INTERRELATEDNESS OF MALAYSIAN FOREIGN EXCHANGE MARKETS: COMPARING TWO DIFFERENCE REGIMES

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Abstract

This paper examines different aspect of Malaysian foreign exchange market, specifically relationships among difference currencies in two different regimes, i.e floating and pegging (fixed) regimes. Daily rates for five foreign exchange rates (Great Britain pound, Singapore dollar, Japan yen, China yuan, Germany Deutsche mark) for the period from 1990 to 2001 are used. The study finds that volatility of the currencies under investigation shows large different between these two periods. This is expected since the two subperiods are in difference regime and difference economic conditions. Our results also show there is significant relationship between currencies of countries for only three cases in subperiod one and one case in subperiod two. In both cases the relationship is between currencies situated in the same region, i.e. yen, yuan and dollar (Singapore). This suggests the dominance of the Japanese and surprise emergence of new economic power of China in distributing information to other part in the same region.

JEL classifications: G15; F30, F21
Keywords: Malaysian foreign currency market; Floating and pegging regimes; Common information factors.

1.1 **Introduction**

Foreign exchange market linkages between and among countries continue to be increasingly importance, particularly with the event surrounding the Asian financial and economics crises and recently, have been the subject of considerable empirically analyses to better understand the interactions. The attack on currencies value in some of the Asian countries believe to be the job of currency's speculator has destabilized not only the regions economic activities but also other countries around the world. The effects are so great particularly to the basic economic fundamentals of a country which could also jeopardize political stability as trade flows are greatly disrupted, production cost increase and the cost of imported goods and services sky rotting, giving rise to social unrest. This scenario will not only affect potential investors from coming into the country but also the governments of a country as they strive to sustain economic growth and political stability in trying to achive their domestic economic goals.

Against this backdrop, it is not surprising that the Prime Minister of Malaysian in combating this speculator, introducing the capital control in July 1997 in order to maintain economic stability and growth of the country. One of the important elements in this capital control is to peg the Malaysian ringgit (RM) against the US dollar at the rate of RM3.80, a decision, which is not quite well received by majority of foreign economist. Even some argue that this decision will affect Malaysian economic stability in a long run if it is use for a long period. In a recent statement by the Governor of Bank Negara Malaysia that Malaysian ringgit will continue to tight to US dollar although most of the major world currency are weaken due to the pressure from the Japanese yen. Her argument is that this downward pressure is only temporary and it will go back to normal in a near future. And as such the system will be not be changed unless there is fundamental structure changed in Asia region. Moreover the current measure implemented by the government is able to help local traders and investors. It is hoped as mentioned by the Prime Minister that the ringgit will not be traded indiscriminately to gain quick profit in the open market by the speculator.

Extensive research has focused on the foreign exchange market, either spot or futures market. Some of the studies have investigated the efficiency of foreign exchange market while others specifically look at their behaviour over time and also their relationship with others variables such as stock price.

This paper contributes to the present literature by exploring a largely unexploited data set that covers both floating and pegging regime exchange rate on a daily basis over the period January 1990 – December 2002. We focus on the Malaysian foreign exchange market to see whether there are systematic differences between these two periods, i.e the rapid economic growth period during the early nineties through mid nineties and the slumping period of the late nineties. Until now there are no such studies that focus on the fixed exchange rate. Much of the previous studies focus on modeling of floating exchange rate.

Studies on foreign exchange market in Malaysia context after the introduction of capital control are rare as many critics argue that since Malaysian ringgit is pegged to US dollar and all other currencies are pegged to US dollar with a fixed rates, then there is no variation in rates to make analysis possible and meaningful. However, we argue that eventhough other currencies are pegged to US dollar, the variation of rates during this periods are quite large, suggesting that there might exist some element of market force (demand and supply) in the Malaysian foreign exchange market.

The main objectives of this study are two fold: First, the study examined the behaviour i.e. the volatility of the exchange rate for currencies under investigation for the two sample period of floating exchange rate regime and pegging (fixed) exchange rate regime. Second, we investigate relationship between foreign currencies in the Malaysian foreign exchange market to uncover if there is cause effect relationship between them.

The remaining of this paper is organized as follows. The Section 1.2 we review selected literature. The data and methodology are explained in Section 1.3. Section 1.4 presents the empirical results and Section 1.5 contains our summary and conclusion.

