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THE REAL EXCHANGE RATE MALAYSIA

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Abstract

This study examines the real exchange rate determination in Malaysia. The results of the cointegrating vectors show that an increase in productivity differential, the real oil price or reserve differential will lead to an appreciation of the real exchange rate. The results of the generalised forecast error variance decompositions show that the real oil price is an important determinant of the real exchange rate. Generally, productivity differential, the real oil price, reserve differential, and the real interest rate differential are important in the real exchange rate determination.

JEL Classification: F31; F37; F10
Keywords: *Real exchange rate; real oil price; reserve differential; cointegration; variance decomposition.*

1. Introduction

The world oil price tended to increase over the period (Figure 1). In the period 1971-1975, the mean of the world oil price was the United States (US) dollar 6.2 per barrel and increased to the US dollar 20.5 per barrel in the period 1976-1980. In the period 1981-1985, the mean of the world oil price increased further to the US dollar 30.2 per barrel. Nonetheless, the means of the world oil price were low in the periods 1986-1990, 1991-1995, and 1996-2000, that is, the US dollars 17.6, 17.7, and 19 per barrel, respectively. In the 2001-2005 period, the mean of the world oil price increased again to the US dollar 33.9 per barrel. In 2006, a barrel of oil in the world market was the US dollar 64.3 and decreased to the US dollar 60.1 per barrel in 2009. On 6 August 2010, the world oil price

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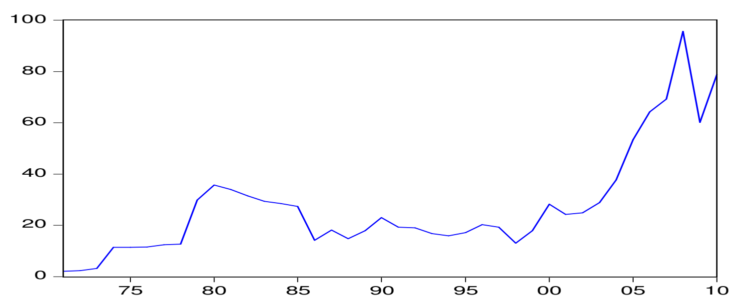
was the US dollar 78.8 per barrel. In the period 1971 - 6 August 2010, the standard deviation of the world oil was 20.80 and the kurtosis and skewness of the world oil price were 5.16 and 1.59, respectively (Table 1). Thus the distribution of the world oil price was not normal and skewed. Askari and Krichene (2008) show that oil price was characterised by high volatility, high intensity jumps, and strong upward drift for the period 2002-2006. These characteristics were consistent with the changes in the oil market and the world economy, that is, oil supply was rigid and uncertain and oil demand was high. Moreover, the world oil price was expected to be volatile and jumpy with a higher probability to increase above the expected mean. The real oil price could influence the real exchange rate (Bergvall, 2004; Chen and Chen, 2007; Huang and Guo, 2007; Lizardo and Mollick, 2010).

A country with a high international net-asset position tends to have a strong currency whilst a country with a low international net-asset position tends to have a weak currency. One way to increase international net-asset position is to increase exports through a depreciation of the real exchange rate (Lane and Milesi-Ferretti, 2002). Reserve differential could influence the real exchange rate. Egert, Lommatzsch, and Lahreche-Revil (2006) show that, amongst others, an increase in debt will lead to an appreciation of the real exchange rates in the Baltic countries. Moreover, an increase in the net-foreign assets will tend to an appreciation of the real exchange rates in the long run in the Central and Eastern European Economies (CEE). Aizenman and Riera-Crichton (2006) show that the real exchange rates of developing countries tend to be more sensitive to changes in international reserve assets. Wang, Hui, and Soofi (2007) conclude that, amongst others, an increase in the foreign exchange reserve will lead to a revaluation of the real effective exchange rate in China.

This study examines the real exchange rate determination in Malaysia using annual data for the period 1971-2008. More specifically, this study examines the impact of the real oil price and reserve differential on the real exchange rate determination. The real oil price is said to be important in the real exchange rate determination (Bergvall, 2004; Chen and Chen, 2007; Lizardo and Mollick, 2010). The world oil price is volatile (Askari and Krichene, 2008). Thus the real exchange rate would be volatile as well. Malaysia adopts a managed floating exchange rate regime (Fischer, 2008). For a managed floating exchange rate regime, the real exchange rate will be strongly influenced by the external shocks such as the world oil price shock. Generally, Malaysia is a net-oil exporting country. The real oil price is argued to have different impact on the net-oil exporting country and the net-oil importing country. An increase in the real oil price will lead to an appreciation of the real exchange rate for the net-oil exporting country whilst a depreciation of the real exchange rate for the net-oil importing country (Bergvall, 2004). Moreover, Malaysia is a relatively open economy especially after the year 1978. In the period 1971-1975, the mean of trade openness of Malaysia, where trade openness is measured by the ratio of trade of goods and services to Gross Domestic Product (GDP) multiplied by 100, was 83.4 per cent. Trade openness of Malaysia was less than 100 until 1978. In 1979, trade openness of Malaysia was marginally more than 100 per cent. In 1981-1985, the mean of trade openness of Malaysia was 108.1 per cent. In 2001-2005, the mean of trade openness of Malaysia increased to 215.1 per cent. In 2006, trade openness of Malaysia was 210.5 per cent. In 2008, trade openness of Malaysia decreased to 184.1 per cent (Table 2). For an open economy, the external shocks such as the real oil price shock will have much impact on the real exchange rate.

