Exchange Rates in Singapore and Malaysia: Are They Driven by the Same Fundamentals?*

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Abstract: This study examines the empirical link between exchange rates and fundamentals using the monetary model of the exchange rate for the Malaysian ringgit and the Singapore dollar against two key bilateral rates—the US dollar and the Japanese yen. We formally tested for the long-run monetary model of exchange rate determination and found several interesting results. First, a unique cointegrating relationship was identified, based on theory and data, which means that monetary variables and the exchange rate are connected. Second, we found that it is the exchange rate that adjusts to the long-run equilibrium after a shock and not the other way round. Finally, it is shown that the fundamentals-based model produced out-of-sample forecasts that can outperform a random walk model both in the medium and long terms.

Keywords: Exchange rates, fundamentals, out-of-sample forecasts
JEL classification: F31, F41

1. Introduction

Despite its theoretical appeal, the empirical validity of the monetary model of the exchange rate is not without controversy (see Meese and Rogoff 1983).[1] Empirical studies in the 1990s (e.g., MacDonald and Taylor 1993; McNown and Wallace 1994; Moosa 1994) that make use of sophisticated econometric methods to deal with the issue of non stationary

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[1] In their seminal paper, Meese and Rogoff (1983) found that a naïve random walk model (without drift) outperforms an array of structural models, including those based on monetary fundamentals in predicting US dollar exchange rates at horizons of up to 12 months during the late 1970s and early 1980s.

data found that the monetary model is a valid framework to analyse movements in major currencies. For instance, an influential paper by MacDonald and Taylor (1993) found evidence that the model not only produces sensible long-run relationships, but also outperforms a random walk in an out-of-sample forecasting exercise. Others papers that have documented the usefulness of fundamentals include Rapach and Wohar (2002), Kilian and Taylor (2001) and Mark (1995).

From the perspective of the East Asian countries, two recent papers by Chinn (2000 a; b) and Husted and MacDonald (1999) stand out. Both papers have demonstrated that the fundamentals-based exchange rate model explains the movement of exchange rates in the region, including those under current investigation. They used different estimation methods based on the Japanese yen to reach their conclusion. Chinn (2000 a) relied on pure time-series method with the dollar-based rates while Husted and MacDonald (1999) employed a panel framework with the yen-based rates to model the exchange rates of the regional currencies. The efforts from these latter studies rekindle the hope that a simple set of monetary fundamentals - relative money supplies, interest rate differential and relative output - are appropriate for modeling exchange rate processes in East Asia.[2]

A growing body of empirical literature using post-1973 data concludes that purchasing power parity (PPP), which is the basic building block of the monetary model, holds over the recent float. Authors such as Lee (1999), Bahmani-Oskooee (1993), and more recently Wu *et al.* (2004) and Baharumshah and Masih (2005) found PPP to be a valid long-run relationship for the East Asian countries (including Malaysia and Singapore). These favourable findings have motivated us to re-examine the relevance of monetary fundamental-based models in Malaysia and Singapore. However, most previous studies using the monetary model to analyse Asian currencies have ignored the forecasting performance of the model; particularly, the out-of-sample forecasts (see, in particular, Frankel and Rose 1995).[3] To a large extent, this is due to the fact that evaluating the out-of-sample forecast can be a challenging exercise. In this paper, we take up this challenge by extending the forecasting horizon to include the period during the 1997 Asian financial crisis.

In this paper, we are concerned with the role of monetary fundamentals in affecting the exchange rate of the ASEAN countries. We studied the Malaysian ringgit (MYR) and the Singapore Dollar (SGD) *vis-à-vis* two major currencies—the US dollar (USD) and the Japanese yen (JPY). The cases of MYR and SGD merit special attention because they appear to be the most flexible currencies among the ASEAN currencies, particularly against the currencies that have smaller weights in the basket of currencies. The MYR was severely affected by the Asian financial crisis, and in September 1998, it was fixed to the US dollar at

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[2] In this paper the term *fundamental variables* refer to money, interest rate and income. Flood *et al.* (1991) also adopted the same term for these three variables.

[3] Frankel and Ross (1995) in a survey reached the conclusion that structural models have 'relatively little explanatory power' and thus contained little forecasting ability compared to very simple alternatives (p. 1705). This then led many to believe that exchange rate movements are disconnected from economic fundamentals. A more recent study by De Grauwe (2000) has found that there is overwhelming empirical evidence that exchange rates of the major currencies are generally unrelated to fundamentals identified by economic theory. He has thereby demonstrated that the decline of the euro against the US dollar during 1999-2000 was largely unrelated to observed news underlying fundamentals.

MYR 3.80/USD as a part of an economic recovery package. Later, in July 2005, Malaysia abandoned the dollar peg in favour of a managed float. This suggests that even a middle-income country like Malaysia cannot sustain a fixed peg for a long period.[4] Singapore with its large international reserves, on the other hand, was only slightly affected by the currency crisis and therefore pursued a managed float throughout the period. Unlike the MYR, the SGD was undervalued and as such suffered a modest decline in value during the recent currency crisis (Chinn 2000a). Both the MYR and SGD have now returned to an orderly behaviour nine years after the landmark event. It is worth mentioning that these two nations have also growth experiences that are sufficiently different from each other in terms of timing, resource dependence and industrial structure although they may have shared the common "growth miracle" (see Chow and Kim 2003).

Having said that, we have two major objectives in this paper. The first is to determine whether a long-run relationship exists between exchange rates and their fundamental determinants for two of the ASEAN countries, namely, Singapore and Malaysia. Our focus is more on predictability over a longer horizon since the bulk of the evidence has shown that exchange rates are essentially unpredictable over a short horizon (1 year or less).[5] The second objective is to evaluate the forecasting ability of the model. The purpose of this article is not to produce the best model, but rather to show that our model yields good predictive power for the in-sample as well as the out-of-sample forecasts. The theoretical basis of our investigation is the standard monetary model and we relied on an estimation procedure outlined in a recent paper by Rapach and Wohar (2002) to provide the long-run estimates of the structural component of our model.[6] To demonstrate the robustness of our model, we extended the out-of-sample forecasts to include the post-crisis period that ended in 2004:Q2 before calculating the equilibrium exchange rates.

