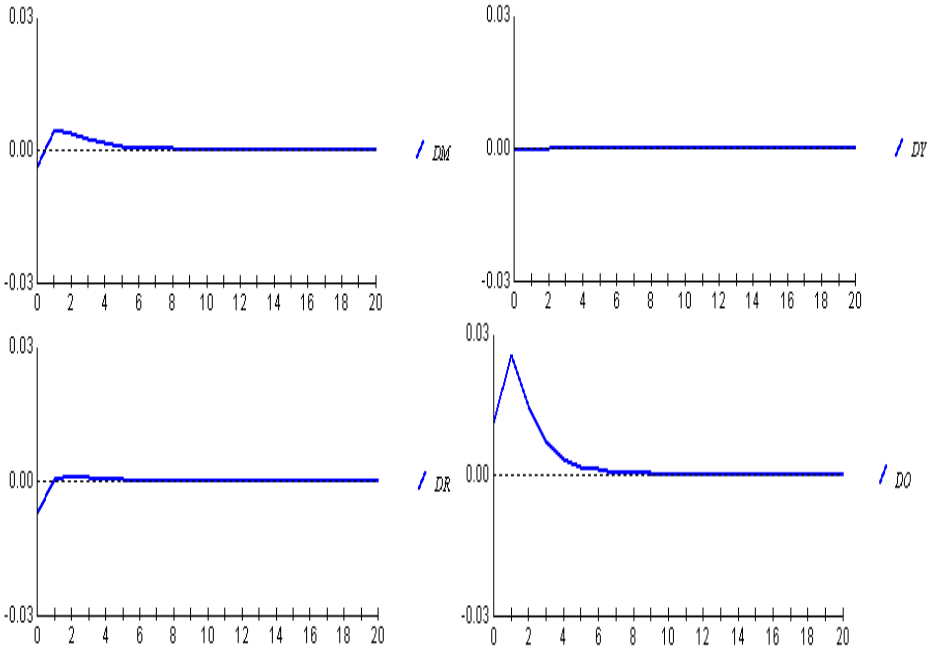
Table 5 The Generalised Forecast Error Variance Decomposition

Horizon	$\Delta \log ER_t$	$\Delta \log M_t$	ΔY_t	ΔR_t	$\Delta \log O_t$
0	1.0000	0.0358	0.0012	0.0272	0.0082
1	0.9891	0.0325	0.0063	0.0265	0.0098
2	0.9843	0.0337	0.0067	0.0264	0.0098
3	0.9823	0.0345	0.0067	0.0265	0.0098
4	0.9816	0.0349	0.0066	0.0266	0.0098
5	0.9813	0.0350	0.0066	0.0267	0.0098
10	0.9812	0.0351	0.0066	0.0267	0.0098
15	0.9812	0.0351	0.0066	0.0267	0.0098
20	0.9812	0.0351	0.0066	0.0267	0.0098

Note: The estimation is biased on VAR=1.

The generalised impulse response function traces the dynamic responses of a variable to innovations in other variables in a system. The results of the generalised impulse response function are shown in Figure 4. The results of the generalised impulse response function are plotted over the 20 horizon periods or equivalent to five year periods. The responses of exchange rate to one standard error shock in relative money supply are positive over the 0-6 horizon periods and then die out. The responses of exchange rate to one standard error shock in interest rate differential are negative over the 0-1 horizon periods and then die out. The responses of exchange rate to one standard error shock in oil price are positive over the 0-9 horizon periods and then die out. Finally, the responses of exchange rate to one standard error shock in relative demand are almost zero over the whole period. Generally, the impact of relative money supply, relative demand, interest rate differential or oil price on exchange rate is short, mostly less than two years.

Figure 4 Plots of the Generalised Impulse Response Functions to One Standard Error Shock in the Equation for the First Difference of the Natural Logarithm of Exchange Rate (Δ log ER_t)



Note: DM = Δ log M_t, DY = Δ log DY_t, DR = Δ DR_t, and DO = Δ log O_t.

Generally, relative money supply, interest rate differential, and oil price are found to have a significant impact on exchange rate. However, there is no strong evidence that relative demand is found to have a significant impact on exchange rate. Another proxy for the relative demand may be tried in the estimation in the future. Baharumshah and Masih (2005) and Baharumshah, Siti Hamizah, and Ahn (2009), amongst others, show the importance of the monetary model in the determination of exchange rate in Malaysia. Chen and Chen (2007) show the importance of real oil price and real interest rate differential in the determination of real exchange rate. Bagchi, Chortareas, and Miller (2004), and Bergvall (2004) also show the importance of real interest rate differential in the determination of real exchange rate.

Money supply is important to influence exchange rate especially in the long run. An increase in money supply will lead to a decrease in exchange rate. Thus monetary policy is useful to influence exchange rate. A strong currency may have difficult to promote exports especially exports are competitive in prices in the world markets. On the other hand, a weak currency may encourage more exports. However, imported inflation may be more difficult to check with a weak currency especially imports are important for economic growth.

Oil price is important in the determination of exchange rate. Thus change of oil price in the world market could have a significant impact on exchange rate. Oil price is characterised by high volatility, high intensity jumps, and strong upward drift (Askari and Krichene, 2008). This implies that exchange rate will be volatile. Thus there is a need to smooth down the volatility of oil price on Malaysian economy. The policy of the central bank of Malaysia on ringgit exchange rate is let it to be determined by market forces. Interventions are carried out from time to time to smooth down the excessively volatile of ringgit (Bank Negara Malaysia, 1999).

A relatively high interest rate could be used to influence exchange rate in the long run. The Asian financial crisis is found to have a negative impact on exchange rate in Malaysia. After the crisis, Malaysia has devalued its currency against the American dollar with the aim to promote exports and thus economic growth. There is no strong evidence to conclude relative demand to have a significant impact on exchange rate in the long run.

6. Concluding Remarks

This study has examined the determination of exchange rate using the monetary model augmented with oil price. The results of the PSS bounds testing approach show that the variables examined are cointegrated. The result of ARDL approach shows that an increase in relative money supply or interest rate differential will lead to a decrease in exchange rate in the long run whilst an increase in oil price will lead to an increase in exchange rate in the long run. Interest rate differential, oil price, and the Asian financial crisis are found to have a significant impact on exchange rate in the short run. The results of the generalised forecast error variance decompositions show that oil price is relatively least important than relative money supply in the determination of exchange rate. Monetary policy can be used to influence exchange rate in Malaysia.

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