Tests of the Different Variants of the Monetary Model in a Developing Economy: Malaysian Experience in the Pre- and Post-crisis Periods

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Tests of the different variants of the monetary model in a developing economy: Malaysian experience in the pre- and post-crisis periods

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Abstract

This study examines the validity of four different variants of the monetary model of exchange rate determination for Malaysia covering both the pre- and post-crisis periods using the vector error-correction models. The findings demonstrate that for both periods, the variables used are cointegrated. Tests tend to suggest that of the four variants of monetary model, the sticky-price model holds in both periods and the flexible-price model holds only in the post-crisis period. The proportionality between the exchange rate and relative money does not hold in any period. The plotted actual and fitted exchange rates for both sub-samples show that the models are able to track the actual exchange rate trend quiet well.

I. INTRODUCTION

Over the past 30 years Malaysia has undergone a significant liberalization in its financial system and experienced remarkable economic growth. Before the currency crisis, Malaysia was considered as the best "development success story" among the second-tier newly industrializing economies in East Asia. During 1987-96, the Malaysian economy grew at an average annual rate of 8.8%. The economy was virtually at full employment for the last six years prior to crisis, with modest inflation, rapid export growth, manageable external debt and improvement in current account deficits. However, this impressive growth changed dramatically with the onset of the currency crisis. Malaysia adopted a flexible exchange rate policy in 1973 and had pursued this policy for more than two decades. For 25 years prior to the currency crisis, the ringgit fluctuated around RM2.50 per USD. But, currency turmoil sweeping Southeast Asia had forced the Malaysian ringgit to depreciate severely from around RM2.50 per USD in July 1997 to around RM4.20 per USD in August 1998 until the Malaysian government pegged their currencies to US Dollar at the rate of RM3.80 = USD1 on 1 September 1998. However, recently on 21 July 2005, Bank Negara Malaysia announced that the RM3.80 peg against the USD would be scrapped and replaced with a managed float against an undisclosed basket of currencies of Malaysia's major trading partners.

There is a growing agreement among economists and policymakers that stability in the exchange rate promotes economic expansion and improved welfare. In accordance with the growing importance of exchange rate stability, this paper seeks to understand the forces driving the movements in the RM/USD exchange rate. We operationalize this problem by establishing a conventional theoretical baseline model - the monetary model and by further asking whether and how the economic fundamentals have affected the exchange rates.

According to the monetary models of exchange rate determination, there are four variables that explain movements in exchange rates - relative money stocks, relative incomes, relative interest rates, and relative inflation levels. An examination of the relationships between these variables and the RM/USD exchange rate will be indicative of the policies which could be pursued in promoting exchange rate stability for the country. If we are able to know which variables significantly affected the exchange rates, then the policy makers could use various instruments to achieve the optimal policy.

In terms of literature, despite the extensive research on monetary model of the exchange rate determination, there have been only a few analyses for the developing countries. Very few such studies can be found and those which have came to our notice are Chua and Bauer (1995) for Malaysia; Cao and Ong (1995), and Chia and Bauer (1995) for Singapore; and Husted and MacDonald (1999), and Chinn (2000a, 2000b) for the Asian countries. In particular, Chua and Bauer (1995) estimated a traditional sticky-price monetary exchange rate model for the bilateral exchange rates of the ringgit against the U.S. dollar for the period 1976-1993 using the traditional multiple regression. Their findings do not support the monetary model of exchange rate determination. The result is perhaps not surprising when viewed against the behavior of most of the monetary variables which are upward trending and the traditional multiple regression is not a suitable framework to test whether there exists a long-run monetary relationship in the presence of non-stationarity in the series. Therefore, it is our interest, from both the theoretical and policy perspectives, to examine how much of the ringgit exchange rate fluctuations can be explained by monetary factors using different versions of the monetary approach by employing the recent cointegration techniques. In this paper, we will examine the validity of the different versions of the monetary models including the commonly imposed restrictions of proportionality between the exchange rate and relative money; the restoration of the long-run equilibrium exchange rates, and the in-sample forecasts of monetary models for Malaysia during the pre- and post-crisis periods using cointegration and vector error-correction model (VECM).

This paper extends the existing literature in two directions. First, it studies a longer data period 1980-2006, a period long enough to cover the time of floating exchange rate, the financial pre-crisis as well as the post-crisis periods. Second, it investigates how well the different versions of the monetary approach to exchange rate can explain the nominal exchange rate of the ringgit-USD in both the pre-crisis and post crisis periods.

The outline of the remainder of the paper is as follows. In Section II we discuss the different versions of the monetary models of exchange rate determination. Section III describes the methodology and the data set used. Empirical results and discussions are presented in Section IV. Section V provides the summary conclusions and the policy implications of the study are highlighted in the final section VI.

II. THE DIFFERENT VARIANTS OF THE MONERARY APPROACH TO EXCHANGE RATE DETERMINATION

Monetary models of exchange rate determination were developed after the collapse of the fixed exchange rate system in the early 1970s. Its basic rationale is that since an exchange rate is the price of one country's money in terms of that of another, it is important to analyse the determinants of that price in terms of the outstanding shocks of and demand for the two monies.