1.2 Literature Review

Literature related to the behaviour of foreign exchange markets are voluminous [see for example, Kohlhagen (1978), Wasserfallen and Zimmermann (1985) and Hsieh (1988) and (1989)]. Many previous studies have focused on testing for the relationship between foreign exchange market and its efficiency. For example, testing for unit roots in exchange rates was pioneered by Meese and Singleton (1982). The authors argued that the test for unit roots is important because assuming that levels or differences of exchange rates are stationary can lead to substantially different conclusion. Testing for the presence of unit roots in the autoregressive representation of a time series amounts to testing whether certain coefficients are unity.

Cheng (1997) applies Hsiao's version of the Granger causality method with the aid of cointegration and error-correction modeling in reexamines the causality between dollar and pound for the period 1951-94. The Phillips-Perron test for unit roots and Johansen test of cointegration are performed. The study finds a bi-directional causality between the US-UK, relative prices and exchange rate in the long run. This study therefore supports the PPP theory that exchange rates between dollar and pound adjust to reflect changes in the price level of two countries.

Asimakoupoulos, Ayling and Mahmood (2000) investigate the daily returns for four currency futures by employing a test for non-linear causality. The authors find a significant unidirectional non-linear Granger causality relationship in four cases, implying a degree of market inefficiency. However, after taking into account the persistence in variance for each currency return, they find much weaker relationships suggesting that the ignorance of a common informational factor may provide misleading results.

Nieh and Lee (2001) explore the dynamic relationships between the stock prices and the exchange rates for each G-7 country employing both the Engle Granger (EG) two steps and the Johansen maximum likelihood cointegration tests. They also use framework of Vector Error Correction Model (VECM) to assess both the short-run intertemporal comovement between these two financial variables and their long-run equilibrium relationship. Two major results are found from their time series estimations. First, there is no long-rung significant relationship between stock prices and exchange rates in the G-7 countries. Second, short-run significant relationship has only been found for one day in certain G-7 countries.

Swanson (2003) examines different aspects of global financial markets, specifically relationship among equity markets, money markets and foreign exchange markets across countries using Engle and Granger (bivariate method) and Johansen and Juselius (multivariate method). The results of the study show strong relationships among the equity markets, with causality emanating from the US and the German markets. As for the foreign exchange, the yen appears to be relatively independent and the only Eurodeposit return relationships are between dollars and marks.

1.3 Data and Methodology

The data set used in this study consist of daily prices for Great Britain pound, Singapore dollar, Japan yen, China yuan and Germany deutsche mark which are traded (average of buying and selling rates) in the Interbank Foreign Exchange Market in Kuala Lumpur. The rates used are direct quotations i.e units of ringgit equivalent to one unit of foreign currency. The data used are obtained from Bank Negara Malaysia and cover the period from January 1990 through December 2001, totaling 2968 observations. The data are in the logarithmic form. The sample is divided into two subperiods. The floating exchange rate is from January 1, 1990 to July 31, 2001 while the fixed exchange rate is from August 1, to December 2001. The numbers of observations are 1873 and 1096, respectively.

Table 1: Summary Statistics

Panel A: Floating Exchange Rate (January 1990- July 1997)					
	SD	DM	BP	Yen	Yuan
No. of Obs.	1873	1873	1873	1873	1873
Mean	0.50059	0.49483	1.4451	0.80243	-0.8016
Std. Dev.	0.06550	0.05800	0.1002	0.12612	0.4565
Min.	0.34784	0.34932	1.3124	0.53608	-1.3307
Max.	0.59537	0.62106	1.6832	1.11179	0.6317
Panel B: Fixed Exchange Rate (August 1997- December 2001)					
	SD	DM	BP	Yen	Yuan
No. of Obs	1096	1096	1096	1096	1096
Mean	0.79287	0.65955	1.7723	1.1564	0.87761
Std. Dev.	0.05126	0.11474	0.0877	0.1007	0.09741
Min.	0.57661	0.33569	1.4369	0.7874	0.53286
Max.	0.97516	0.94600	2.0361	1.3202	1.15880
Analysis of Variance (oneway) Between Two Subperiods					
F-Value	2800	2075	4523	8886	7700
P-Value	0.00	0.00	0.00	0.00	0.00

Table I shows the summary statistics for the two subperiods. Panel A describes the statistics for floating exchange rates while Panel B describes the statistics for fixed exchange rates. The summary statistics for both periods should reflex difference results since they are from difference regimes. The null hypothesis is rejected for cases since the f-value exceed the critical value and p-value is less than the specified α of 0.05. As such our results show significant difference between these two periods. The subperiod two is more volatile than subperiod one. This is quite reasonable since subperiod two include the turbulent period of financial and currency crises in 1997.