The remainder of the paper is organised into four sections. In Section 2, we briefly describe the theoretical model, empirical methodology and the data used in the analysis. Section 3 presents the empirical results from the simple monetary model. Using the cointegration coefficients from the Johansen approach, Section 4 derives the equilibrium exchange rate and the degree of misalignment of the two ASEAN countries for the period before and after the financial crisis to see if we can find evidence to show that the currency crisis was due to an over-valuation of the currencies. The out-of-sample forecasting performance of the model is also presented in this section. Finally, some concluding remarks are contained in Section 5.

2. Methodology and Data

The monetary model of exchange rate determination relies on a stable money demand function for the domestic and foreign countries, continuous stock equilibrium in the money

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[4] Obstfeld and Rogoff (1995) pointed out that only a small number of countries survive for several years.

[5] Readers may refer to the articles by Mark (1995) and Chinn and Meese (1995) on the issue. For example, Mark (1995) found that the monetary model produces lower RMSE than the random walk at the 3- and 4-year horizons.

[6] Rapach and Wohar (2002) provided convincing evidence for half of the 14 industrialised countries considered in the analysis using the US dollar as the reference currency. Hence, a thorough analysis limited to ASEAN countries could offer new insights into the behaviour of the exchange rate.

market, purchasing power parity (PPP) and uncovered interest parity (UIP).[7] Equilibrium in the domestic and foreign money markets is given by

$$m_t - p_t = \alpha_1 i_t + \alpha_2 y_t , \tag{1}$$

$$m_t^* - p_t^* = \alpha_1 i_t^* + \alpha_2 y_t^* , \tag{2}$$

where m_t, y_t, i_t and p_t denote money supply, real income, interest rate and price level at time t, respectively.[8] Asterisks are used to denote foreign-country variables (in our case, the US and Japan). The money demand parameters, α_1<0 and α_2>0, are assumed to be identical in the domestic and foreign countries. The price level and exchange rate are linked through purchasing power parity (PPP), which is given by

$$er_t = p_t - p_t^* , \tag{3}$$

where er_t is the nominal exchange rate while the condition for uncovered interest parity (UIP) is specified by

$$i_t - i_t^* = E(\Delta er_{t+1} \mid I_t) , \tag{4}$$

where the term $E(\cdot|I_t)$ denotes the expectations operator conditional on information available at time period t. Based on this assumption, if er_t is an $I(0)$ or $I(1)$ process, then $\Delta er_{t+1} = 0$ in the steady state, which would imply that $i_t = i_t^*$. Using this assumption, the model reduces to[9]

$$er_t = (m_t - m_t^*) - \alpha_2 (y_t - y_t^*) \tag{5}$$

The model establishes a long-run relationship between the nominal exchange rate and a simple set of monetary fundamentals—money and income differentials. Mark (1995), Mark and Sul (2001) and Rapach and Wohar (2002; 2004) impose an additional restriction on Eq. (5), that is, $\alpha_2 = 1$, so that the simple version of the model becomes

$$er_t = (m_t - m_t^*) - (y_t - y_t^*) \tag{6}$$

In what follows, testing the long-run monetary model requires the existence of a stable long-run relationship among er_t, $m_t – m_t^*$ and $y_t – y_t^*$.

It is worth noting that if all the variables in Eq. 6 are $I(1)$, then the long-run monetary model requires these three variables to be cointegrated, so that in practice the following relationship is estimated to test[10]:

$$er_t = \beta_0 + \beta_1 (m_t - m_t^*) - \beta_2 (y_t - y_t^*) + \varepsilon_t \tag{7}$$

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[7] The monetary approach to exchange rate determination is built on perfect capital mobility and substitutability. For discussion on the degree of integration for goods, capital and foreign exchange, see Moosa and Bhatti (1997). Moosa and Bhatti (1997) and Faruquee (1992) provide evidence that strongly support the validity of long-run uncovered interest parity (UIP) in Singapore and Malaysia. The extensive capital market integration has also been documented by Phylaktis (1999).

[8] This specification of money demand assumes that domestic money depends on domestic variables. Note that several authors have argued that if the demand for money is stable than the demand for the currencies is also necessarily stable.

[9] As in Mark and Sul (2001), we used only the core set of monetary fundamentals to see how far the model can explain the exchange rate movements. We left out the other factors for further work.

[10] We also evaluated the model with their theoretical value. All in all, it showed that the version with the estimated coefficient yielded better forecast at a longer horizon based on the lowest RMSE.

where the β's in Eq (7) are parameters to be estimated and ε_t is the usual residual term assumed to be normally distributed with zero mean and constant variance.[11] Therefore, the first step is to determine the integrating properties of all the variables that appear in Eq (7). Next, we tested for cointegration among er_t, $m_t - m_t^*$ and $y_t - y_t^*$ using the popular Johansen (1988; 1991) cointegration approach.[12]

2.1 Error Correction Model

In this study, we also estimated the vector error-correction model (VECM) to investigate the causal relation between the core monetary fundamentals and exchange rate and to show how the long run equilibrium is restored, following a shock. The VECM may be presented as follows:

$$\Delta er_t = \gamma_0 + \sum_{i=1}^{p} \gamma_{1i} \Delta er_{t-i} + \sum_{i=1}^{p} \Delta f_{t-i} + \lambda_{\Delta er,z} z_{t-1} + \varepsilon_{1t} \tag{8}$$

$$\Delta f_t = \gamma_0 + \sum_{i=1}^{p} \gamma_{1i} \Delta er_{t-i} + \sum_{i=1}^{p} \Delta f_{t-i} + \lambda_{\Delta f,z} z_{t-1} + \varepsilon_{2t} \tag{9}$$

where $f_t = (m_t - m_t^*) - (y_t - y_t^*)$ and $z_t = er_t - f_t$. Both the error correction coefficients, $\lambda_{\Delta er, z}$ and $\lambda_{\Delta f, z}$ direct the adjustment to the long-run equilibrium. Monetary fundamentals are said to be weakly exogenous if only the error correction coefficient in the exchange rate equation, that is, $\lambda_{\Delta er, z}$ is significant. This would then imply that the exchange rate adjusts to restore long run equilibrium over the sample. Similarly, the exchange rate is said to be weakly exogenous if only the error correction coefficient in the monetary fundamentals, $\lambda_{\Delta f, z}$ is statistically significant. However, if both coefficients appear to be significant and correctly signed, then both the exchange rate and monetary fundamentals adjust to restore long run equilibrium[13] – the so-called feedback relationship.