Over the past three decades, we have seen an enormous growth in the literature on exchange rate economics. Several versions have been put forward giving rise to two main types of models: first, the flexible-price monetary model (FPMM) due to Frenkel (1976) and Bilson (1978); and second, the sticky-price monetary model (SPMM) of Dornbusch (1976) and its variant the real interest rate differential model of Frankel (1979).

All monetary models rely on the twin assumptions that the purchasing power parity (PPP) holds continuously (Equation 1) and that the money demand functions are stable for the domestic and foreign economies (Equations 2 and 3):

$$e_t = p_t - p_t^* \tag{1}$$

$$m_t = \gamma_1 p_t + \gamma_2 y_t + \gamma_3 r_t \tag{2}$$

$$m_t^* = \gamma_1 p_t^* + \gamma_2 y_t^* + \gamma_3 r_t^*{}_t \tag{3}$$

where e_t is the spot exchange rate (defined as the price of a unit of foreign money in terms of domestic money), m_t is the domestic money supply, p_t is the domestic price level, y_t is the domestic real income, r_t is the domestic interest rate, while an asterisk denotes the corresponding foreign variables, and all variables except for interest rate, are expressed in natural logarithms.

Solving Equations 2 and 3 for the relative price levels, and substituting into Equation 1 yields the basic flexible-price monetary model:

$$e_t = (m_t - m^*_t) - \beta (y_t - y^*_t) + \lambda (r_t - r^*_t) \quad (4)$$

If the flexible-price monetary model is supported, then it is expected that the coefficient of the $(m_t - m^*_t)$ should be +1, the sign of the coefficient for $(y_t - y^*_t)$ should be negative and the sign of the coefficient for $(r_t - r^*_t)$ should be positive. According to Equation 4, an increase in domestic (foreign) money supply will lead the domestic currency to depreciate (appreciate). An increase in domestic (foreign) real income will raise the money demand, causing the domestic currency to appreciate (depreciate). Finally, an increase in the home (foreign) interest rate will result in a depreciation (appreciation) of the exchange rate via a reduction of the demand for money.

A further assumption underlying the flexible-price model is that the uncovered interest rate parity (UIP) holds continuously - that is, the domestic-foreign interest rate differential equals the expected rate of depreciation of the domestic currency[1].

[1] The UIP relationship is usually invoked when domestic and foreign assets are perfect substitutes, there is no uncertainty and there is absence of capital controls and transaction costs.

$$E_t\,(e_{t+1} - e_t) = (r_t - r^*_t) \quad (5)$$

We may substitute the UIP equation into Equation 4 to get

$$e_t = (m_t - m^*_t) - \beta\,(y_t - y^*_t) + \lambda\,E_t\,(e_{t+1} - e_t) \quad (6)$$

$E_t\,(e_{t+1} - e_t) = E_t\,(\pi_{t+1} - \pi^*_{t+1})$ can be derived from a weaker version of PPP relation, where $E_t\,\pi_{t+1} = E_t\,(p_{t+1} - p_t)$ and $E_t\,\pi^*_{t+1} = E_t\,(p^*_{t+1} - p^*_t)$ are the expected inflation rates conditional on all available information at time *t*. Thus, Equation 6 becomes

$$e_t = (m_t - m^*_t) - \beta\,(y_t - y^*_t) + \lambda\,E_t\,(\pi_{t+1} - \pi^*_{t+1}) \quad (7)$$

An alternative version of the monetary model was developed by Dornbusch (1976) in which prices are rigid, adjusting gradually so that PPP holds only in the long-run.

$$\overline{e}_t = \overline{p}_t - \overline{p}^*_t \quad (8)$$

where the upper bar denotes the long-run value of that variable. Thus, Equation 7 gives the long-run value of the exchange rate as,

$$\bar{e}_t = (m_t - m^*_t) - \beta (y_t - y^*_t) + \lambda E_t (\bar{\pi}_{t+1} - \bar{\pi}^*_{t+1}) \quad (9)$$

Under this assumption, the sticky-price monetary model allows short-run overshooting of the nominal exchange rate above its long-run value.

However, according to Frankel (1979), the sticky-price monetary model contains a deficiency in that it does not incorporate differences in secular rates of inflation between countries. 'Expectations' are formed according to the rule,

$$E_t (e_{t+1} - e_t) = \theta (e_t - \bar{e}_t) + E_t (\bar{\pi}_{t+1} - \bar{\pi}^*_{t+1}) \quad (10)$$

which implies that the expected rate of depreciation is a function of the gap between the exchange rate and its long-run value, and of the expected long-run inflation differential between the domestic and foreign countries. Frankel (1979) says that in the short-run the exchange rate is expected to return to its equilibrium value at a rate which is proportional to the gap between the exchange rate and its long-run value, and that in the long-run, when $e_t = \bar{e}_t$, it is expected to change at the long-run rate $E_t (\bar{\pi}_{t+1} - \bar{\pi}^*_{t+1})$.