Methodology

The earlier researcher discusses the most popular problems dealing with time series data where most of them are not statistically stationary. The non-stationary data may results in spurious or dubious regression. Therefore, cointegrating approach develops by Engle and Granger (1987) is adopted in order to account for the non-stationary problem in the variables time series. In this study, Augmented Dickey Fuller (ADF) and Dickey Fuller tests are employed for detecting unit roots. The Engle and Granger and Johansen procedures are applied to test for cointegration so that the results can be compared.

This test first for stationarity of the series is conducted to establish whether simple vector autoregressive (VAR) models or error correction model (ECM) are more appropriate for examining relationships between the currency exchange rate. If the series are stationary or nonstationary but cointegrated, the ECM estimation is appropriate. A common approach for testing stationary (no unit roots) is utilized. They are the univariate Dickey-Fuller (DF) and the Augmented Dickey-Fuller (ADF) tests. The Dickey-Fuller unit root test is based on an OLS regression; the first difference of the variable is regressed on its own level lagged one period:

$$\Delta Y_t = \alpha + \beta Y_{t-1} + u_t \qquad \textbf{(1)}$$

In the case of ADF test, lagged first differences are added to the equation:

$$\Delta Y_t = \alpha + \beta Y_{t\text{-}1} + \sum_{i=1}^{n} {}_{i=1}\gamma \Delta Y_{t-1} + \varepsilon_t \qquad \textbf{(2)}$$

where lags order *n* are selected so that the residual ε_t are white noise. The null hypothesis is that the exchange rate series, Y_t contains a unit root. If it does, then the estimated coefficient, β, should not be statistically significantly different from zero suggesting nonstationarity in the series under investigation. In other words, we test H*o*: β < 0 comparing the *'t-statistic'* with the appropriate critical values provided by Fuller (1976). If the time series are nonstationary, the same tests are repeated on first differences of the series. Differencing will continued until the null hypothesis of a unit root (β =0) is rejected. If the time series are nonstationary and integrated of the same order, it shows some common stochastic trends and be cointegrated.

There are two test used to find cointegration. They are Engle and Granger (1987) testing procedure using bivariate analysis and Johansen and Juselius (1990), testing procedure using multivariate testing procedure. The null hypothesis of non-cointegration against the alternative of cointegration, and the procedure is to test for unit roots in the residual obtained by estimating the cointegrating regression. If the residual are found to be non-stationary then X_t and Y_t are not cointegrated.

According to the Engle and Granger (1987) procedure, the cointegration or equilibrium regression test using OLS is as follows:

$$Y_t = \alpha + \beta X_t + u_t \qquad \textbf{(3)}$$

where the residual, μ_I , are tested for unit roots. The residuals can be seen as temporary deviations from long-run equilibrium. The ADF test for the residual is one period lagged return for the residuals (refer eq. 1). The difference between ADF and DF test is that in the case ADF test, additional lags of Δu_t are used to ensure the residuals form the DF regression are serially uncorrelated (refer eq. 2).

The Engle and Granger two step cointegration procedure shown above, consists of two parts where one variable is regressed on the other, and then the residuals from that regression are tested for stationary, and this procedure is used by the majority of studies which investigate efficiency by applying cointegration tests. Johansen's (1988) and Johansen and Jelius's (1990), extend Engle and Granger's cointegration to multivariate dimensions. The Johansen procedure is based on a vector autoregressive model (VAR), which is estimated using maximum likelihood (ML). The Johansen (1988) cointegration tests rely primarily on two test statistics. They are trace test statistic and maximum eigenvalue test statistic. Both methods test for the nonzero characteristic roots. The trace test formulation is as follows:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{k} In(1 - \lambda_t^{/})$$

where T is the number of observations and $\lambda_t^{/}$ is the eigenvalues. The second test, the maximum eigenvalue formulation, is represented by:

$$\lambda_{\max}(r, r+1) = -TIn(1-\lambda_t^{/})$$

The trace formulation tests the null hypothesis that the number of r-cointegrating vectors of r = 0, that is, there are no cointegrating vectors in the system. If it is rejected, then sequential testing of $r \leq 1, r \leq 2, \ldots.$ is used. The maximum formulation tests the null that the number of cointegrating vectors is r against the alternatives hypothesis of r + 1 cointegrating vectors. Johansen and Juselius (1990) provide critical value for the two statistics.

