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Exchange Rates and Macroeconomic Fundamentals: Linear Regression and Cointegration Analysis On Emerging Asian Economies

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Primary objective of this paper is to find out the common sources of fluctuations in currency prices of Pak rupee, Indian rupee, Indonesia Rupiah, Korean Won and Sri Lankan Rupee against United States Dollar. Using quarterly data from 1984 to 2008, we document that economic variables are not senseless in determination of exchange rates. Results of ordinary least squares and Johansen's cointegration reveal that long term relationship exists among exchange rates and macroeconomic fundamentals of sample economies. Furthermore, it has been found that emerging Asian economies share a set of common economic variables, which cause their currency prices to move over time.

Field of Research: Banking/Finance

1. Introduction

Exchange rate determination is a far from settled issue in the literature of international finance and is the focus of this paper. . Different studies have used different economic variables and have presented different relationships of these variables with exchange rate. Such wide variety of estimates is not surprising because empirically, the modeling of exchange rate behavior is very difficult. Such sharp variance in results can partly be attributed to methodology used in the study and partly to the choice of variables and the period of study.

Purchasing power parity argues that it is inflation differential, which causes exchange rates to move. Interest rate parity argues that it is interest rate differential between domestic and foreign country, which drives exchange rates to fluctuate. Absorption approach argues that when a country produces more than what it absorbs, there will be trade surplus and exchange rate will appreciate and vice versa. Monetary model argues that it is level of money supply in domestic and foreign country, which acts as main determinant of exchange rate. Monetary model incorporates purchasing power parity in it. Purchasing power parity can be thought of application of quantity theory of money to open economy.

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Since the abolishment of Bretton Woods in 1971, exchange rates have undergone huge fluctuations especially those of developing economies and thus, ask for formal investigation into their behavior. This paper is an attempt to explain the currency behavior of five emerging Asian economies namely; Pakistan, India, Indonesia, Korea and Sri Lanka.

By employing Ordinary Least Squares and Johansen's Cointegration techniques on quarterly data from 1984 to 2008, this paper makes an attempt to gauge the relationship between exchange rates and macro economic fundamentals. Both regression and cointegration results reveal that long term relationship exists between exchange rates and set of macroeconomic variables. Therefore, macroeconomic variables are not senseless. Furthermore, on the basis of empirical investigation, we document that sample economies share a set of common factors in determination of exchange rates.

2. Literature Review and Exchange Rate Approaches

Two different approaches on exchange rate determination are fundamentalism and Chartism. Fundamentalists explain exchange rates on the basis macro economic factors while chartists totally ignore the role of economic theories and attempt to explain exchange rate behaviour on the basis of its lagged values. Findings on exchange rate behaviour are mixed. Sufficient research has been conducted on comparison of fundamentalism versus chartism. Some researchers have argued that economic models cannot beat simple repeated patterns model like random walk. Musa (1979) documented that random walk model had the capacity to outperform economic models of exchange rate determination. Later on, Meese and Rogoff (1983) tested various types of exchange rate models and argued that no economic model had the power to beat random walk model in the field of forecasting. However, many researchers argue that exchange rate forecasting capacity is not a justified criterion for comparison of models. They say that if a model does not perform well in forecasting, it does not mean that those models are senseless. Their poor performance might be due to non linear relationship or time varying parameters. Hendry (1986) and Pagan (1987) conducted a research and put forward similar arguments. They said comparing exchange rate models on the basis of how correctly they forecast is not reasonable. Some researchers document that predictive capacity of fundamentals based approaches can be increased by incorporating parameters' instability. However, this also lacks empirical support. For example, Wright (2003) documented that fundamentals based models might produce better forecasts in comparison with those of random walk model, but simultaneously many researchers had incorporated time dependent coefficients in their studies and found that random walk outperformed economic models even when coefficient were allowed to vary over time. Wolff (1987) reported some sort of similar results. He argued that structural models, even in the presence of time varying coefficients did not have the power to beat naïve random walk model. However, it could be argued that limitations of economic models of exchange

rate forecasting, was not that the variables used were senseless rather it might be due to existence of non-linearity between currency prices and macro economic explanatory variables. Hsieh (1989), Baille and Mcmahon (1989)and Hong and Lee (2003) investigated exchange rate behaviour using non linear techniques and reported that exchange rate was non linearly dependent upon economic fundamentals. However, they found that macroeconomic fundamentals were often uncorrelated with currency prices. Diebold and Nasan (1990) and Meese and Rogoff (1990) used non parametric techniques like kernel regression and compared different economic models against random walk model. They documented that even non parametric models were not able to outperform random walk model in the field of exchange rate prediction. Meese and Rogoff (1991), also incorporated non-linearity into their econometric modelling of exchange rate behaviour but concluded that such inclusion did not improve the forecasting capacity of economic models. Engel and Hamilton (1990) and Engel (1994) compared performance of Markov- Switching model to that of random walk and concluded that the later had the power to defeat the structural models of exchange rate forecasting.