The above model was applied, respectively, to the Malaysian ringgit/US dollar (MYR/USD), Malaysian ringgit/yen (MYR/JPY) and Singapore dollar/US dollar (SGD/USD) and Singapore dollar/yen (SGD/JPY) bilateral rates. Quarterly data frequency covering the period from 1971: Q1 to 2004: Q2 (Malaysia) and 1973: Q3 to 2004: Q2 (Singapore) were utilised in this study. Needless to say, our sample period is one in which major shifts in the currencies occurred and it includes the period of recession of the mid-1980, when the currencies took a sharp fall against those of the major trading partners, namely, the US dollar and the yen. Another landmark event is the 1997 Asian financial crisis when the Thai baht fell dramatically, triggering a wave of exchange rate collapses in the region.

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[11] Our purpose here is to show that monetary fundamentals contain useful information in forecasting the future currency prices for the two countries under investigation. Like the other researchers on the host subject, we do not intend to obtain the most reasonable estimates of the model parameters in Eq. (7).

[12] This section draws heavily on a recent article by Rapach and Wohar (2002). Interested readers may refer to Rapach and Wohar (2002) for more detailed discussion.

[13] Rapach and Wohar (2002) used this strategy to estimate the vector error correction model (VECM) for monetary model for a collection of 14 industrialised countries and report on the adjustment process to long run equilibrium.

The exchange rate is the nominal bilateral rate, and narrow money plus quasi money was used as a proxy for broad money. The yen/local currency units were calculated from the US/yen rate. Income was proxied by industrial production and interest rate was the 3-month treasury bills rate. All the data, which were not seasonally adjusted, were extracted from the International Monetary Fund's *International Financial Statistics Online* and measured in log-levels, except for the interest rate.

3. Empirical Results

3.1 Unit Root Test

To accomplish the objectives of this study, we drew on time-series econometric methods. For the univariate stationarity testing procedures, we relied on Ng and Perron (2001, NP) and Kwiatkowski *et al.* (1992, KPSS). Further, we utilised the multivariate maximum likelihood cointegration tests of Johansen (1988; 1991) to determine the number of cointegration vectors in the US dollar-based and Japanese yen-based systems. Results of the unit root tests results are displayed in Table 1. For money and income, the results clearly indicate a failure to reject the unit root null hypothesis of the NP test, but a rejection of the null in the case of the KPSS test.[14] In fact, this is true for both Malaysia and Singapore. Meanwhile, expressing the exchange rate series in first-difference form appeared to induce stationarity. These results confirm the earlier finding that these variables appear to be generated by processes with a single unit root.

As for the interest rate differential, we observed that the NP tests strongly rejected the non stationary null while the KPSS tests failed to reject the stationary null for the US- based system. This suggests that the local-US interest rate differential is an $I(0)$ process. For the local-Japanese interest differential, the results were mixed in that the standard NP unit roots rejected the null hypothesis that the series contain unit roots but the evidence from the KPSS yielded somewhat mixed results. We note that it is not uncommon to find that the interest rate differential follows a stationary process. This result allowed us to exclude interest rates in Eq. (7), Eq. (8) and Eq. (9) (see Rapach and Wohar 2002 and the articles therein).

3.2 Cointegration Test

Since the series of nominal exchange rate (er_t), money differential ($m_t – m_t^*$) and income differential ($y_t – y_t^*$) were shown to be of the same order of integration (i.e., $I(1)$), the long- run monetary model required these variables to be cointegrated. If there is no combination of the three variables, er_t, $m_t – m_t^*$ and $y_t – y_t^*$ is $I(0)$, then the error from any forecast will become arbitrarily large as time goes on to emerge bigger than the benchmark error. In this study, the popular Johansen multivariate cointegration approach was applied to test for the null

[14] Rapach and Wohar (2002) rejected the monetary model for Denmark, Norway and Sweden based on unit root tests. They argued that if one of the variables (er_t, $m_t – m_t^*$ and $y_t – y_t^*$) is *I(1)* while the other two are *I(0)*, then no linear combination can be *I(0)* or stationary and as such the monetary model can be rejected.

Table 1. Unit root test

Variable/Country	Ng-Perron				Kwiatkowski-Phillips-Schmidt-Shin			
	MS		SP		MS		SP	
	No trend	Trend	No trend	Trend	No trend	Trend	No trend	Trend
A: US Dollar-based system								
er	-1.02804	-1.29945	-0.44828	-2.00778	0.8767**	0.2501**	1.0534**	0.1496**
m-m*	0.34970	-2.58096	0.81646	-2.54615	1.3745**	0.3926**	1.2932**	0.1271**
y-y*	1.34146	-2.21766	1.55686	-2.23777	1.4303**	0.1844**	1.3079**	0.1482**
ir-ir*	-3.55176*	-4.31791*	-3.78537*	-10.4411*	0.3761	0.0612	0.5158	0.0451
Δer	-6.10123*	-5.77956*	-2.89912*	-4.46761*	0.3396	0.0485	0.1551	0.1217**
Δm-m*	-2.05905**	-3.93147*	-2.75376*	-3.42380*	0.1449	0.1029	0.1251	0.1155
Δy-y*	-3.70476*	-29.1792*	-16.5479*	-6.83532*	0.0527	0.0313	0.0918	0.0548
Δir-ir*	-2.19894**	-4.07008*	-9.00177*	-4.63559*	0.0931	0.0370	0.05963	0.0508
B: Japanese Yen-based system								
er	0.94879	-2.42845	-0.57332	-2.05277	1.3761**	0.1276**	1.0534**	0.1496**
m-m*	0.73338	-2.27313	1.40063	-1.83446	1.3541**	0.1919**	1.2932**	0.1271**
y-y*	1.45165	-2.49504	1.51339	-1.85204	1.4249**	0.2242**	1.3079**	0.1482**
ir-ir*	4.97915*	3.19417**	-2.62888*	-3.92760*	0.3434	0.1223***	0.3397	0.0451
Δer	-4.55254*	-7.62414*	-4.79405*	-6.74346*	0.0615	0.0492	0.1551	0.1217**
Δm-m*	-3.80588*	-3.04811**	-2.67369*	-3.50831*	0.1812	0.0864	0.1251	0.1155
Δy-y*	-8.95074*	-8.83626*	-3.56238*	-3.72203*	0.0447	0.0245	0.0918	0.0548
Δir-ir*	-6.98227*	-34.0006*	-4.27811*	-5.21549*	0.3852	0.1619**	0.0596	0.0508