If the series are cointegrated, then the ECM becomes appropriate to be employed. The bivariate ECM autoregression is as follows:

$$\Delta Y_t = \alpha_0 + \phi_0 \upsilon_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \sum_{j=1}^{n} \delta_j \Delta X_{t-j} + \nu_t \qquad \textbf{(6)}$$

The coefficient of the error correction term, ϕ , measures the single-period response of the dependent variable to departures from equilibrium. If the two time series are cointegrated, causality must exist in at least one direction. The m and n are the optimal number of lags for the lagged dependent and lagged dependent variables, respectively, and, ν is the residual. The results of Equation 6 provide a test of the relationship between change in the dependent variable, Y_t , lagged change in the dependent variable, X_t ,. Similarly, by reversing the role of X_t and Y_t , it is possible to test the impact of lagged Y_t on changing X_t employing the same equation. For the issue concerning selection of an appropriate lag length, m and n for the lag variables of Y_{t-i} and X_{t-j} , the study follows the criteria of mininising the mean square of error of prediction [Akaike (1974)], Akaike's final prediction error (FPE) test .

One important implication of the above model described in literature (Engle and Granger 1987), is that prices in an efficient speculative market cannot be cointegrated. If it they are cointegrated, then it implies that the market is inefficient since there must be 'Granger causality running in at least one direction. In other words, return of one variable can be used to forecast the other return, even after taking into consideration the lagged values of the forecast price.

1.4 Empirical Results

The results in table 1 shows that both the Dickey Fuller and the Augmented Dickey are not significant at the level 5 percent significant level, leading us to accept the null hypothesis of unit root implying that the series of exchange rates are non-stationary. Therefore, in the next stage, the unit root test is applied to the differenced price series of the currencies exchange rates and the results are presented in table 2. In all cases, the null hypotheses of unit roots in exchange rate changes are strongly rejected, indicating that the time series are stationary. Therefore all the variables seem to be integrated of first order, I (1). We can conclude that, the exchange rate series are of the same order of integration and as such they are candidates for cointegration.

INSERT TABLES 1 and 2

The study then tests the residual from the cointegrating regression applying the Augmented Dickey-Fuller unit root tests and the results are reported in table 3.

INSERT TABLES 3

The DF and ADF test statistics are highly significance and thus reject null hypothesis of the existence of a unit root in the residuals for all currency return at usual 5 % level. The results suggest that they are pairwise cointegrated. The findings of cointegration imply that there is a stable long run equilibrium relationship between exchange rate of one currency with another currency. This finding can be interpreted as no systematic divergences between the currencies that could profitably be exploited by traders. Any divergences that do exist are essentially temporary and random. In order to confirm these results, we employ the alternative methodology of Johansen's cointegration testing procedure and the results are reported in table 4.

INSERT TABLE 4

For maximum eigenvalue and trace statistics, the null hypothesis is that there are, at most, r cointegrating vectors, whereas the alternative hypothesis are r = 1 and at least r =1 for the maximum eigenvalue and trace statistics, respectively.

Starting with the maximum eigenvalue test results, the null hypothesis r = 0 (no cointegration) is rejected in favor of r = 1 in each currency exchange rate. Furthermore, the null hypothesis of r <= 1 cannot be rejected in favor of the alternative hypothesis of r = 2. These results indicate the presence of one cointegrating relationship for each currency exchange rate.

For the trace test results, we obtain similar conclusions when null hypothesis of r = 0 is tested against the alternative hypothesis of r = 1 in each currency exchange rate. Also null hypothesis r <= 1 cannot be rejected in all cases. The findings suggest that there is a long run equilibrium relationship among the currencies.