Using UIP (Equation 5), the expectations rule (Equation 10) and Equation 9, he developed the real interest differential monetary model that combines elements of both flexible-price and sticky-price monetary models:

$$e_t = (m_t - m^*_t) - \beta(y_t - y^*_t) + \phi(r_t - r^*_t) + \delta E_t(\bar{\pi}_{t+1} - \bar{\pi}^*_{t+1}) \quad (11)$$

where $\delta = \lambda - (1/\theta)$ and $\phi = 1/\theta$. If sticky-price monetary model is supported, then it is expected that the coefficient of the $(m_t - m^*_t)$ should be +1, the sign of the coefficient for $(y_t - y^*_t)$ should be negative, the sign of the coefficient for $(r_t - r^*_t)$ should be negative and the sign of the coefficient for $E_t(\bar{\pi}_{t+1} - \bar{\pi}^*_{t+1})$ should be positive. It is interesting to note that the last two effects are the opposites of the ones that are expected in the flexible-price model. This model, generally regards a relative increase in the domestic interest rate leads to capital inflows, and hence to an appreciation of the exchange rate. In addition, an increase in the expected long-run inflation results in agents switching from domestic currency to bonds (both domestic and foreign). Thus the demand for domestic currency decreases, causing a depreciation of the domestic currency.

Although this model is theoretically very appealing, its empirical validity is surrounded by controversy. Using the data up to the end of 1978, early tests of Frenkel (1976), Bilson (1978), Hodrick (1978), Dornbusch (1976) and

Frankel (1979) tend to provide supportive results for the model. However, later studies by Rasulo and Wilford (1980), Haynes and Stone (1981) and Driskill and Sheffrin (1981) employing data beyond 1978 have led to results, which are unsupportive of the theory. It has been argued that the above mentioned empirical works have used data, which suffer from non-stationarity and therefore the tests used in their analysis were inappropriate to make any valid statistical inference. The recently developed theory of Johansen (1988, 1991) cointegration techniques provide a suitable framework within which we can test whether there exists a long-run monetary relationship, in the presence of non-stationarity in the series. Within this framework, MacDonald and Taylor (1991, 1993, 1994a, b) have tested the validity of the monetary model in a few of their studies and found evidences of at least one significant cointegrating vector in all cases.

Kouretas (1997), Diamandis *et al.* (1998), Reinton and Ongena (1999), Hwang (2001) and Tawadros (2001) among others, provide evidence for the long-run validity of the model as well as its out-of-sample forecasting performance for a number of key currencies. Most recently, Husted and MacDonald (1999) and Groen (2000) test for a stable long-run relationship between nominal exchange rates and monetary fundamentals using panel cointegration tests for the post–Bretton Woods float and they reported strong evidence in favour of the monetary approach. However, using data spanning over 115 years (1880-1995), Rapach and Wohar (2002) identify a number of countries for which the long-run monetary model does not hold, while the panel cointegration tests in Groen (2000) accept the monetary model for each member of the entire panel.

III. METHODOLOGY AND DATA

Methodology

The long-run structural system in Equation 11 can be re-expressed as a structural vector error-correction model:

$$\Delta e_t = c + \sum_{i=0}^{n}\Gamma_{1i}\Delta e_{t-i-1} + \sum_{i=0}^{n}\Gamma_{2i}\Delta(m-m^*)_{t-i} + \sum_{i=0}^{n}\Gamma_{2i}\Delta(y-y^*)_{t-i} + \sum_{i=0}^{n}\Gamma_{3i}\Delta(r-r^*)_{t-i}$$
$$+ \sum_{i=0}^{n}\Gamma_{5i}\Delta(\pi-\pi^*)_{t-i} + \Pi Z_{t-1} + \varepsilon_t \qquad (12)$$

where c denotes a constant, ε_t denotes an error term, Z_t represents the cointegrating vector normalized on e_t and Π-matrix captures the adjustment of the exchange rate towards its long-run equilibrium value. $\Pi = \alpha\beta'$, where α represents the speed of adjustment to disequilibrium while β is a matrix of long-run coefficients such that the term βZ_t embedded in Equation 12 represents up to (n - 1) cointegration relationships in the multivariate model which ensures that the Z_t converge to their long-run steady-state solutions.

Data

All the data series were obtained from various issues of the International Monetary Fund's International Financial Statistics yearbook. The data were collected at the quarterly frequency from 1980Q1 to 2006Q1. The sample periods were chosen so as to include the years before and after currency crisis, where the data during the flexible exchange rate period and before the currency misalignment (Sazanami and Yoshimura, 1999; Husted and MacDonald, 1999; Furman and Stigliz, 1998; Chinn and Dooley, 1999; Chinn, 2000a and Chinn, 2000b) i.e. 1980Q1 to 1995Q1 were used to formulate model for pre-crisis period, while the data from 1997Q3 to 2006Q1 were chosen to estimate model for post-crisis period.