The empirical evidence of the impact of the real oil price on the real exchange rate in Malaysia is limited. It is important to identify the impact of the world oil price on the real exchange rate as the world oil price has been characterised by high volatility, high intensity jumps, and strong upward drift above the expected mean rather than to fall (Askari and Krichene, 2008: 2134; Dvir and Rogoff, 2009: 9).[2] The real exchange rates of developing countries are said to be sensitive to changes in international reserve assets (Aizenman and Riera-Crichton, 2006; Wang, Hui, and Soofi, 2007). However, the empirical evidence of the impact of reserve differential on the real exchange rate in Malaysia is limited. This study provides some evidence of the impact of productivity differential, the real oil price, reserve differential, and the real interest rate differential on the real exchange rate in a managed floating exchange rate regime and a relatively open economy of Malaysia. This study uses two measures of the real interest rate differential to examine their impact on the real exchange rate.

Figure 1
The World Oil Price, 1971- 6 August 2010 (US Dollars per Barrel)



Source: IFS, IMF.

Table 1

[2] Askari and Krichene (2008: 2135) find that oil price volatility measured by implied volatility was excessively high, that is, in the range of 30 per cent. This implies that oil price was facing uncertainty regarding future price development and sensitive to small shock and to news.

The Mean of the World Oil Price, 1971-2010

Year	US Dollars per Barrel
1971-1975	6.2
1976-1980	20.5
1981-1985	30.2
1986-1990	17.6
1991-1995	17.7
1996-2000	19.8
2001-2005	33.9
2006	64.3
2007	69.2
2008	95.6
2009	60.1
6 August 2010	78.8

	1971 - 6 August 2010
Mean	27.42
Standard Deviation	20.80
Kurtosis	5.16
Skewness	1.59
Minimum	2.19
Maximum	95.60

Sources: IFS, IMF and US Energy Information Administration.

Table 2
Trade Openness of Malaysia, 1971- 2008

Year	Trade Openness
1971-1975	83.4
1976-1980	98.9
1981-1985	108.1
1986-1990	124.9
1991-1995	168.0
1996-2000	204.7
2001-2005	215.1
2006	210.5
2007	200.7
2008	184.1

Source: IFS, IMF.

2. A Literature Review

Chen and Chen (2007) examine the impact of the real oil price on the real exchange rate in the G7 countries namely Canada, France, Germany, Italy, Japan, the United Kingdom, and the US using a monthly panel data for the period 1972:1-2005:10. The results of the Johansen (1988) cointegration method show a link between the real oil price and the real exchange rate. Moreover, the panel predictive regression suggests that the real oil price has significant forecasting power. The out-of-sample prediction performances demonstrate greater predictability over longer horizons. Furthermore, the results exhibit productivity differential and the real interest rate differential to have important impact on the real exchange rate. Huang and Guo (2007) analyse the real oil price and the real effective exchange rate in China using monthly data for the period 1990:1-2005:10. The results of a four variables structural vector autoregressive (SVAR) model, which includes the real oil price, relative industrial production, the real effective exchange rate, and relative Consumer Price Indexes, demonstrate that, amongst others, an increase in the real oil price will lead to a minor appreciation of the real effective exchange rate in the long run as China depends less on imported oil. Bergvall (2004) and Lizardo and Mollick (2010), amongst others, find the importance of the real oil price in the real exchange rate determination.

Aizenman and Riera-Crichton (2006) investigate the impact of international reserve, terms of trade, and capital flows on the real exchange rate. The results display that international reserve cushions the impact of terms of trade shock on the real exchange rate. This effect is important for developing countries but not for industrial countries. This buffer effect is particularly important for Asian countries and for countries exporting natural resources. Financial depth reduces the buffer role of international reserve in developing countries. The real exchange rates of developing countries seem to be more sensitive to changes in international reserve assets whilst industrial countries display a significant relationship between hot money and the real exchange rate. Wang, Hui, and Soofi (2007) estimate the real effective exchange rate of China as a function of terms of trade, relative price of tradable goods to non-tradable goods, the foreign exchange reserve, and the change of money supply using annual data for the period 1980-2004. The results of the Johansen (1988) cointegration method show that, amongst others, an increase in the foreign exchange reserve will lead to an increase in the real effective exchange rate. The study concludes, amongst others, an increase in the foreign exchange reserve or national income will lead to revaluation of the real effective exchange rate in China. Kasman and Ayhan (2008) study the relationship between the foreign exchange reserves and exchange rates in Turkey using monthly data for the period 1982:1-2005:11. The results reveal that there is long-run relationship between the foreign exchange reserves and exchange rates. Moreover, the direction of both long-run and short-run causality is from the foreign exchange reserves to the real effective exchange rate. Egert, Lommatzsch, and Lahreche-Revil (2006), amongst others, uncover the importance of the international reserve in the real exchange rate determination.

Choudhri and Khan (2005) inspect the impact of the Balassa (1964) and Samuelson (1964) (BS) hypothesis in 16 developing countries using an annual panel data. The BS hypothesis is argued to provide an explanation of the long-run real exchange rate behaviour in terms of productivity differential of tradable goods to non-tradabled goods. The real exchange rate will appreciate with an increase in productivity differential of tradable goods to non-tradable goods and vice versa. The results exhibit that differential in labour productivity exerts a significant impact on the real exchange rate through its influence on relative price of non-tradable goods. However, it is sensitive to whether the sample includes crisis periods or not in the estimation. The BS hypothesis is an empirically useful framework for investigating the long-run behaviour of the real exchange rate. Bergvall (2004), Alexius (2005), Candelon *et al.* (2007), and Guo (2010), amongst others, show the importance of productivity differential in the real exchange rate determination.