Overall, the Johansen's maximum likelihood tests indicate that there exist cointegration vector for all currency exchange rates tested either using maximum eigenvalue statistics or trace statistics, a result consistent with our earlier findings of the Engle and Granger tests. Thus the currency exchange rates pairwise are not efficient in a weak form in the long-run. These results are supported by Dutt and Ghosh (1999) who also report a rejection of the weak form of the efficient market hypothesis. But, the possibility of the existence of short-run disequilibrium between the variables series still remains. Therefore, as the final step, we will construct an error correction procedure to reconcile the short-run dynamics with the long-run behaviour of the variables series. The short-run estimation is also importance for all currency exchange models as an attempt to identify the nature of the short run dynamics (see Salmon, 1982 and Engle and Granger, 1987).

Table 5 shows the bivariate test results for the period of floating exchange rate. Similar to the full period, only two significant cases are detected. They are the values of the yuan, which have negative effects on the Singapore dollar (negative) and the values of the yen, which have positive effect on the Singapore dollar (positive). It seem that Singapore dollar receive much of the effects from the other currencies. No bi-directional causality is detected for all cases. Table 6 reports the bivariate causality test results for the second subperiod, i.e. the period of fixed exchange rates. Only one significant relation is detected. The yen positively affects the values of the yuan.

INSERT TABLES 5 AND 6

In summary, the bivariate test results indicate that three currencies are closely related with each other. They are Japanese yen, China yuan and Singapore dollar. The significant relationships may be explained partially by the fact that these countries are situated in the same region thus they may have common information factor.

1.5 Summary and Conclusions

This paper examines the behaviour for five foreign exchange rates (Great Britain pound, Singapore dollar, Japan yen, China yuan, Germany deutsche mark) in two different sample periods. The period under investigations are period of floating exchange rate and the period of fixed exchange rate. The statistical properties of the data in both periods show significant differences. This is not unexpected since the two periods under investigation are in different economic conditions. The general belief that the volatility measure by variance in floating exchange rate period is much more larger than the fixed or pegging exchange rates does hold with an exception of the DM.

With regard to relationship between currencies, we find that there is significant causality effect between currencies of a country in a same region, i.e. yen, yuan and dollar (Singapore). The partly reasons for this behaviour is because of the common information factor driving these currencies up and down. The ECM results show there is significant relationship between currencies of countries situated in the same region, i.e. yen, yuan and dollar (Singapore). This suggests continuation of dominance on the part the Japanese. What surprises us in the results is the emergence of new economic power of China in the region. The results suggest that the China is slowly replacing Singapore in distributing information to other Asian markets.

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Table: 1 Unit root tests on raw series data

Variables	Sample Size	Dickey Fuller Test	Augmented Dickey Fuller Test (AR1)
GBP	2969	-1.3935	-1.3786
SGD	2969	-1.5113	-1.5982
JPY100	2969	-1.5950	-1.6675
CHF	2969	-0.78562	-0.81222
DEM	2969	-2.3484	-2.4598

Table 2: Unit root tests on the first difference

Variables	Sample Size	Dickey Fuller Test	Augmented Dickey Fuller Test (AR1)
GBP	2968	-55.0614	-36.9780
SGD	2968	-48.7685	-37.9409
JPY100	2968	-50.8771	-38.5625
CHF	2968	-53.2238	-38.8632
DEM	2968	-51.9000	-38.2431

Notes: 95% critical value for the augmented Dickey-Fuller statistic = -2.8630. The Dickey-Fuller regressions include an intercept but not a trend, GBP = Great Britain Pound, SGD = Singapore Dollar, JPY100 = Japan Yen, CHF = China Yuan, DEM = Germany Deutsche mark