Exchange rates are quarterly averages in terms of RM/USD. The chosen monetary aggregates are broad money stock. The industrial product indices are utilized as proxies for quarterly domestic income. The interest rates are the short-term market rates. Preceding 4 quarters growths in consumer price indices are used for the unobservable expected inflation rate. All variables are in natural logarithmic form (except interest rate and expected inflation rate), while an asterisk denotes a series corresponding to the U.S.

IV. RESULTS AND DISCUSSIONS

The results of Dickey-Fuller GLS unit root test show that all variables are $I(1)$ processes and the Johansen-Juselius likelihood cointegration test shows that exchange rate, money stock, income, interest rate and expected inflation rate differentials are cointegrated during the pre- and post-crisis periods[2].

Next, we proceed to test different versions of the monetary model by imposing relevant restrictions on the cointegrating vector[3]. Table 1 Column 3 stated the restrictions imposed for different versions of the monetary model. First, we normalized on the coefficient of the exchange rate. This unrestricted model will be representing sticky-price monetary model (label as Case 1). Next, besides normalizing on the coefficient of the exchange rate, we imposed zero restriction on the coefficient of the expected inflation rate differential. This relationship describes the flexible-price monetary model (label as Case 2). In order to test whether the popular monetary restriction, i.e. the proportionality between the exchange rate and relative money hold, we further imposed restriction of one on the coefficient of the money differential on both Case 1 and Case 2. These sticky-price and

[2] The results of unit root test and cointegration test are available in Appendix: Table A1 and A2.

[3] For the post-crisis period where there are three cointegrating vectors, zero restrictions were imposed on the adjustment coefficient (α) of the second and third cointegrating vectors and the likelihood ratio failed to reject the imposition. Hence, the analyses proceed with single cointegrating vector.

flexible-price monetary models with proportionality between the exchange rate and relative money are reported as Case 3 and Case 4. The results of the likelihood ratio test for the acceptance of the restrictions are reported in Table 1 Column 4. For pre-crisis period, the results show that the likelihood ratio test statistics for Case 2, Case 3, and Case 4 are significant and thus we rejected the joint restrictions. This means the cointegrating vector is not interpretable as flexible-price monetary model and the restriction of proportionality between the exchange rate and relative money do not hold in both sticky-price and flexible-price monetary models. In other words, we were able to identify one long-run relationship as describing the sticky-price monetary model (Case 1). This suggests that the expected inflation differential cannot be excluded from the model. The intuition is that the expected inflation differential has been nonzero throughout the period and thus failure to incorporate them into the model will produce a misspecified exchange rate relationship. For post-crisis period, the results show that the likelihood ratio test statistics for Case 3 and Case 4 are significant. Hence, our system accepted Case 1 and Case 2. This means we were able to identify one long-run relationship as describing the sticky-price or flexible-price monetary model but the restriction of proportionality between the exchange rate and relative money do not hold in both sticky-price and flexible-price monetary models.

Table 1

Equations 13, 14 and 15 are the estimated long-run monetary models for Malaysia during the pre- and post-crisis periods. The values in parentheses below the coefficient estimates are *t*-values[4].

SPMM for pre-crisis:

$$e_t = -0.02(m - m^*)_t + 0.27(y - y^*)_t - 0.04(r - r^*)_t - 0.05E_t(\bar{\pi} - \bar{\pi}^*)_{t+1} \quad (13)$$
$$\quad (-0.24) \qquad (2.09) \qquad (-0.08) \qquad (-7.60)$$

SPMM for post-crisis:

$$e_t = 0.04(m - m^*)_t - 0.04(y - y^*)_t - 0.09(r - r^*)_t + 0.002E_t(\bar{\pi} - \bar{\pi}^*)_{t+1} \quad (14)$$
$$\quad (4.33) \qquad (-2.34) \qquad (-1.01) \qquad (0.33)$$

FPMM for post-crisis:

$$e_t = 0.11(m - m^*)_t - 0.11(y - y^*)_t + 0.04(r - r^*)_t \quad (15)$$
$$\quad (7.43) \qquad (-3.51) \qquad (0.24)$$

For the pre-crisis period, Equation 13 showed that only the estimated coefficient of interest rate differential has the same sign as predicted by the sticky-price monetary model, however it is insignificant. The estimated coefficients of income and expected inflation rate do not have the anticipated sign but are statistically significant. The money differential is insignificant in the long-run. Our result is consistent with the finding of Chua and Bauer (1995). For post-crisis, Equations 14 and 15 showed that all the estimated coefficients carried the expected sign, however, only the

[4] The results in table form are available in Appendix: Table A3.

estimated coefficients of money and income differentials are statistically significant. The comparison of pre- and post-crisis shows that the signs of the coefficients of the money and income differentials had changed. In particular the money differential is both correctly signed and statistically significant, this suggests that the change in money supply, which had no significant impact on exchange rate before the crisis had become important after the crisis.