However, many researchers have documented that neural network models of exchange rate forecasting have the power to beat the random walk model. But findings of majority of these models are based on *out of sample forecasting* ability not on *in the sample forecasting*. For example, Kuan and Liu (1995) applied Neural Networks techniques on daily currency prices and reported lower *out of sample* forecasting errors when compared to those of random walk models. Their findings were supported by Brooks (1997). Furthermore, significant research has been conducted on effects of outliers in the series. Most commonly reported effects are biased parameters, which harm the forecasting performance of exchange rate models (Ledolter, 1989; Hotta, 1993)

Rossi (2006) argued that portion of exchange rate fluctuations explained by economic models was almost zero. In empirical investigation of nominal exchange rate movements, she documented that in some countries random walk models failed to explain exchange rate movement. This finding rejected the discussion that macroeconomic variables had no link with exchange rate movement. Thus, the rejection of macroeconomic models might not be due to their irrelevance with exchange rate rather due to their unstable relationship over time. The question, whether existing economic models of exchange rate beat random walk model or not, is unsettled but prevailing answer to this question is ‘No’. Random walk models better explain the movements in exchange rate but they ignore economic theories (Meese and Rogoff, 1983). Researchers have compared economic models with random walk and other autoregressive techniques but no work has been conducted on what the common factors are, causing fluctuations in emerging Asian economies. This question is at the heart of this paper.

3. Methodology

As our understanding of factors causing fluctuations in exchange rates is very limited (Najand and Bond, 2000), therefore application of structural models on determination of exchange rate fluctuations consists of two steps

1. In the first step, related variables are identified and their underlying theories are discussed and

2. In the second step, suitable statistical and econometrics techniques and procedures are selected

3.1 Explanatory Variables

There are different theories of exchange rate determination, which consider different factors as determinants of exchange rate. Most common factors are relative inflation, relative interest rate, relative income level, government restrictions and market expectations. According to Edwards (1988), and Zakaria et al (2007), following factors can have possible impact on the movement of exchange rates.

Relative Interest Rate (RIR)

Inflation affects exchange rate through current account, while interest rate differential affects it through capital account. Before 1970s, the role of interest rate in exchange rate determination could not attain significant attention of researchers and practitioners because of very limited capital mobility across the national boundaries. However, with the inception of monetary model of exchange rate and removal of controls on capital mobility by different countries, it has gained significant attention of researchers and practitioners. Higher real interest rate in domestic country attracts foreign investments into the country. This increases the demand of local currency in foreign exchange market and puts upward pressure on its price and vice versa. Thus theoretically, higher real interest rate has positive expected relationship with exchange rate. This variable is measured as under:-

$$RIR_t = \frac{i_t^{\,f}}{i_t^{\,h}} \text{ ----------(I)}$$

Where RIR_t is relative interest rate, $i_t^{\,f}$ is foreign interest rate and $i_t^{\,h}$ is home interest rate at time t.

Relative Inflation Level (RIL)

Relative Inflation rate has been measured as under:-

$$RIL_t = \frac{I_t^{\,f}}{I_t^{\,h}} \text{----------(II)}$$

Where RIL_t is relative inflation rate, $I_t^{\,f}$ and $I_t^{\,h}$ are foreign and domestic price levels at time t respectively.

Terms of Trade (TOT)

Foreign terms of trade or simple terms of trade is defined as under

$$TOT_t^{\,f} = \frac{X_t^{\,f}}{I_t^{\,f}} \text{----------(III)}$$

Where $TOT_t^{\,f}$, $X_t^{\,f}$ and $I_t^{\,f}$ are foreign terms of trade, foreign export and import levels respectively. Whether terms of trade affects exchange rate positively or negatively, depends upon whether income effect overcomes substitution effect or substitution effect overcomes income effect. According to income effect, when export level of foreign country increases, its income level rises and it affects foreign currency negatively. This is equivalent to appreciation of domestic currency. According to the substitution effect, when there is increase in the price of foreign exportable, it shifts production resources away from non-tradable to tradable ultimately raising the price level of non-tradable. When price of tradable falls relative to non-tradable, terms of trade improve and foreign currency appreciates. This is equivalent to depreciation of local currency of sample economies in this study. Therefore, relationship of terms of trade with exchange rate is theoretically, vague and is subject to empirical analysis. However, some researchers have documented positive relationship between terms of trade and exchange rate (Edwards 1988).