Bagchi, Chortareas, and Miller (2004) examine the impact of the expected real interest rate differential and terms of trade on the real exchange rate in nine small and developed economies namely Australia, Australia, Canada, Finland, Italy, New Zealand, Norway, Portugal, and Spain using the Johansen (1988) cointegration method. The results show that the expected real interest rate differential and terms of trade affect the real exchange rate in the long run but the impact of terms of trade is generally more consistent. The speed of adjustment for the expected real interest rate differential in error correction model is quantitatively larger than the one of terms of trade. In five economies namely Australia, Canada, Finland, Italy, and Portugal, the expected real interest rate differential possesses the predicted negative relationship with the real exchange rate. Byrne and Nagayasu (2010) examine the relationship between the real exchange rate, that is, the United Kingdom pound against the US dollar real exchange rate and the real interest rate differential using monthly data for the period 1973:1-2005:5. The study finds that the real interest rate differential is an important determinant of the real exchange rate. Bagchi, Chortareas, and Miller (2004), amongst others, show that the real interest rate differential is found to have a significant impact on the real exchange rate.

Naseem, Tan and Hamizah (2009) investigate the effect of real exchange rate misalignment and volatility on Malaysian import flows using the quarterly data for the period 1991:Q1 to 2003:Q4. The real exchange rate (ringgit against the US dollar) is estimated as a function of the ratio of government consumption to GDP deflator, the real interest rate differential between domestic and the world real interest rate, the terms of trade (the ratio of the export price index to the import price index) and the productivity index. The model is constructed with the intention to capture open economy properties such as international trade, cross border capital flow and domestic economic performance and government consumption. Sidek and Yusoff (2009) find productivity, government consumption expenditure, and trade openness are important determinants of the ringgit long run equilibrium value using quarterly data for the period 1991:Q1 to 2008Q1. The results suggest that the ringgit was persistently overvalued prior to the 1997 crisis. After the crisis, the ringgit fluctuates around its long run equilibrium and the misalignments are eliminated over a relatively short period.

3. Data and Methodology

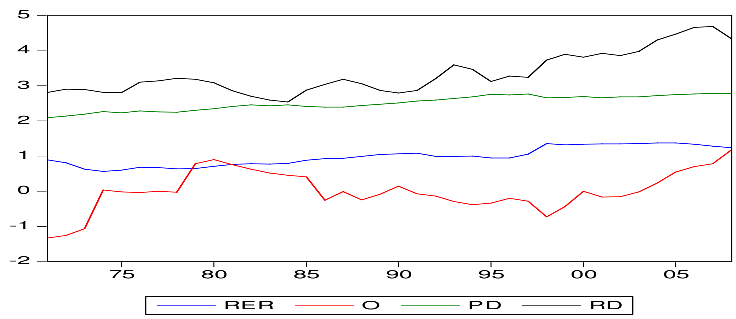
The real exchange rate (RER_t) is expressed by $ER_t \times (CPI_{us,t} / CPI_{m,t})$, where ER_t is the Malaysian ringgit against the US dollar, $CPI_{i,t}$ ($i = m, us$) is Consumer Price Index (CPI, 2000 = 100), and subscripts m and us denote Malaysia and the US, respectively. Thus an increase in the real exchange rate means a depreciation of the real exchange rate of Malaysia. Productivity differential (PD_t) is expressed by $PD_t = \frac{Y_{m,t}}{N_{m,t}} - \frac{Y_{us,t}}{N_{us,t}}$, where $Y_{i,t}$ ($i = m, us$) is GDP volume (2000 = 100) and $N_{i,t}$ ($i = m, us$) is employment (million). The real oil price (O_t) is expressed by the world oil price (3 Spot Price Index, 2000 = 100) divided by $CPI_{m,t}$. Reserve differential (RD_t) is expressed by $RD_t = \frac{R_{m,t}}{Y_{m,t}} - \frac{R_{us,t}}{Y_{us,t}}$, where $R_{i,t}$ ($i = m, us$) is the total reserve plus gold value (million US dollar) and $Y_{i,t}$ ($i = m, us$) is the GDP value (million US dollar). The real interest rate differential is expressed by ($r_{m,t} - r_{us,t}$), where $r_{m,t}$ is the real money market rate (or the real deposit rate) of Malaysia and $r_{us,t}$ is the real money market rate (or the real deposit rate) of the US. This study uses two measures of the real interest rate differential. First, the real interest rate is expressed by subtracting inflation rate from the money market rate. Inflation rate is measured by the changes of CPI ($DR_{1,t}$). Second, the real interest rate is expressed by subtracting inflation rate from the deposit rate ($DR_{2,t}$) (Chen and Chen, 2007). The first measure of the real interest rate differential examines the influence of the real short-term interest rate differential on the real exchange rate whilst the second measure of the real interest rate differential examines the influence of the real medium-term interest rate differential on the real exchange rate. All the data were obtained from *International Financial Statistics*, the International Monetary Fund (IFS, IMF). The sample period is 1971-2008. The choice of sample period is subject to the availability of the data at the source.[3] All the data were transformed into the natural logarithms before estimation, except interest rate.

Figure 2 shows the plots of the natural logarithms of the real exchange rate, productivity differential, the real oil price, and reserve differential whilst Figure 3 shows the plots of the real interest rate differentials. Generally, these series, namely the real exchange rate, productivity differential, the real oil price, and reserve differential move in a same

[3] Mylonidis and Paleologou (2011) reassess the real uncovered interest parity for the cases of Canada and the United States using the Johansen (1988) cointegration method. The data are annually for the period 1972-2006.