Several conclusions can be drawn upon the findings from the long-run parameters of the monetary model. First, the money stock and interest rate differentials are found to account for a very small portion of the ringgit variation in the pre-crisis period. These seem to indicate that the interest rate and monetary policies were unable to influence the Malaysian exchange rate. However, these loose relationships between ringgit and the monetary fundamentals may be due to the interventions of Bank Negara Malaysia in the foreign exchange market[5]. Second, domestic-foreign income differential explains most of the variation in the ringgit in the pre-crisis period. However, this positive correlation, contrary to the prediction of the monetary model, implies that rapid growth experience in the past two decades tends to weaken the RM/USD rate. One possible explanation is that

[5] Prior to pegging of the ringgit to the USD on 2 September 1998, BNM actively intervenes in the foreign exchange market to ensure orderly market conditions and to moderate day-to-day fluctuations in the value of the ringgit (Chua and Bauer, 1995; Bank Negara Malaysia, 1999: p.270).

the demand for imports would tend to increase substantially with domestic growth and this would lead to depreciation in the domestic currency and therefore a low spot exchange rate is expected[6]. Third, money and income differentials explain most of the variation in ringgit during the post-crisis period. This indicates that the monetary policy, which had no significant impact on exchange rate before the crisis had become a very useful tool after the crisis. The money differential enters in with a positive sign, indicating that an increase in the Malaysian money supply relative to the US induces a depreciation to the ringgit. Significant negative income differential implies that the economic growth (recession) during the post-crisis period tends to strengthen (weaken) the RM/USD rate.

Next, following the general-to-specific methodology, the final parsimonious VECM monetary models for Malaysia during the pre- and post-crisis periods are obtained as Equations 16, 17 and 18[7]. The values in parentheses below the coefficient estimates are *t*-values.

Short-run SPMM for pre-crisis:

$$\begin{aligned} e_t = \; & -0.0001 - 0.34\Delta e_{t-1} + 0.18\Delta(m - m^*)_{t-3} + 0.01\Delta(y - y^*)_{t-3} \\ & \quad (-0.04) \quad (-5.74) \qquad\quad (4.08) \qquad\qquad\quad (0.26) \\ & +0.18\Delta(r - r^*)_{t-1} + 0.009\Delta(\bar{\pi} - \bar{\pi}^*)_{t-3} - 0.10Z_{t-1} + 0.05D1 \\ & \qquad (1.94) \qquad\qquad\quad (5.31) \qquad\qquad (-6.23) \quad (10.84) \end{aligned} \tag{16}$$

[6] Explanation provided by Soon (1995) for similar result for Malaysia.

[7] These final parsimonious specifications are obtained by removing the insignificant regressors. In order to avoid mis-specification, at least one of the lag variable (with largest t-ratio) will be retained in the case of all the lagged variables are not significant.

Short-run SPMM for post-crisis:

$$e_t = \underset{(7.04)}{0.01} + \underset{(5.82)}{0.15}\Delta e_{t-1} + \underset{(0.99)}{0.05}\Delta(m - m^*)_{t-2} + \underset{(4.21)}{0.15}\Delta(y - y^*)_{t-2}$$

$$+\underset{(2.22)}{0.42}\Delta(r - r^*)_{t-2} \underset{(-1.51)}{-0.003}\Delta(\bar{\pi} - \bar{\pi}^*)_{t-2} \underset{(-36.06)}{-0.58}Z_{t-1} + \underset{(15.63)}{0.05}D2 \quad (17)$$

Short-run FPMM for post-crisis:

$$e_t = \underset{(6.00)}{0.01} + \underset{(4.55)}{0.13}\Delta e_{t-1} + \underset{(0.68)}{0.04}\Delta(m - m^*)_{t-2} + \underset{(5.23)}{0.21}\Delta(y - y^*)_{t-2}$$

$$+\underset{(2.50)}{0.49}\Delta(r - r^*)_{t-2} \underset{(-31.12)}{-0.57}Z_{t-1} + \underset{(13.11)}{0.05}D2 \quad (18)$$

where D1 and D2 are dummy variables introduced to correct for normality[8]. The models had passed all the diagnostics tests[9]. The results show that all the coefficients for error-correction term (ECT) are correctly signed and statistically significant. The exchange rates respond to the error correction terms by moving to reduce the disequilibrium. The speeds of adjustment for pre- and post-crisis are 10% and 57% or 58%, respectively. The comparison of pre- and post-crisis shows that Malaysia reacted more rapidly in adjusting towards its long-run equilibrium after the currency crisis.

Using the obtained final parsimonious models, the in-sample predictions for Malaysia ringgit are generated[10]. Evidences of the goodness of fit are revealed in Figure 1 and Figure 2. The models fit the data very closely through out the periods. The plotted actual and fitted exchange rates values

[8] The detail of residual plots and technique used to correct non-normality are available from the authors upon request.
[9] The results are available in Appendix: Table A4.
[10] Forecast for exchange rates are made using the actual data for the explanatory variables.

show that the models are able to track the actual exchange rates well and manage to get a considerable number of correct turning points. In order to compare the performance of sticky-price and flexible-price monetary models for the post-crisis period, the root-mean squared errors (RMSE) of the in-sample forecasts are computed. As presented in Figure 2, the sticky-price monetary model has the smaller RMSE, thus sticky-price monetary model outperformed flexible-price monetary model in the forecasting performance.