Table 3: Unit Root test applied to residuals of the cointegration regression

	Regression (OLS Estimation)	DF	ADF
GBP	GBP = -.9816E-4 + 2.2898SGD	-68.3463	-43.8261
	GDP = .9166E-4 +.86723JPY100	-61.4032	-39.0345
	GBP = .9901E-4 + .50276CHF	-57.5020	-38.0636
	GBP = .3134E-3 + 1.8679DEM	-71.1961	-44.8580
SGD	SGD = .1583E-3 + .13859GBP	-60.3668	-43.1488
	SGD = .1069E-3 + .30829JPY100	-53.0417	-38.4975
	SGD = .1329E-3 + .13801CHF	-50.6679	-38.0334
	SGD = .1944E-3 +.44412DEM	-57.4529	-41.0592
JPY100	JPY100=.2450E-3 + .24780GBP	-56.7551	-40.1863
	JPY100=.3235E-4 + 1.4554SGD	-55.3459	-39.3457
	JPY100=.2023E-3 + .24169CHF	-52.2797	-38.3643
	JPY100= .3081E-3 +.3081E-3DEM	-55.5947	-39.4097
CHF	CHF = .4714E-3 + .26362GBP	-55.6108	-39.9085
	CHF = .3200E-3+ 1.1956SGD	-55.2950	-39.1658
	CHF = .4223E-3 + .44351JPY100	-54.6766	-38.7411
	CHF = .5376E-3 + .90748DEM	-54.8545	-38.8056
DEM	DEM= -.5938E-4 +.25550GBP	-66.9793	-45.2996
	DEM= -.1732E-3+ 1.0037SGD	-61.2160	-42.0269
	DEM= -.9594E-4+ .39751JPY100	-56.7404	-39.1602
	DEM= -.9618E-4 + .23674CHF	-53.5296	-38.1102

Notes: GBP = Great Britain pound, SGD = Singapore dollar, JPY100 = Japan yen, CHF = China yuan, DEM = Germany Deutsche mark. DF = Dickey Fuller, ADF = Augmented Dickey Fuller. The critical value obtained from two tailed t distribution table at the 5% significant level is –3.3438

Table 4: Johansen test for cointegration with *I* (1) variables: Pairwise

	Regression (OLS Estimation)	Null	Alt	Statistic (maximum eigenvalue)	Statistic (trace)
GBP	GD	r = 0 r<= 1	r = 1 r = 2	148.7205* .049262	122.5050* .040758
	JPY100	r = 0 r<= 1	r = 1 r = 2	133.8958* .044462	106.2562* .035449
	CHF	r = 0 r<= 1	r = 1 r = 2	138.1604* .045845	120.0727* .039965
	DEM	r = 0 r<= 1	r = 1 r = 2	128.4754* .042701	100.7556* .033645
SGD	GBP	r = 0 r<= 1	r = 1 r = 2	148.7205* .049262	122.5050* .040758
	JPY100	r = 0 r<= 1	r = 1 r = 2	149.7881* .049606	110.4836* .036833
	CHF	r = 0 r<= 1	r = 1 r = 2	145.2738* .048148	121.9186* .040567
	DEM	r = 0 r<= 1	r = 1 r = 2	146.0067* .048385	113.0363* .037668
JPY100	GBP	r = 0 r<= 1	r = 1 r = 2	133.8958* .044462	106.2562* .035449
	SGD	r = 0 r<= 1	r = 1 r = 2	149.7881* .049606	110.4836* .036833
	CHF	r = 0 r<= 1	r = 1 r = 2	136.9706* .045460	106.3371* .035475
	DEM	r = 0 r<= 1	r = 1 r = 2	126.5562* .042077	117.1580* .039014
CHF	GBP	r = 0 r<= 1	r = 1 r = 2	138.1604* .045845	120.0727* .039965
	SGD	r = 0 r<= 1	r = 1 r = 2	145.2738* .048148	121.9186* .040567
	JPY100	r = 0 r<= 1	r = 1 r = 2	136.9706* .045460	106.3371* .035475
	DEM	r = 0 r<= 1	r = 1 r = 2	137.2824* .045561	109.6867* .036572
DEM	GBP	r = 0 r<= 1	r = 1 r = 2	128.4754* .042701	100.7556* .033645
	SGD	r = 0 r<= 1	r = 1 r = 2	146.0067* .048385	113.0363* .037668
	JPY100	r = 0 r<= 1	r = 1 r = 2	126.5562* .042077	117.1580* .039014
	CHF	r = 0 r<= 1	r = 1 r = 2	137.2824* .045561	109.6867* .036572

Notes: GBP = Great Britain pound, DEM = Germany Deutsche mark, JPY100 = Japan yen, CHF = China yuan, SGD = Singapore dollar. For the tests based on maximal eigenvalue of the stochastic matrix, when the null hypothesis is r=0, the critical value at 5% significant level = 11.03 and at 10% significance level = 9.28 when the null hypothesis is r<=1. The critical value at 5% significance level = 12.71 and at 10% significance level = 6.31. For the tests based on the trace of the stochastic matrix, when the null hypothesis is r=0, the critical value at 5% significance level = 12.30 and at 10% significance level = 10.25. When the null hypothesis is r<=1, the critical values are the same with tests based on maximum eigenvalue of the stochastic matrix.