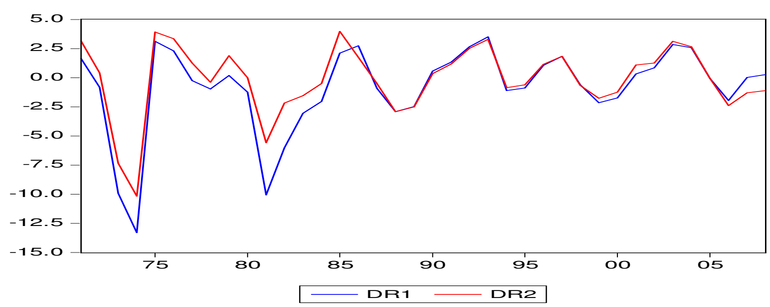
direction. Thus these variables tend to be cointegrated. Moreover, there is no strong evidence that there is structural break in these variables. The real interest rate differentials are moving closely together especially after the year 1987.

Figure 2
The Plots of the Natural Logarithms of the Real Exchange Rate, the Real Oil Price, Productivity Differential, and Reserve Differential



Note: *RER* = log RER_t, *O* = log O_t, *PD* = log PD_t, and *RD* = log RD_t.

Figure 3
The Plots of the Real Interest Rate Differentials



Note: *DR1* = $DR_{1,t}$ and *DR2* = $DR_{2,t}$

The long-run cointegrating vector to be estimated is specified as follows: [4]

$$\log RER_t = \beta_{10} + \beta_{11} Trend + \beta_{12} \log PD_t + \beta_{13} \log O_t + \beta_{14} \log RD_t + u_{1,t} \quad (1)$$

where log is the natural logarithm, RER_t is the real exchange rate, *Trend* is a time trend, PD_t is productivity differential, O_t is the real oil price, RD_t is reserve differential, and $u_{1,t}$ is a disturbance term. The real interest rate differential is not included in the long-run cointegrating vector as it is a stationary variable. However, it will be entered in the estimation as an exogenous variable. This study uses two measures of the real interest rate differential ($DR_{1,t}$ and $DR_{2,t}$). The vectors with the

[4] The theoretical framework of this study is derived based on the purchasing power parity and the uncovered interest rate parity and by including the real oil price and reserve differential (Wong, 2010).

first and second measures of the real interest rate differential are named Vectors 1 and 2, respectively. Moreover, the dummies variables are included in the estimation as exogenous variables namely the dummy variable to examine the influence of the Asian financial crisis, 1997-1998, that is, one for the period 1997-1998 and the rest are zero ($D_{1,t}$) and the dummy variable to examine the influence of the fixed ringgit against the US dollar exchange rate at ringgit 3.80 for one US dollar, that is, one for the period 1999-2004 and the rest are zero ($D_{2,t}$). Chen and Chen (2007) estimate the real exchange rate in the G7 countries using panel data as a function of productivity differential, the real oil price, and the real interest rate differential. Generally, the coefficient of the real oil price is expected to be negative for the net-oil importing country (Bergvall, 2004). Moreover, the coefficients of productivity differential, reserve differential, and the real interest rate differential are expected to be negative (Bagchi, Chortareas, and Miller, 2004; Aizenman and Riera-Crichton, 2006; Chen and Chen, 2007).

Engle and Granger (1987) demonstrate that cointegration implies an error correction model. The error correction model for model (1) can be estimated as follows:

$$\begin{aligned}\Delta \log RER_t = \beta_{20} &+ \sum_{i=0}^{p} \beta_{21i} \Delta \log PD_{t-i} + \sum_{i=0}^{q} \beta_{22i} \Delta \log O_{t-i} + \sum_{i=0}^{r} \beta_{23i} \Delta \log RD_{t-i} \\ &+ \sum_{i=1}^{s} \beta_{24i} \Delta \log RER_{t-i} + \sum_{i=0}^{v} \beta_{25i} DR_{t-i} + \beta_{26} D_{1,t} + \beta_{27} D_{2,t} \\ &+ \beta_{28} EC_{t-1} + u_{2,t} \end{aligned} \quad (2)$$

where Δ is the first difference operator, DR_t is a measure of the real interest rate differential, EC_{t-1} is the one period lag of error correction term, $D_{1,t}$ is the dummy variable to examine the influence of the Asian financial crisis, 1997-1998, $D_{2,t}$ is the dummy variable to examine the influence of the fixed ringgit against the US dollar exchange rate at ringgit 3.80 for one US dollar (1999-2004), and $u_{2,t}$ is a disturbance term.[5] The coefficient of the one period lag of error correction term is expected to have a negative sign. The one period lag of error correction terms generated from the cointegrating vectors are included in the estimation as additional explanatory variables in order to avoid the lost of potentially relevant information.

The Johansen (1988) cointegration method is used to examine the long-run relationship among the variables. The generalised forecast error variance decomposition and generalised impulse response function are used to examine the relationship of the variables. The generalised

[5]In the period from September 1998 to July 2005, ringgit was pegged to the US dollar at RM3.8 for one US dollar (Koske, 2008).

forecast error variance decomposition identifies the proportion of forecast error variance in one variable caused by the innovations in the other variables. Therefore 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 the other variables. 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). 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).