Notes: The letters er, m-m*, y-y* and ir-ir* denote the exchange rate, money, income and interest rate differentials, respectively. The Δ indicates first-difference operator. The asterisks *, ** and *** denote statistical significance at 1%, 5% and 10% level, respectively. Critical values are based on Ng and Perron (2001) and Kwiatkowski, Phillips, Schmidt and Shin (1992).

hypothesis of no cointegrating vector.[15] Briefly, the Johansen procedure provides two log-likelihood ratio (LR) tests for determining the number of cointegrating vectors. The trace statistic was used for testing the null hypothesis of at most *r* cointegrating vector against the alternative of *m* cointegrating vectors. The maximum eigenvalue (λ-*max*) was used in testing the null of *r*-1 against *r* cointegrating vectors. If a non zero vector(s) was identified by these tests, (a) stationary long-run relationship(s) between the relevant variable was implied. Detailed accounts of the test are found in Johansen (1988) and Johansen and Juselius (1990). The two statistics mentioned above may be compared to the critical value provided by Johansen and Juselius (1990) and Osterwald-Lenum (1992).

We note at this juncture that Boswijk and Franses (1992) and Reimers (1992) have argued that the maximum lag length used in the specification of the vector autoregression (VAR) model can affect the determination of the number of cointegrating vectors. Specifically, they point out that insufficient lags could lead to rejection of the null hypothesis of no cointegration too often, whereas over-parameterisation of the dynamic structure would lead to loss of power. To overcome this problem, the optimum lag length for the unrestricted VAR (UVAR) was determined using the Akaike Information Criteria (AIC). Apart from that, we also relied on the LM test for autocorrelation to determine the appropriate lag length.

The results of the Johansen test for the US dollar- and yen-based equations (MYR/USD, SGD/USD, MYR/JPY and SGD/JPY) are reported in Table 2. To account for the possibility of a structural break in the long-run relationship, we have added a dummy variable (one for 1997: Q3 – 1998: Q3 and zero elsewhere) as an exogenous variable to account for the Asian financial crisis period in all the models. For the SGD/USD rate, an additional dummy (one before 1979: Q3 and zero elsewhere) was added to the system. Importantly, we found a significant improvement in the stochastic properties of the VAR model by adding the dummy variables and these dummy variables were included in the subsequent analysis. Both the λ-max and trace statistics led to the rejection of the null hypothesis that there are zero cointegrating vectors for the two-ringgit bilateral and two-Singapore dollar bilateral rates. This result implies that for all the four bilateral rates, evidence of at least one cointegration vector emerged from the data, that is, among the three variables, there is evidence of a common stochastic trend.

Gonzalo (1994), for example, suggested that when the number of variables combined with the lag specification is 'large' relative to the size of the data set, there can be substantial small-sample bias toward finding cointegration. In a related article, Reinsel and Ahn (1992) suggested a finite-sample scaling factor adjustment of $T(T\text{-}pk)$, where T is the sample size, p is the number of variables, and k is the lag length of the estimated VAR system, to the asymptotic critical values of the Johansen test statistics in order to obtain their finite-sample counterparts. We found that the results from the adjustment statistics did not affect our conclusion regarding the number of vectors in the systems.

Normalising the cointegration vector on exchange rates facilitated the interpretation of the results of the monetary model given by Equation 7. For Malaysia, the sign and size of

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[15] The procedure provides more robust results when there are more than two variables (Gonzalo 1994) and when the number of observations is greater than 100 observations (Hargreaves 1994). In addition, it is shown to be robust compared to other methods even when the errors are non normal (Gonzalo 1994).

Table 2. Cointegration test results

Model	Test H_0	H_A	λ-trace	Critical value	λ-max	Critical value
			A: US Dollar-based system			
MYR/USD						
I	p = 0	p=1	72.54[c]	21.45	64.74	15.57
	p ≤ 1	p=2	7.80	10.25	7.17	9.28
	p ≤ 2	p=3	0.06	3.04	0.06	3.04
II	p = 0	p=1	63.56[a]	15.4	62.81[a]	14.10
	P ≤ 1	p=2	0.75	0.65	0.75	3.80
SGD/USD						
	p = 0	p=1	45.77[a]	29.70	32.38[a]	21.00
	p ≤ 1	p=2	13.39	15.40	11.60	14.10
	p ≤ 2	p=3	1.79	3.80	1.79	3.80
			B: Japanese Yen-based system			
MYR/JPY						
	p = 0	p=1	38.79[c]	31.93	21.63[c]	19.86
	p ≤ 1	p=2	17.17	17.88	11.29	13.81
	p ≤ 2	p=3	5.88	7.53	5.88	7.53
SGD/JPY						
	p = 0	p=1	32.50[c]	21.46	24.85[c]	15.57
	p ≤ 1	p=2	7.65	10.25	7.04	9.28
	p ≤ 2	p=3	0.06	3.04	0.06	3.04