Figure 1

Figure 2

V. SUMMARY CONCLUSIONS

In this study, we have examined four different variants of the monetary approach to exchange rate determination with an application to Malaysia during both the pre- and post-crisis periods using cointegration and vector error-correction techniques. The findings demonstrated that for both periods, there exists one cointegrating vector between the exchange rate and the monetary fundamentals. Then, we proceeded to impose independent linear restrictions on them. Based on the likelihood ratio tests, we accepted the cases of sticky-price monetary model for both the pre- and post-crisis periods but the flexible-price monetary model is a valid model only in the post-crisis period, and we rejected the restriction of proportionality between exchange rate and relative money in both periods. The estimated long-run parameters provide weak support to the theory of monetary models during the pre-crisis period but provide strong support to the theory during the post-crisis period. As for the pre-crisis period, only the estimated coefficient of interest rate differential has the same sign as predicted by the sticky-price monetary model while for the post-crisis, all the estimated coefficients for both models have the expected signs. Nevertheless, the sticky-price monetary model outperformed the flexible-price monetary model in the forecasting exercise during the post-crisis period.

VI. POLICY IMPLICATIONS

The policy implication of this study is straightforward. **First,** The existence of a cointegrating vector in each sub-period may be interpreted to mean that the Malaysian exchange rate is theoretically related to the economic fundamental variables contained in the monetary models. Hence, these economic fundamental variables can be used as stabilization tools for the Malaysian exchange rate. **Second**, among the fundamental variables, money and income differentials explain most of the variation in ringgit for the post-crisis period. Therefore the monetary policy rather than the interest rate policy is likely to be a more powerful tool for stabilizing Malaysia exchange rate. The money differential enters in with a positive sign, indicating that an increase in the Malaysian money supply relative to the US will lead to a depreciation of the ringgit. Therefore, Malaysia should tighten its monetary policy to strengthen the ringgit. **Third,** the insignificance of the interest rate differential and the expected inflation rate differential in the post-crisis period might be related to the official dollar-ringgit peg in most of the post-crisis period. However, the role of interest rate and expected inflation rate are likely to change after the recent de-pegging of the Malaysian ringgit. **Finally,** a significant negative income differential implies that economic growth (recession) during the post-crisis period tends to strengthen (weaken) the ringgit/US$ rate.

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Table 1: Testing of cointegrating vector subject to β restrictions

Pre-crisis (1980Q1-1995Q1)		Monetary model restrictions	LR
Case 1:	SPMM	[- 1, • , • , • , •]	-
Case 2:	FPMM	[- 1, • , • , • , 0]	31.778[a]
Case 3:	SPMMp	[-1, 1 , • , • , •]	13.802[a]
Case 4:	FPMMp	[- 1, 1 , • , • , 0]	31.801[a]
Post-crisis (1997Q3-2006Q1)			
Case 1:	SPMM	[- 1, • , • , • , •]	-
Case 2:	FPMM	[- 1, • , • , • , 0]	0.787
Case 3:	SPMMp	[-1, 1 , • , • , •]	9.916[a]
Case 4:	FPMMp	[- 1, 1 , • , • , 0]	15.217[a]

Notes: SPMM (FPMM) is sticky-price (flexible-price) monetary model and SPMMp (FPMMp) is sticky-price (flexible-price) monetary model with proportionality between the exchange rate and relative money. LR denotes likelihood ratio statistics (asymptotically distributed χ^2) for testing the restrictions as specified in the normalized cointegrating vector and • denotes an unspecified column of β, to be estimated from data. a and b and denotes significance at 1% and 5% levels.

Figure 1: Actual and forecasted exchange rates for Malaysia (Pre-crisis: 1980Q1 - 1995Q1)