4. Empirical Results and Discussions

The results of the DF and PP unit root test statistics are reported in Table 3. The lag lengths used to estimate the DF unit root test statistics are based on the Schwarz Bayesian Criterion (SBC). The lag lengths used to compute the PP unit root test statistics are based on the Newey-West automatic bandwidth selection, with the maximum lag length is set to three. The results of the DF unit root test statistics show that all the variables are non-stationary in their levels but become stationary after taking the first difference, except the real interest rate differentials.

The results of the cointegration method are reported in Table 4. The results of the λ_{Max} and λ_{Trace} test statistics are computed with unrestricted intercepts and restricted trends in the VAR. The λ_{Max} and λ_{Trace} test statistics show no evidence of cointegration. However, the λ_{Max} test statistic shows that it is almost significant at the 10 per cent level. The results of the normalised cointegrating vectors are reported in Table 5. The lag lengths used to estimate the normalised cointegrating vectors are based on the SBC. The likelihood ratio test statistic for the cointegrating Vector 2 is 168.1856, which is marginally higher than the likelihood ratio test statistic for the cointegrating Vector 1, that is, 167.9746. For Vector 1 or Vector 2, an increase in productivity differential, the real oil price or reserve differential will lead to an appreciation of the real exchange rate.

Table 3
The Dickey and Fuller (1979) (DF) and Phillips and Perron (1988) (PP) Unit Root Test Statistics

	DF - No Trend	PP - No Trend	DF - Trend	PP - Trend
log RER_t	-1.0458(1)	-0.8000 (2)	-2.7185(1)	-2.8307(3)
Δ log RER_t	-4.3367***(0)	-4.2277***(3)	-4.2975***(2)	-4.1803**(3)
log PD_t	-1.7983(0)	-1.7911(1)	-2.9090(2)	-2.3301(2)
Δ log PD_t	-5.6380***(0)	-5.6339***(1)	-5.7508***(0)	-5.7501***(1)
log O_t	-2.0501(0)	-2.0768(1)	-2.0313(0)	-2.0671(1)
Δ log O_t	-5.7797***(0)	-5.7807***(1)	-5.7065***(0)	-5.7077***(1)
log RD_t	-1.4587(1)	-0.9671(3)	-2.8293(1)	-2.0530(3)
Δ log RD_t	-5.5644***(3)	-4.1128***(3)	-5.5159***(3)	-4.0088**(3)
$DR_{1,t}$	4.8000***(1)	-3.7998***(1)	-5.8115***(1)	-4.220050**(3)
Δ $DR_{1,t}$	-7.2807***(1)	-6.2869***(1)	-7.1929***(1)	-6.1461***(3)
$DR_{2,t}$	-5.5952***(1)	-4.0387***(3)	-5.6193***(1)	-4.0163**(3)
Δ $DR_{2,t}$	-6.6637***(1)	-6.4745***(3)	-6.5711***(1)	-6.3507***(3)

Notes: No Trend denotes the DF or PP t-statistic is estimated based on the model including an intercept. Trend denotes the DF or PP t-statistic is estimated based on the model including an intercept and a time trend. Values in parentheses are the lag length used in the estimation of the DF or PP unit root test statistic. Critical values can be obtained from MacKinnon (1996). *** (**) denotes significance at the 1% (5%) level.

Table 4
The Results of the Likelihood Ratio Test Statistics (Johansen, 1988)

Vector		**λ_{Max} Test Statistic**		
H_o:	r=0	r<=1	r<=2	r<=3
H_a:	r=1	r=2	r=3	r=4
1	28.53	16.08	7.03	0.83
2	27.32	14.34	6.98	0.06
c.v. 1	29.13	23.10	17.18	10.55
Vector		**λ_{Trace} Test Statistic**		
H_o:	r=0	r<=1	r<=2	r<=3
H_a:	r≥1	r≥2	r≥3	r≥4
1	52.47	23.94	7.86	0.83
2	48.70	21.38	7.04	0.06
c.v. 1	59.16	39.34	23.08	10.55

Notes: The VAR = 1 is used in all the estimations. c.v. 1 denotes the 10% critical value. Critical values can be obtained from Pesaran, Shin, and Smith (2000).

Table 5
The Results of the Normalised Cointegrating Vectors

Vector 1	log RER_t = - 1.2842 log PD_t - 0.0421 log O_t - 0.0981 log RD_t
	(-6.2129***) (-2.0009**) (-2.6156**)
	+ 0.0496 *Trend* + 3.0268
	(10.5464***)
	LL = 167.9746
Vector 2	log RER_t = - 1.2468 log PD_t - 0.0329 log O_t - 0.0897 log RD_t
	(-5.7475***) (-1.4563) (-2.3069**)
	+ 0.0478 *Trend* + 2.9610
	(9.8622***)
	LL = 168.1856

Notes The VAR = 1 is used in all the estimations. LL is the likelihood ratio test statistic of the vector. Values in parentheses are the t-statistics. *** (**) denotes significance at the 1% (5%) level.