Notes: The superscripts ([a], [b] and [c]) denote statistical significance at 1%, 5% and 10% levels, respectively. The letter 'p' indicates number of cointegrating vectors. The λ-max and λ-trace are Johansen maximum eigenvalue and trace eigenvalue statistics for testing cointegration. Critical values (C.V.) are from Obsterwald-Lenum (1992). Johansen (1991) shows that the LR ration test for linear restriction or the cointegration vector is asymptotically distributed χ^2 where the degree of freedom is equal to number of restrictions. A dummy variable (one for 1997: Q3 – 1998: Q3 and zero elsewhere) was added as an exogenous variable to account for the Asian financial crisis period in all the models. For SGD/USD, an additional dummy (one before 1979: Q3 and zero elsewhere) was added to the system. This was to account for the overvaluation of the Singapore dollar and Singapore's deterioration in competitiveness during the period (see Chinn 2000a; Moreno 1988:192).

money supply and income variables in the MYR/USD equation are not consistently the same as suggested by theory. As such, we dropped the income variable and the results in Table 3 show that the coefficient on money supply is positive.[16] For Singapore, the sign and size of the coefficients of both the income and money supply variables are much closer to that predicted by theory.

For the yen-based system, however, all of the variables carry the correct sign and are statistically significant at usual significance levels. The domestic-foreign income differential

[16] Additionally, we found that the forecasting performance of the MYR/USD model with income variable fits the data poorly.

Table 3. Estimated cointegrated vectors in Johansen Estimation

Model/Variable	er	m-m*	y-y*	Constant
		A: US Dollar-based system		
MYR/USD	-1.0000	-0.4736 (0.0380)	0.6265 (0.1059)	-
	-1.0000	0.2033 (0.0707)	-	-
SGD/USD	-1.0000	1.0576 (0.3787)	-1.9295 (0.5339)	-
		B: Japanese Yen-based system		
MYR/JPY	-1.0000	0.3474 (0.1808)	-1.2110 (0.2041)	2.6687 (0.5969)
SGD/JPY	-1.0000	0.5377 (0.0136)	-0.2743 (0.1028)	-

Notes: The letters er, m-m* and y-y* denote the exchange rate, money and income differentials, respectively. All the coefficients on the estimated cointegrating vector(s) are normalised on exchange rate based on the cointegration test. Figures in parentheses are standard errors.

is -1.211 and -0.274 for Malaysia and Singapore, respectively. This result compares favourably with -0.546 for Indonesia to -3.008 for Thailand as reported by Chinn (2000a) on the East Asian countries using data from the early 1980s to 1996. The domestic-foreign money stock coefficient has the expected positive sign in both the models but the size of the coefficient is found to be less than unity, as predicted by theory.[17]

To sum up the cointegration analysis, there is strong evidence of a long-run relationship, in the cointegration sense, between exchange rate and monetary fundamentals. Two papers by Rapach and Wohar (2002) and Mark and Sul (2001) also found that the nominal exchange rates and the fundamental variables are cointegrated. Specifically, Rapach and Wohar (2002) rejected the null hypothesis of no cointegration in 6 out of 12 countries, namely France, Italy, Spain, the Netherland, Belgium and Portugal. Mark (1995), however, found evidence to the contrary for the same set of currencies.

In all cases, we observed that all the coefficients were correctly signed except in the MYR/USD case, where the coefficients of both the relative income differential and money carried the wrong signs. However, this ‘sign failure’ is not uncommon in this type of study as it is now well-known that in the context of standard cointegration analysis, the estimators do not necessarily generate coefficients which are uncontaminated by serial correlation and endogeneity. In what follows, we dropped the income variable and re-estimated the model to evaluate its forecasting ability.

3.3 Error Correction Model

The dynamics of the relationship between the exchange rate and the fundamentals were investigated using a vector error correction model (VECM). The ordinary least square

[17] Our results are in sharp contrast with Chinn (2000a) who found the coefficient not to be significantly different from implied theory for most of the Asian countries. The results are different due to a different sample period, choice of variables and estimation technique.

Table 4. Error-correction coefficient estimates

Model	Coefficient	*p*-value
A: US Dollar-based system		
MYR/USD		
Exchange rate equation, $\lambda_{\Delta er, z}$	-0.0155 (0.0066)	0.0201**
Fundamental equation, $\lambda_{\Delta f, z}$	0.0026 (0.0042)	0.5408
SGD/USD		
Exchange rate equation, $\lambda_{\Delta er, z}$	-0.0204 (0.0092)	0.0284**
Fundamental equation, $\lambda_{\Delta f, z}$	0.0101 (0.0177)	0.5691
B: Japanese Yen-based system		
MYR/JPY		
Exchange rate equation, $\lambda_{\Delta er, z}$	-0.0285 (0.014)	0.0510***
Fundamental equation, $\lambda_{\Delta f, z}$	0.0243 (0.0236)	0.3043
SGD/JPY		
Exchange rate equation, $\lambda_{\Delta er, z}$	-0.0541 (0.0204)	0.0093*
Fundamental equation, $\lambda_{\Delta f, z}$	0.0224 (0.0300)	0.4558

Notes: The asterisks (*, ** and ***) denote statistical significance at 1%, 5% and 10% level, respectively. Figures in parentheses are standard errors.

(OLS) estimates of the error correction coefficients, $\lambda_{\Delta er, z}$ as well as $\lambda_{\Delta f, z}$ are reported in Table 4. The first column in the table reports the coefficient estimates of the error correction term from the nominal exchange rate and the fundamental equations. We found the monetary fundamentals to appear weakly exogenous for all the cases since the error correction term from the exchange rate equation appears significant with the correct negative sign (Engle *et al.* 1983). Additionally, the results reveal that the error correction term for the fundamental equation is insignificant at conventional significant levels. The significance of this finding is that we were able to establish sufficient evidence to indicate that the error correction term predicts future exchange rates and that there is no evidence to suggest that the error correction model predicts future fundamentals for both the MYR and SGD bilateral rates.