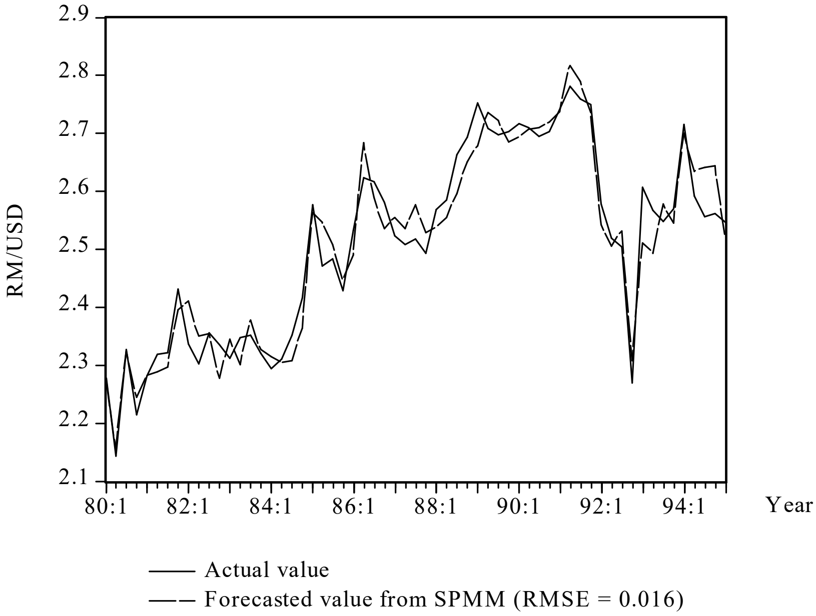
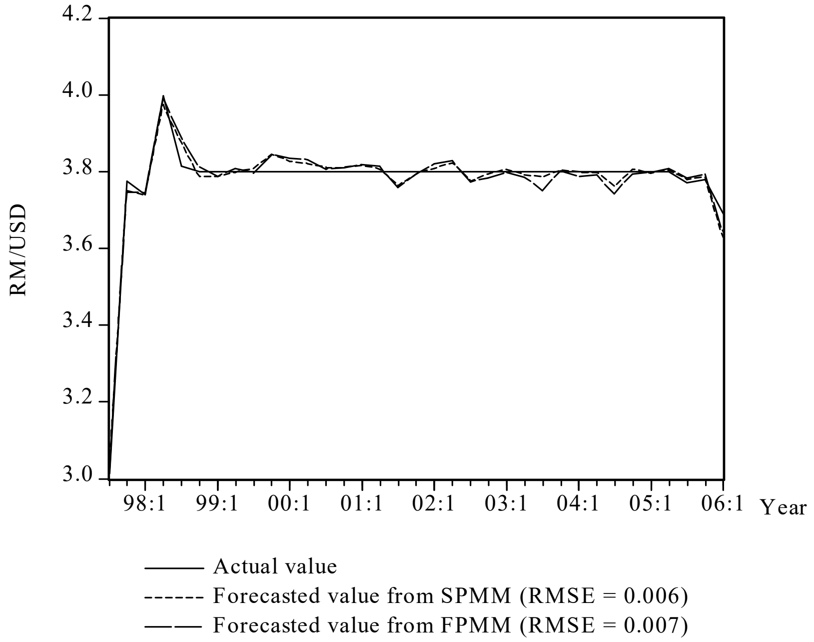


Figure 2: Actual and forecasted exchange rates for Malaysia (Post-crisis: 1997Q3 - 2006Q1)



APPENDIX

Table A1: Dickey-Fuller GLS unit root tests for Malaysia

Series	**Pre-crisis** (1980Q1-1995Q1)				**Post-crisis** (1997Q1-2006Q1)			
	constant without trend		constant with trend		constant without trend		constant with trend	
	Level	First Difference	Level	First Difference	Level	First Difference	Level	First Difference
e	-0.77 (1)	-10.65 (0) [a]	-1.87 (1)	-11.51 (0)[a]	-1.62 (1)	-3.83 (0)[a]	-2.74 (1)	-4.38 (1)[a]
m-m*	1.17 (0)	-8.73 (0) [a]	-1.10 (0)	-9.62 (0)[a]	1.35 (0)	-3.91 (0)[a]	-0.98 (1)	-4.33 (0)[a]
y-y*	0.28 (2)	-7.64 (1) [a]	-3.02 (0)	-7.91 (1)[a]	-0.26 (0)	-3.11 (2)[a]	-2.16 (2)	-3.44 (5)[b]
r-r*	-1.67 (0)	-4.06 (2) [a]	-3.04 (0)	-4.36 (2)[a]	-1.93 (2)	-3.13 (0)[a]	-3.01 (3)	-3.39 (0)[b]
π-π*	-1.41 (1)	-6.31 (0) [a]	-2.60 (1)	-6.37 (0)[a]	-1.77 (4)	-3.38 (0)[a]	-2.86 (1)	-3.41 (0)[b]

Notes: Figures are the t-statistics for testing the null hypothesis that the series is nonstationary. a and b denotes significance at 1% and 5% levels. For pre-crisis results, the critical values for rejection at 1% and 5% for series included constant and trend are –3.72 and -3.15 while the critical values for rejection at 1% and 5% for series included constant and without trend are -2.60 and -1.94. For post-crisis results, the critical values for rejection at 1% and 5% for series included constant and trend are –3.77 and -3.19 while the critical values for rejection at 1% and 5% for series included constant and without trend are -2.63 and -1.95. Figures in parenthesis are lag length. e ,m, m*, y and y* series are log transformed.