This study uses the general-to-specific modelling strategy to estimate the error correction model.[6] Initially, three lags of each first difference variable are used, and then the dimensions of the parameter space are reduced to a final parsimonious specification by sequentially imposing statistically insignificant variables and also take into consideration the goodness of fit of the estimated model, that is, the adjusted R^2. The results of the error correction models are reported in Table 6. The adjusted R^2 for Vector 2 is 0.8188, which is marginally higher than the adjusted R^2 for Vector 2, that is, 0.8124. The coefficients of the error correction terms are found to be negative and statistically significant at the 1 per cent level. The models fulfil the conditions of no-autocorrelation, normality and homoscedasticity of disturbance terms, and no-functional form. Figure 4 shows the plots of cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ). There is no evidence of instability of the error correction models. Generally, the results show productivity differential, the real oil price, reserve differential, and the real interest rate differential to have a significant impact on the real exchange rate. Moreover, both the dummy variables are found to have a significant negative impact on the real exchange rate. The adjusted R^2 of Vector 2 where the real interest rate differential measured by the real medium-term interest rate differential is marginally higher than the one of Vector 1 where the real interest rate differential measured by the real short-term interest rate differential. Thus the real exchange rate is about the same to the change of the real short-term interest rate differential or the real medium-term interest rate differential. The half-life periods of

[6]The general-to-specific modelling strategy begins with a general statistical model that captures the essential characteristics of the underlying dataset. Then the general statistical model is reduced in complexity by eliminating statistically insignificant variables, checking the validity of the reductions at every stage to ensure congruence of the final model (Hendry, 1993; Campos, Ericsson, and Hendry, 2005). Monte Carlo studies show that the general-to-specific modelling strategy has excellent characteristics for model selection (Hoover and Perez, 1999, 2004).

shocks in Vectors 1 and 2 are 0.5433 and 0.5483, respectively.[7] Thus the difference between the actual real exchange rate and the equilibrium real exchange rate is reduced by half, about one year after an exogenous shock. Thus the half-life period is relatively short.

Table 6
The Results of the Error Correction Models

Vector	1	2
constant	-0.0225	-0.0171
	(-1.9934*)	(-1.5093)
$\Delta \log PD_{t-1}$	0.6213	0.6167
	(3.1725***)	(3.1634***)
$\Delta \log PD_{t-2}$	-0.5396	-0.5455
	(-3.1521***)	(-3.2191***)
$\Delta \log O_t$	-0.0680	-0.0661
	(-3.0230***)	(-2.9942***)
$\Delta \log RD_t$	0.0594	0.0710
	(1.8621**)	(2.1819**)
$\Delta \log RER_{t-1}$	0.4174	0.4234
	(4.1160***)	(4.2431***)
DR_t	-0.0039	-0.0054
	(-1.9924*)	(-2.0922**)
DR_{t-2}	-0.0058	-0.0074
	(-0.5735***)	(-3.5640***)
$D_{1,t}$	0.1597	0.1594
	(6.3093***)	(6.4523***)
$D_{2,t}$	0.0571	0.0635
	(2.5935**)	(2.7107**)
EC_{t-1}	-0.7208	-0.7175
	(-5.5978***)	(-5.6295***)
Diagnostic tests:		
Adj. R^2	0.8124	0.8188
LM(1)	0.4549	0.2163
LM(2)	3.8910	4.0517
ARCH(1)	0.0357	0.0482
ARCH(2)	0.3032	0.2621
Hetero	0.7230	0.3488
Reset	1.6440	1.0887
Normal	3.5735	2.6260

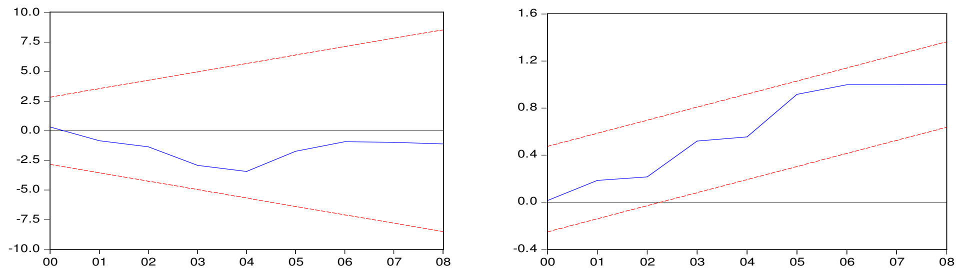
Notes: Adj. R^2 is the adjusted R^2. LM is the Lagrange multiplier test of disturbance term serial correlation. ARCH is the Lagrange multiplier test for autoregressive conditional heteroskedasticity (ARCH) in disturbance term (Engle, 1982). Hetero is the test of heteroscedasticity (Koenker, 1981). Reset is the test of functional form. Normal is the test of the normality of disturbance term. Values in parentheses under the coefficients are the t-statistic whilst values in the parentheses in the diagnostic tests are the lag lengths used in the computing the test statistics. *** (**,*) denotes significance at the 1% (5%, 10%) level.

[7] The half-life period is calculated as - log (2) / log (1 + α), where α is the coefficient of the error correction term (Wu and Chen, 2008: 689).

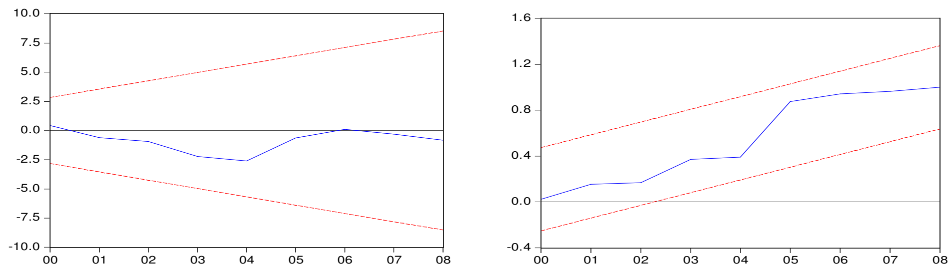
Figure 4
The Plots of Cumulative Sum of Recursive Residuals (CUSUM) and Cumulative Sum of Recursive Residuals (CUSUMSQ)