To summarise, first, cointegration between fundamental variables and the exchange rate is confirmed by the significance of the lagged error correction term; see Kremers *et al.* (1992) on this issue. Thus, the link between monetary fundamentals and nominal exchange rate appears to be robust. Second, the findings lead us to conclude that the exchange rate adjusts to restore the long run equilibrium for all four systems. In comparing the out-of-sample forecasting performance of the monetary model, Berkowitz and Giorgianni (2001) have established a close connection between forecasting ability of the model with the weak exogeniety test results. They recommend testing for cointegration and weak exogeneity before proceeding to forecasting as the performance will depend on the existence of cointegration and weak exogeneity.

4. Exchange Rate Misalignment and Forecasting Performance

Many observers have expressed the opinion that the East Asian currencies were overvalued before the currency crisis.[18] For the purpose of investigating this, we computed the deviation of the actual exchange rate from the exchange rate predicted by the estimated model for each of the four bilateral rates. As depicted in Figure 1, the MYR/USD rate appears to be substantially overvalued 5-6 years prior to the mid-1997 financial turmoil. We note that the monetary model failed to capture the sharp fall of the MYR/USD rate during the 1997-98 Asian financial crises, suggesting that the crisis could have been driven by bad fundamentals—a point also made by Chinn (1998). During the post-crisis period (1998-2004), we observed that the actual rates diverged considerably from the equilibrium rates (undervalued by 1 to 2%) due to the pegging of the Malaysia ringgit to the US dollar. Nevertheless, the gap between the actual and equilibrium value has somewhat narrowed in recent years, suggesting that the ringgit is reflecting its fundamental value.[19] Another period of particular interest is the third quarter of 2005 when Bank Negara Malaysia abandoned the dollar peg and returned to a managed float system. The prediction from the model yielded 3.70 MYR/USD, which was close to the average market rate of MYR 3.76/1 USD (i.e., undervalued by 10%) after returning to the managed float regime.

We also observed that the SGD had undergone a similar experience, albeit to a lesser extent (see Figure 2). In general, the estimated equilibrium values captured the trend of appreciation of the SGD/USD from 1974 to 1997; however, at the same time they were unable to capture the depreciation of the post-1997 period. The equilibrium rate, therefore, remained consistently below the actual rate, suggesting that the SGD was undervalued from 1997-2004. Again, there is no evidence to suggest that the fall of the SGD/USD rate was due to bad fundamentals since the SGD/JPY rate appeared to be misaligned for most part of the sample period prior to the currency crisis. Both the MYR/USD and SGD/USD rates, however, continued to strengthen during most of 2004-2005.

For the yen-based nominal rates, our model predicts that the MYR and SGD were overvalued beginning 1994. The currency crisis led to the actual MYR-yen rates to rise above the equilibrium rates (undervalued) before reversing the trend in 2001. In contrast, the SGD remained overvalued several years after the crisis, but like the MYR, the gap between the actual and the equilibrium values has considerably narrowed over the past decade (1995-2004). To sum up, both the ringgit and Singapore dollar have responded to major external disturbances like the Plaza Accord in 1985 and the Asian Financial crisis in 1997 (Figures 3 & 4).

Now, how well do monetary factors predict the MYR and the SGD? To answer this question, out-of-sample forecasts were generated at a short-horizon (k=1), an intermediate-horizon (k=4) and a long-horizon (k=12). We relied on the estimated coefficient from the

[18] For further discussion on this issue, see Chinn (2000a;b), Husted and MacDonald (1999) and Goldfajn and Baig (1998), among others.

[19] It turns out that our results confirm the findings of Breitung and Candelon (2005) that describe the Asian financial crisis as corresponding more to the second-generation type of crisis. The authors showed that the deviation from long PPP is temporary as the Asian countries (including Malaysia and Singapore) adopted a flexible exchange rate regime.

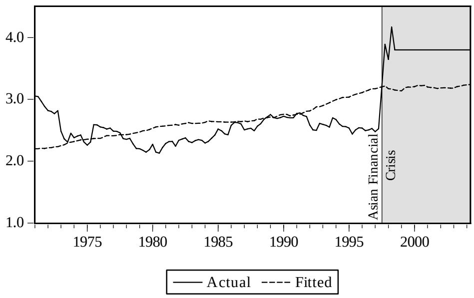

Figure 1: *Actual and fitted value of MYR/USD*

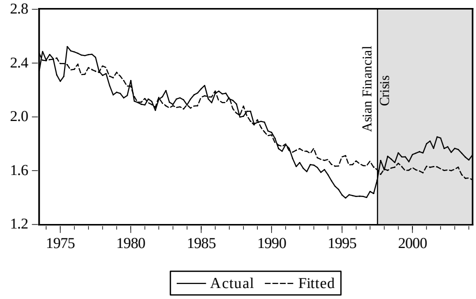

Figure 2: *Actual and fitted value of SGD/USD*

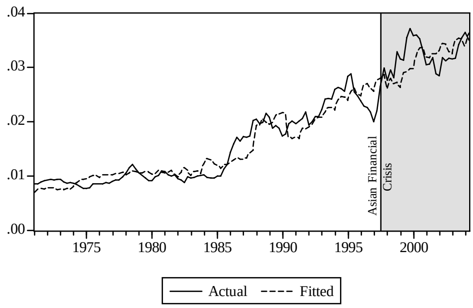

Figure 3: *Actual and fitted value of MYR/JPY*

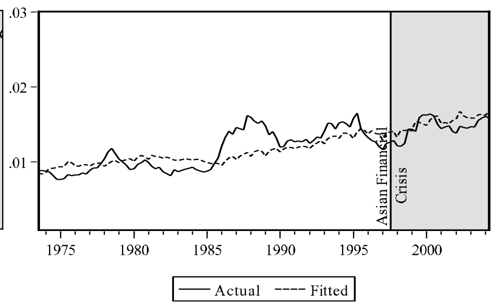

Figure 4: *Actual and fitted value SGD/JPY*

regression of exchange rate on relative money supplies and relative outputs, together with the future value of the fundamentals to form the forecast. We first estimated the model given by Eq. (7) using data that ended in 1995:Q4 and forecast the 1-, 4- and 12-quarter ahead values of the exchange rate in 1996:Q1, 1996:Q4 and 1998:Q4, respectively. We then updated the sample period by one period by adding the observation for 1996:Q1 and then repeating the procedure. By repeating the process recursively, we obtained the estimated values for the 1-, 4-, and 12-quarter horizon forecasts. Extending the data to include the post-crisis period that ended in 1998:Q4, through 2004:Q4, allowed us to examine the accuracy of our forecast following the global events in the late nineties and early 2000 (bank crisis in Japan, German-unification, oil price shocks in the post-Iraq War). This is a particularly interesting period since it also includes a speculative attack against the currencies under investigation in the 1997-1998 period.