Table 5: Error correction model: Bivariate (Period of floating exchange regime)

$$\Delta Y_t = \alpha_0 + \phi_0 \upsilon_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t\ i} + \sum_{j=1}^{n} \delta_j \Delta X_{t-j} + \nu_t$$

	α	Φ	β	δ	R2	F
GBP/SGD	-.3980E-4 -.25800	-.8292E-3 (-.77780)	-.0073789 (-.31858) [1]	-.017097 (-.30089) [3]	.4259E-3	.26504
GBP/JPY100	-.5457E-4 -.33928	-.5591E-3 (-.55857)	-.0069373 (-.29934) [1]	.017702 (.83344) [4]	.5836E-3	.36303
GBP/CHF	-.4321E-4 -.28237	-.0017802 (-1.2509)	-.0080999 (-.34933) [1]	-.9527E-3 (-.27166) [4]	.9112E-3	.56695
GBP/DEM	.2212E-4 .13460	.0010648 (.74001)	-.0073811 (-.31848) [1]	.0058952 (.27369) [3]	.3812E-3	.23705
SGD/GBP	.9824E-4 1.5311	-.6446E-3 (-1.1862)	.0088540 (.38248) [1]	.015309 (1.6280) [3]	.0022974	1.4315
SGD/JPY100	.1001E-3 1.5172	-.8666E-3 (-.78160)	.0089572 (.38655) [1]	.0041234 (.47718) [3]	.5582E-3	.34722
SGD/CHF	.1090E-3 1.7338	-.6088E-3 (-1.0115)	.0085330 (.36974) [1]	-.0053284 -3.7592* [3]	.0080606	5.0517
SGD/DEM	.9393E-4 1.3155	-.5429E-3 (-.70946)	.0077938 (.33634) [1]	.013186 (1.5044) [3]	.0016438	1.0236
JPY100/GBP	.3089E-4 .18021	-.001230 (-1.3166)	-.090776 (-3.9374) [1]	-.032821 (-1.3068) [3]	.0099389	6.2407
JPY100/SGD	.7472E-4 .45295	-.0019151 (-.98590)	-.0019151 (-4.5706) [1]	.17134 (2.6380)* [1]	.012282	7.7303
JPY100/CHF	.4548E-4 .26934	-.0012372 (-1.3002)	-.091049 (-3.9467) [1]	.0012782 (.33644) [3]	.0091161	5.7193
JPY100/DEM	.2457E-4 .13334	-.0010789 (-.83169)	-.090688 (-3.9318) [1]	.0014540 (.062232) [3]	.0085135	5.3380

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	α	Φ	β	δ	R2	F
CHF/GBP	.3469E-3 .33472	-.0019079 (-.96482)	-.0087359 (-.37698) [1]	-.048756 (-.31795) [3]	.6180E-3	.38444
CHF/SGD	.3202E-3 .31257	-.0023628 (-1.4355)	-.0096808 (-.41779) [1]	-.015116 (-.040233) [3]	.0011775	- .4292E-3
CHF/JPY100	.4015E-3 .37464	-.7818E-3 (-.55271)	-.0092361 (-.39906) [1]	-.20906 (-1.4884) [2]	.0014240	.88652
CHF/DEM	.1697E-3 .14766	-.00119- (.75184)	-.0088346 (-.38152) [1]	.026886 (.18859) [2]	.4037E-3	.25106
DEM/GBP	-.7682E-4 -.47093	-.0034713 (-1.3712)	-.039801 (-1.7136) [1]	.017573 (.70666) [2]	.0026929	1.6786
DEM/SGD	-.7489E-4 -.45840	-.0023602 (-.92549)	-.038106 (-1.6400) [1]	-.2862E-3 (-.004680) [2]	.0018573	.2517E-3
DEM/JPY100	-.1306E-3 -.77625	-.0034592 (-1.3487)	-.038496 (-1.6597) [1]	-.0049341 (-.21653) [2]	.0023967	1.4936
DEM/CHF	-.8906E-4 -.53832	-.0012589 (-.62835)	-.037182 (-1.6055) [1]	-.0070576 (-1.8809) [2]	.0034655	2.1619