CUSUM **CUSUMSQ**

Vector 1



Vector 2



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

The results of the generalised forecast error variance decompositions are reported in Table 7. The results of the generalised forecast error variance decompositions, which are reported, are based on the 0-5, 10, 15, and 20 horizon periods. The result of Vector 1 shows that productivity differential is the most important contributor to the forecast error variance of the real exchange rate. This is followed by the real oil price and reserve differential. Productivity differential accounts for about 17 per cent of the forecast error variance of the real exchange rate whilst the real oil price and reserve differential account for about 12 and 9 per cents, respectively. The result of Vector 2 shows the important contributor to the forecast error variance of the real exchange rate is the same as Vector 1. Productivity differential accounts for about 18 per cent of the forecast error variance of the real exchange rate whilst the real oil price and reserve differential account for about 11 and 9 per cents, respectively. Thus the important contributors of the two vectors are about the same. Productivity differential, the real oil price, and reserve differential are important in the real exchange rate determination.

Table 7
The Generalised Forecast Error Variance Decomposition

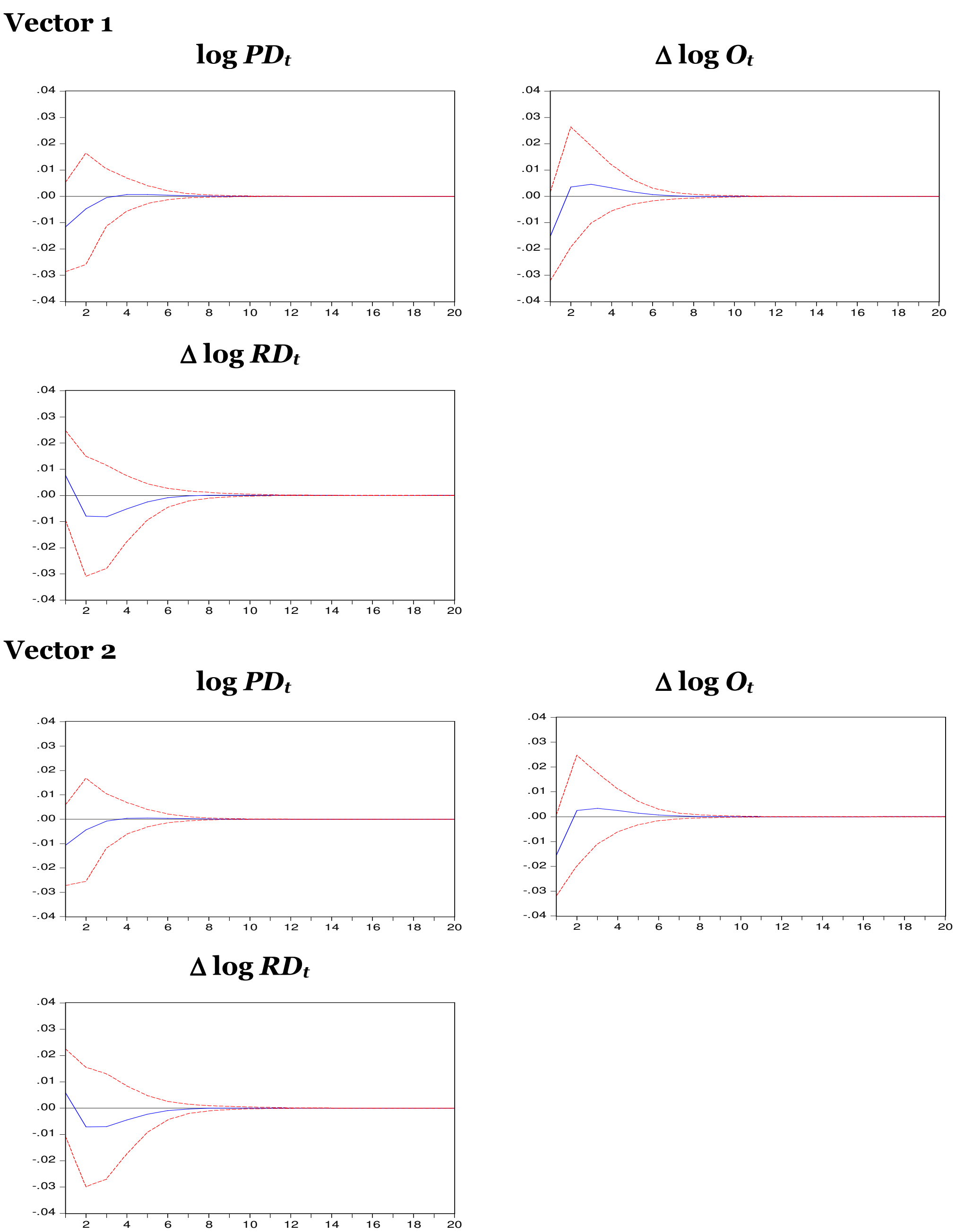
Horizon	Δ log RER_t	Δ log PD_t	Δ log O_t	Δ log RD_t
		Vector 1		
0	1.0000	0.1034	0.1129	0.0995
1	0.8156	0.1496	0.1004	0.0797
2	0.7751	0.1633	0.1134	0.0839
3	0.7709	0.1653	0.1159	0.0856
4	0.7708	0.1653	0.1161	0.0858
5	0.7708	0.1653	0.1161	0.0858
10	0.7707	0.1653	0.1161	0.0858
15	0.7707	0.1653	0.1161	0.0858
20	0.7707	0.1653	0.1161	0.0858
		Vector 2		
0	1.0000	0.1015	0.1171	0.1113
1	0.8069	0.1639	0.1005	0.0849
2	0.7728	0.1814	0.1062	0.0853
3	0.7699	0.1833	0.1072	0.0858
4	0.7698	0.1834	0.1073	0.0859
5	0.7698	0.1834	0.1073	0.0859
10	0.7698	0.1834	0.1073	0.0859
15	0.7698	0.1834	0.1073	0.0859
20	0.7698	0.1834	0.1073	0.0859

Note: The VAR=1 is used in all the estimations.