As mentioned in the introduction, we compared the forecasts from the simple monetary model with those from the random walk model, the usual benchmark model used in a forecasting exercise.[20] Relative forecast accuracy was measured using Theil's *U*-statistic—the ratio of the root-mean-square prediction error (RMSE) for the two alternative models.[21]

Table 5 displays the Theil-*U* statistics for 1-, 4-, and 12-quarter horizon prediction result over the full 1996:Q1 through 2004:Q2, the forecasting period for a nominal exchange rate. Based on the results, we note that most of the ratio of the regression's prediction RMSE relative to the random walk appeared to be less than unity except for the 1-quarter (k=1) forecasting horizon. At the 4-quarter horizon, more than 80 per cent of the monetary fundamentals forecasts dominated the random walk for MYR/USD and SGD/JPY rates. For MYR/JPY and SGD/USD rates, the monetary model outperformed the random walk in 71 per cent and 55 per cent of the forecasts, respectively.

For the long term prediction (12-quarter), we found that the structural monetary model performed much better than the short- and medium-term forecasts. For instance, in the case of the MYR-USD rate, we found that the monetary model out-performed the random walk in only 32 per cent of the cases for the 1-quarter forecasts. For the 4-quarter (12-quarter) forecasts, the model outperformed the random walk model by more than 81 per cent (96%). These findings allow us to conclude that the structural model yields more accurate forecasts than the naïve random walk model for the medium and long-term forecasts. This result also implies that the monetary model is able to detect the nominal exchange rate movement in the case under study.[22] We note that, our results are consistent with that of MacDonald and Taylor (1993; 1994), among others.

5. Concluding Remarks

This study has examined the empirical link between the exchange rate and monetary fundamentals for two major ASEAN currencies, namely, the Singapore dollar and the Malaysia ringgit. The results presented in this paper are generally consistent with the empirical studies of exchange rates that cover the major industrialised countries as reported in Rapach and Wohar (2002).

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[20] The comparison constitutes an acid test for evaluating exchange rate models (see Mark and Sul 2001; Cerra and Saxena 2008, among others).

[21] The Theil's *U* statistic is based on standard symmetric loss function:

$$U = \frac{\sqrt{\sum_{i=i_0}^{i_0+T} (x_i - x_i^f)^2}}{\sqrt{\sum_{i=i_0}^{i_0+T} (x_i - x_{x_{i-1}})^2}}$$

where x_i is the actual value and x_i^f the forecast value. As defined earlier, the Theil's *U* statistic is the ratio of the root mean square error (RMSE) of forecasts from the structural monetary model to the RMSE of the naïve random walk prediction. Therefore, a value of Theil's *U* less than one indicates better performance of the monetary model compared to the random walk specification.

[22] The recent article by Baharumshah and Masih (2005) also showed that the monetary model of the exchange rate produced good forecasting results. Similarly, Mark and Sul (2001) applied the model to a quarterly panel of 19 countries (including Germany, Great Britain, Canada, France, Italy and Japan). They found that the forecast from the monetary model outperformed the predictions of the PPP and the random walk model as well. They argued that the monetary model worked because long-run nominal exchange rate is determined directly by monetary fundamentals and not by relative price. We note that these studies were based on different currencies and a different time period.

Table 5. Out-of-sample forecast evaluation

Horizon (k)/ Model	n-quarter ahead forecast																
	1996:1	1996:2	1996:3	1996:4	1997:1	1997:2	1997:3	1997:4	1998:1	1998:2	1998:3	1998:4	1999:1	1999:2	1999:3	1999:4	2000:1
MYR/USD																	
1	**4.8518**	0.6407	0.0130	0.7496	**1.3855**	0.9848	0.9285	0.7790	**1.1838**	**1.7356**	**2.5185**	**3.5723**	**3.4116**	0.7300	**5.8559**	**2.0918**	**3.7603**
4	0.9628	**1.4166**	**1.2479**	0.3036	0.5979	0.4604	0.4027	0.5568	**2.4216**	**1.3044**	**1.2482**	0.8462	0.6883	0.1910	**1.3356**	0.4291	0.8071
12	0.3414	0.3154	0.2908	0.1225	0.2643	0.2408	0.2350	0.2772	**1.9444**	0.5735	0.6276	0.2112	0.1712	0.0798	0.3364	0.1205	0.1988
SGD/USD																	
1	0.1357	0.8342	**1.9271**	**2.9029**	0.8118	**1.6551**	0.9776	0.9684	**1.4148**	**1.3339**	**4.6911**	**1.2943**	0.8572	**2.7089**	**9.3568**	**2.0356**	0.6607
4	0.4240	0.5763	0.5838	0.5762	0.4790	0.5811	0.4629	0.6105	**2.0806**	0.8886	**2.3106**	**1.3436**	**1.3883**	**1.6826**	**1.6158**	**1.1157**	0.2927
12	0.2506	0.2438	0.2344	0.2107	0.1945	0.2349	0.2149	0.3065	**1.0324**	0.4766	0.9181	0.6488	0.6601	**1.0373**	0.6441	0.5148	0.3489
MYR/JPY																	
1	**1.4041**	0.2748	0.0021	0.7680	0.7499	**1.2388**	0.7485	0.7466	**1.3045**	0.5264	**2.1764**	**1.1974**	0.4750	**1.0058**	**1.8428**	0.1924	**1.0493**
4	0.3860	0.4208	0.0316	**1.0641**	0.6552	0.4452	0.4192	**1.0744**	**1.3794**	**1.0661**	**1.9142**	0.7982	**1.2468**	0.9040	0.9266	0.7100	0.3649
12	0.7346	0.6733	0.0398	0.4333	0.3256	0.2369	0.2490	0.4593	**1.1384**	0.5524	0.8232	0.5313	0.4154	0.4891	0.6533	0.2342	0.1877
SGD/JPY																	
1	0.4053	0.0029	0.0034	0.8308	0.9836	0.8549	0.3875	**1.6654**	0.9284	0.3585	**1.3147**	**1.0190**	**10.0984**	**3.2691**	**1.2477**	0.5491	**11.2106**
4	0.3062	0.3225	0.0091	0.6455	0.5225	0.5772	**1.1609**	**1.1183**	**1.0681**	0.6279	0.5580	0.5814	0.8587	0.6236	0.5608	0.7505	0.8962
12	0.5392	0.7090	0.0203	0.2170	0.2062	0.3148	0.3580	0.3440	0.3704	0.2924	0.2870	0.3021	0.5892	0.5576	0.5710	0.4735	0.3454