Notes α = constant of the error correction model, δ and β = coefficients of the independent variables, ϕ coefficient of the error term, σ = standard error of regression. .Lags are in brackets. The t-statistics are in the parentheses. The * indicates significant level at 5%

Table 6: Error correction model: Bivariate (Period of fixed exchange regime)

$$\Delta Y_t = \alpha_0 + \phi_0 \upsilon_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t\ i} + \sum_{j=1}^{n} \delta_j \Delta X_{t-j} + \nu_t$$

	α	Φ	β	δ	R2	F
GBP/SGD	.9947E-3 2.2912	-.019448 (-2.7060)*	-.037240 (-1.2270) [1]	-.024052 (-.58355) [3]	.0076626	2.8081
GBP/JPY100	.5646E-3 1.1956	-.0036235 (-.96149)	-.028660 (-.94716) [1]	-.0058215 (-.20400) [4]	.0016492	.60074
GBP/CHF	.5887E-3 1.7043	-.017502 (-3.7608)*	-.041341 (-1.3668) [1]	-.029695 (-1.0846) [4]	.014522	5.3592
GBP/DEM	.1342E-3 .28505[.776]	.0015538 (.34431)	-.027393 (-.90579) [1]	-.024233 (-.86805) [3]	.0015877	.57833
SGD/GBP	.0017954 2.4486	-.030793 (-2.4238)*	.10485 (3.4723) [1]	-.013030 (-.59170) [3]	.017696	6.5515
SGD/JPY100	.5016E-4 .18264	.0017217 (.48467)	.10983 (3.6503) [1]	.019872 (.95666) [3]	.013052	4.8094
SGD/CHF	.0010883 3.3506	-.027055 (-4.4799)*	.091857 (3.0542) [1]	-.0087868 (-.44244) [3]	.030081	11.2789
SGD/DEM	-.2140E-4 -.061242	.0017438 (.55736)	.10903 (3.6236) [1]	-.0099790 (-.4916) [3]	.012507	4.6059
JPY100/GBP	.9962E-3 2.1538	-.0089931 (-2.5793)*	.11273 (3.7498) [1]	-.011035 (-.34727) [3]	.020124	7.4687
JPY100/SGD	.2167E-3 .61438	-.0070602 (-1.9607)*	.066555 (1.4215) [1]	.091494 (1.3508) [1]	.019132	7.0933
JPY100/CHF	.0010164 2.4228	-.012162 (-3.4567)*	.10752 (3.575) [1]	-.019004* (3.5758) [3]	.025003	9.3258
JPY100/DEM	.5964E-3 1.3995	-.0034425 (-1.5632)	.11595 (3.8553) [1]	-.010683 (-.36363) [3]	.016371	6.0525
CHF/GBP	-.7794E-3 -1.6789	.0048798 (3.6186)*	.058544 (1.9412) [1]	-.031204 (-.94599) [3]	.017304	6.4037
CHF/SGD	-.0013872 -2.5037	.0086000 (3.9286)*	.056718 (1.8841)	.0035135 (.077878)	.018529	6.8655

	α	Φ	β	δ	R2	F
			[1]	[3]		
CHF/JPY100	-.0014879 -2.2014	.0039382 (3.0690)*	.062601 (2.0696) [1]	-.036454 (-1.1665) [2]	.014381	5.3063
CHF/DEM	-.0011061 -1.7422	.0022904 (2.6169)*	.063300 (2.0928) [1]	-.015827 (-.51755) [2]	.011162	4.1049
DEM/GBP	.1775E-3 .48968	-.010081 (-2.1157)*	.051941 (1.7157) [1]	.050330 (1.5352) [2]	.0096409	3.5402
DEM/SGD	.1787E-3 .49270	-.0085545 (-2.1644)*	.058987 (1.9372) [1]	-.037654 (-.83589) [2]	.0085378	3.1316
DEM/JPY100	.2958E-3 .79400	-.0039839 (-1.3055)	.061132 (2.0191) [1]	-.034043 (-1.0982) [2]	.0063795	2.3349
DEM/CHF	.4085E-3 1.1003	-.0092047 (-2.7247)*	.055309 (1.8301) [1]	-.028655 (-.96332) [2]	.011305	4.1581

Notes α = constant of the error correction model, δ and β = coefficients of the independent variables, ϕ coefficient of the error term, σ = standard error of regression. The lags are in brackets. The t-statistics are in the parentheses. The * indicates significant level at 5%

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