The results of the generalised impulse response functions are shown in Figure 5. The results of the generalised impulse response functions are plotted over the 20 horizon periods or equivalent to twenty year periods. The responses of the real exchange rate to one standard error shock in productivity differential or the real oil price are negative and then positive over about 0-8 horizon periods before die out. The responses of the real exchange rate to one standard error shock in reserve differential are positive and then negative over about 0-8 horizon periods before die out. Thus a change in productivity differential, the real oil price or reserve differential would influence the real exchange rate for some periods.

Generally, productivity differential, the real oil price, reserve differential, and the real interest differential are found to have a significant impact on the real exchange rate in the long run and short run. Choudhri and Khan (2005), Candelon *et al.* (2007), and Guo (2010), amongst others, show that productivity differential is important in the real exchange rate determination. Chen and Chen (2007), amongst others, also show the importance of the real oil price, the real interest rate differential, and productivity differential in the real exchange rate determination. Aizenman and Riera-Crichton (2006) show that the real exchange rate and international reserve are negative related. Egert, Lommatzsch, and Lahreche-Revil (2006), Wang, Hui, and Soofi (2007), Kasman and Ayhan (2008), amongst others, show the importance of international reserve in the real exchange rate determination. Bagchi, Chortareas, and Miller (2004), Bergvall (2004), and Byrne and Nagayasu (2010), amongst others, also show the importance of the real interest rate differential in the real exchange rate determination.

Figure 5
The Plots of the Generalised Impulse Response Functions to One Standard Error Shock in the Equation for the First Difference of the Natural Logarithm of the Real Exchange Rate (Δ log RER_t)



Note: The dashed lines represent ± 2 asymptotic standard errors.

The real oil price could influence the real exchange rate determination. The world oil price is characterised by high volatility, high intensity jumps, and strong upward drift (Askari and Krichene, 2008). Thus the real exchange rate shall be volatile. There is a need to smooth down the volatility of the real exchange rate especially in the short run. The policy of the central bank of Malaysia on ringgit exchange rate is let it to be determined by the market. Interventions are carried out to smooth down the excessively volatile of ringgit exchange rate (BNM, 1999). Less volatility of the real exchange rate would promote international trade and investment. The half-life period is relatively short. This could imply that the real exchange rate in Malaysia will adjust back to its long-run equilibrium level fast after a shock and it is well reflected to the fundamentals.

The Asian financial crisis is found to have a negative impact on the real exchange rate in Malaysia. After the crisis, Malaysia devalued its currency against the US dollar and then ringgit was fixed to the US dollar at ringgit 3.80 for one US dollar (1999-2004) before it was removed to allow the market to play a more important role. The fixed ringgit against the US dollar policy was implemented with the aim to promote exports and economic growth. A weak currency is said to encourage exports. However, it is more difficult to control the imported inflation especially because of the world oil price shock. Maintaining a strong international reserve position is important to maintain a sustainable external position. A large reserve is a key element in protecting an economy from the external shocks. This is important to sustain market confidence and stability, enhance credit worthiness, and provide the government with greater flexibility in the conduct of domestic policies (BNM, 1999: 114-115). Moreover, a strong international reserve level is important to achieve the aim of a floating exchange rate regime.

Productivity differential is important in the real exchange rate determination in Malaysia. Rapid economic growth would appreciate the real exchange rate. Rapid economic growth could be achieved through more exports. This could be achieved by attracting more foreign direct investment. Malaysia is a hub for foreign direct investment in the South East Asian region. Thus the competitive policy towards foreign direct investment shall be maintained to attract more foreign direct investment for economic growth and development. Monetary policy through interest rate could affect the real exchange rate especially in the short run. A relatively high interest rate could be used to appreciate the real exchange rate whilst a relatively low interest rate could be used to depreciate the real exchange rate. A strong currency will likely discourage exports and encourage imports. Both the short-term interest rate and the medium-term interest rate are important for the real exchange rate determination.

5. Concluding Remarks

This study has investigated the real exchange rate determination in Malaysia. The results of the cointegrating vectors show that an increase in productivity differential, the real oil price or reserve differential will lead to an appreciation of the real exchange rate. The results of the generalised forecast error variance decompositions show that the real oil price is one of the important determinants of the real exchange rate. Generally, productivity differential, the real oil price, reserve differential, and the real interest rate differential are important in the real exchange rate determination. The world oil price is volatile and thus the real exchange rate shall be volatile as well. Exchange rate interventions are important to smooth down the volatility of the real exchange rate especially in the short run. Maintaining a strong international reserve position is important to maintain a sustainable external position. A large reserve is a key element in protecting an economy from the external shocks such as the world oil price shock. Rapid economic growth would appreciate the real exchange rate. This could be achieved by attracting more foreign direct investment. Monetary policy through interest rate could affect the real exchange rate. A relatively high interest rate could be used to appreciate the real exchange rate. A weak currency is said to encourage exports. More exports will lead to higher economic growth. However, a weak currency is more difficult to control the imported inflation such as because of the high world oil price.

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