Continued on next page

Table 5. Continued

Horizon (k) / Model	n-quarter ahead forecast																
	2000:2	2000:3	2000:4	2001:1	2001:2	2001:3	2001:4	2002:1	2002:2	2002:3	2002:4	2003:1	2003:2	2003:3	2003:4	2004:1	2004:2
MYR/USD																	
1	0.6179	**1.1898**	0.8429	**1.2106**	**3.3226**	**1.6291**	**1.5094**	**2.3820**	**1.3910**	**1.1702**	0.9337	**1.5606**	0.6852	**3.7323**	**1.9862**	**1.5083**	**1.3505**
4	0.1968	0.2606	0.2410	0.2500	0.6693	0.3531	0.3068	0.5230	0.4349	0.2883	0.3608	0.4451	0.3624	0.8147	-	-	-
12	0.0607	0.0743	0.0729	0.0668	0.1526	0.0840	-	-	-	-	-	-	-	-	-	-	-
SGD/USD																	
1	**3.9917**	**2.6842**	0.9333	**1.4141**	**2.0172**	0.4509	**1.2275**	**2.3637**	0.6513	0.8239	0.8357	**1.7633**	**3.3762**	0.3444	0.1010	0.7574	**1.8640**
4	0.8494	0.7316	0.9276	**1.0119**	**1.6519**	**1.6701**	**1.0362**	0.4418	0.4788	**2.3085**	**1.1673**	**1.1697**	0.2896	0.6381	-	-	-
12	0.5700	0.6575	0.8520	0.8786	0.9191	0.7103	-	-	-	-	-	-	-	-	-	-	-
MYR/JPY																	
1	0.6830	0.8847	**1.0601**	**3.0360**	**5.0084**	**3.6391**	**4.2640**	**3.7506**	0.0246	0.5096	**3.0974**	**3.3756**	**1.2557**	0.9317	0.0487	0.3288	0.7386
4	0.4197	0.3226	0.3923	0.7955	**1.2263**	**1.0320**	0.9908	**1.1053**	0.5145	0.5181	0.8010	0.8002	0.5890	0.4310	-	-	-
12	0.2208	0.2165	0.2810	0.2420	0.3200	0.2722	-	-	-	-	-	-	-	-	-	-	-
SGD/JPY																	
1	**1.3442**	0.8748	0.7340	0.0721	**1.3232**	**3.6391**	**4.2640**	**3.7506**	0.0246	0.5096	**3.0974**	**3.3756**	**1.2557**	0.9317	0.0795	0.3288	**1.2029**
4	0.5530	0.3732	0.3442	0.7778	**1.1750**	**1.0320**	0.9908	**1.1053**	0.5145	0.5181	0.8010	0.8002	0.5890	0.4310	-	-	-
12	0.3512	0.2911	0.3746	0.8013	0.5907	0.2722	-	-	-	-	-	-	-	-	-	-	-

Notes: Figures reported in the table are Theil's *U* ($RMSE_{Monetray\ Model}/RMSE_{Random\ Walk\ Model}$). Figures in bold (Theil's *U* ratio >1) indicate monetary model failed to outperform random walk model.

We found that exchange rates and monetary fundamentals are driven by a unique stochastic trend. All in all, first, the coefficients of money and income variables carry the expected sign for the US bilateral rates. This is taken as evidence in favour of the monetary model, meaning that a great deal of exchange rate variability is adequately reflected by monetary fundamentals—money and income. Second, test results indicate that fundamental variables Granger-cause the exchange rate and not the other way round. This means that if the exchange rate deviates from the fundamental variables, it is the exchange rate and not the monetary fundamental that adjusts to the long-run equilibrium value. From a statistical point of view, our results reveal that the simple monetary model has significant predictive power for future exchange rate movements in the MYR and the SGD based on the conventional criterion of root mean squared forecast errors.

Third, the monetary model failed to capture the sharp fall of the ringgit and the Singapore dollar during the 1997-98 Asian financial crisis, suggesting that the crisis could have been driven by bad fundamentals—a point also made by Chinn (1998). Finally, a striking feature of our results is that the weight of the evidence suggests that monetary fundamentals have significant predictive powers for future exchange rate movements (two or more quarters) for both the MYR and SGD bilateral rates. This finding is noteworthy, as most of the earlier studies have found that monetary fundamentals failed to track the salient features of the exchange rates movements. The results hold for the Singapore dollar as well as the ringgit, and our forecasting horizon includes the post-Asian financial crisis. Overall, our results from the cointegration and out-of-sample fit of the monetary model seem to suggest that there is scope for a monetary approach to explain the movements of the two ASEAN currencies during the sample period under investigation.

This study is not without limitations. Berben and Van Dijk (1998) show that asymptotically cointegration is a necessary condition for long horizon predictability to exist. Recent studies have shown that panel-based tests of cointegration have found stronger evidence in favour of monetary exchange rate models (see also Mark and Sul 2001). Hence, a productive direction for future research could perhaps be to consider panel cointegration methods with a larger set of countries. Also, other variables, such as the terms of trade and relative inflation, could be included in the modeling strategy to make the model more general.

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