Table A2: Johansen-Juselius likelihood cointegration tests for Malaysia

Null Hypotheses	Eigenvalue	Trace	Critical Value (1%)	Max-Eigen	Critical Value (1%)
Pre-crisis (1980Q1-1995Q1)					
(r = 0)	0.610479	102.0625[a]	76.07	57.51302[a]	38.77
(r ≤ 1)	0.324670	44.54945	54.46	23.94579	32.24
(r ≤ 2)	0.181162	20.60366	35.65	12.19205	25.52
(r ≤ 3)	0.124548	8.411612	20.04	8.113943	18.63
(r ≤ 4)	0.004868	0.297670	6.65	0.297670	6.65
Post-crisis (1997Q1-2006Q1)					
(r = 0)	0.846558	143.1778[a]	76.07	65.60511[a]	38.77
(r ≤ 1)	0.641906	77.57266[a]	54.46	35.94356[a]	32.24
(r ≤ 2)	0.47182	41.6291[a]	35.65	22.34113[a]	25.52
(r ≤ 3)	0.385568	19.28798	20.04	17.04698	18.63
(r ≤ 4)	0.062022	2.240995	6.65	2.240995	6.65

Notes: r indicates the number of cointegrating vectors. Trace and Max-Eigen denote the trace statistic and maximum eigenvalue statistic. The critical values are obtained from Osterwald-Lenum (1992). a denote rejection of the hypothesis at 1% critical value.

Table A3: Estimated Long-Run Parameters of the Monetary Models for Malaysia

	Model/ Technique	Sample	Coefficient (Expected Sign SPMM/FPMM)				
			e (-1)	m-m* (+)	y-y* (-)	r-r* (-/+)	π-π* (+/0)
This study	SPMM/ VECM	1980Q1-1995Q1 (**Pre-crisis**)	-1	-0.02	0.27[b]	-0.04	-0.05[a]
		1997Q3-2006Q1 (**Post-crisis**)	-1	0.04[a]	-0.04[a]	-0.09	0.002
	FPMM/ VECM	1997Q3-2006Q1 (**Post-crisis**)	-1	0.11[a]	-0.11[a]	0.04	-
Chua and Bauer (1995)	SPMM/ Regression	1976-1993	-1	-0.01	0.67	-1.50[a]	-1.08[c]

Notes: Coefficient is the β coefficient from monetary cointegrating vector normalized on the exchange rate. a, b and c denotes significance at 1%, 5% and 10% levels, respectively. SPMM (FPMM) is sticky-price (flexible-price) monetary model. Coefficients in shade indicate they are correctly signed.

Table A4: Vector Error Correction Model Results for Malaysia

Variables	Expected Sign	Coefficient		
		Pre-crisis (1980Q1-1995Q1)	Post-crisis (1997Q3-2006Q1)	
	SPMM/FPMM	SPMM	SPMM	FPMM
ECT	-	-0.10[a]	-0.58 [a]	-0.57[a]
e_{t-1}	-	-0.34[a]	0.15 [a]	0.13[a]
$(m-m^*)_{t-2}$	+		0.05	0.04
$(m-m^*)_{t-3}$	+	0.18[a]		
$(y-y^*)_{t-2}$	-		0.15[a]	0.21[a]
$(y-y^*)_{t-3}$	-	0.01		
$(r-r^*)_{t-1}$	-/+	0.18[c]		
$(r-r^*)_{t-2}$	-/+		0.42[a]	0.49[a]
$(\pi-\pi^*)_{t-1}$	+/0		-0.003	
$(\pi-\pi^*)_{t-3}$	+/0	0.01[a]		
c		-0.0001	0.01[a]	0.01[a]
D1		0.05[a]		
D2			0.05[a]	0.05[a]
Diagnostic Tests				
R^2		0.786	0.986	0.980
Adjusted R^2		0.758	0.981	0.976
SER		0.017	0.007	0.008
F-statistic		27.83 [a]	262.530[a]	227.820[a]
JB		0.760	2.931	0.716
LM		2.020	0.249	0.283
RESET		1.931	2.397	2.673
ARCH		3.541	0.254	1.200

Notes: SE is the standard error. SER is the standard error of regression. JB is Jarque-Bera statistic for normality. LM is the Breusch-Godfrey Lagrange multiplier test for serial correlation up to 4 lags for pre-crisis and 3 lags for post-crisis, RESET is Ramsey RESET test for functional misspecification and ARCH is ARCH's test for heteroskedasticity. The F-statistics reported for LM, RESET and ARCH are under the relevant null hypothesis that absence of serial correlation, functional misspecification and heteroskedasticity. a and b denotes significance at 1% and 5% level, respectively. Model for pre-crisis includes 4 lags on each variable and a D1 dummy variable introduced to correct for normality (D1 = 1 in 1985:1, 1986:2, 1991:2, 1993:1, 1994:1; D1 = -1 in 1980:2, 1986:4, 1992:1, 1992:2, 1992:4 and zero in all other quarters). Model for post-crisis includes 3 lags on each variables and a D2 dummy variable introduced to correct for normality (D2 = 1 in 1997:4, 1998:2; D2 = -1 in 1997:3, 1998:1, 2006:1 and zero in all other quarters). Trend and seasonal dummies are not included in this test since they had been dropped in the parsimonious model although they had been considered in the preliminary analyses.