Trade Restrictions (TR)

This variable is measured as opposite of trade openness or trade intensity (Zakaria et al 2007). As trade openness is measured by dividing the sum of exports and imports by gross domestic product of a country, therefore, trade restriction is measured by the reciprocal of trade openness. These trade restrictions are tariff on imports, export taxes and import quotas etc. These reduce the trade openness of a country. This variable is constructed as follows

$$TR_t = \frac{No\min al\, GDP_t}{(\mathrm{Im}\, ports + Exports)_t} \text{---------- (IV)}$$

Where TR_t is trade restrictions

Trade Balance Ratio (T.B)

Current account consists of trade balance, net services balance, factor income and unilateral transfers. Trade balance is known as trade surplus, when the value of tangible exports exceeds the value of tangible imports. Theoretically, exports

have positive relationship with exchange rate and imports have negative relationship. This variable is constructed as follows

$$T.B_t = \frac{(Exports - imports)_t}{GDP_t} \text{ ---------- (V)}$$

Where T.B is trade balance and has been measured as percentage of nominal gross domestic product. In regression equation, first difference of above equation has been used

Net Capital Inflows (NKI)

Any change in capital inflows changes the consumption and thus changes the exchange rate. Capital inflow is recorded in capital account in case there is inflow in physical assets and is recorded in financial account in case there is net capital inflow in financial assets such as stocks and bonds. In this study, this variables has been constructed as under

$$N.K.I_t = \frac{Net\,Capital\,Account_t + Net\,Financial\,Account}{No\min al\,GDP_t} \text{ --------(VI)}$$

Where $N.K.I_t$ is net capital inflows at time t

3.2 Regression Equation

In regression equation, six macroeconomic fundamentals have been used to explain the behavior of exchange rates of sample economies. Regression equation is

$$E.R_t = \alpha_0 + \beta_1 * RIR_t + \beta_2 * RIL_{t-1} + \beta_3 * TOT_t + \beta_4 * TR_t + \beta_5 * d(TB_t) + \beta_6 * NKI_t + \varepsilon_t \text{ ---(VII)}$$

Where

$E.R_t$ is exchange rate, measured as natural log of nominal exchange in direct quotation in time t

RIR_t is relative interest rate at time t

RIL_{t-1} is previous period relative inflation level

TOT_t is terms of trade in period t

$D(TB_t)$ is the first difference of trade balance ratio

NKI_t is net capital inflows and

ε_t is error term

According to Najand and Bond (2000) and Zakaria et al (2007), expected signs of coefficients (β_s) are presented in the following table

Table 1: Expected Signs of Explanatory Variables Used in Regression Analysis

Coefficient	Expected Sign	Theory/Approach
β_1	Negative Vague	Interest Rate Parity Theory Portfolio balance approach
β_2	Negative	Purchasing Power Parity Theory
β_3	Vague	Subject to empirical investigation
β_4	Vague	Subject to empirical investigation
β_5	Negative	Current Account Theory
β_6	Negative	Portfolio balance approach

4. Results

4.1 Regression Equation

Table 2 reports the results of regression equation in which exchange rate has been regressed on six explanatory variables. These are relative interest rate (β_1), relative inflation level (β_2), foreign terms of trade (β_3), trade restrictions (β_4), trade balance ratio (β_5) and net capital inflows (β_6). In case of Pak Rupee, relative interest rate, foreign terms of trade, trade restrictions and net capital inflows have significant effect as t statistics exceeds 2. However, it is insignificantly related with relative inflation rate and trade balance ratio. In case of exchange rate between Indian Rupee and United States Dollar, similar variables have been found significant. The only difference is direction of foreign terms of trade. In case of Pak Rupee, it has negative sign while in case of India, it has positive sign. In case of Indonesian Rupiah, significant variables are foreign terms of trade, trade restrictions, trade balance and net capital inflows while relative interest rate and relative inflation rate are insignificantly related to exchange rate. In case of Korean Won, only significant variables are relative interest rate and foreign terms of trade while remaining four explanatory variables are insignificant. In case of Sri Lankan rupee, significant variables are relative interest rate, foreign terms of trade, trade restrictions and net capital inflows while relative inflation rate and trade balance ratio are insignificant related to exchange rate between Sri Lankan rupee and United Stated Dollar.

The sample economies have some common sources of fluctuations in exchange rates. For example, the regression results support that exchange rates of Pakistan, India and Sri Lanka seem to be commonly influenced by relative interest rate, foreign terms of trade, trade restrictions and net capital inflows.

Indonesian Rupee shares foreign terms of trade and trade restrictions as common factors with Pakistan, India and Sri Lanka, while Korea shares relative interest rate and foreign terms of trade with Pakistan, India and Sri Lanka. Among these sample economies, the exchange rates between Pak Rupee and U.S Dollar, Indian Rupee and U.S Dollar and Sri Lankan Rupee and U.S Dollar seem most sensitive to changes in macroeconomic fundamentals, while that between Korean Won and U.S Dollar seems least sensitive to changes in economic fundamentals.

Table 2: Results of Regression Results

	Pakistan		India		Indonesia		Korea		Sri Lanka	
	Coefficients	T-statistics	Coefficients	T-statistics	Coefficients	T-statistics	Coefficients	T-statistics	Coefficients	T-statistics
β_1	-0.806265	-5.369223	-0.788669	-2.858545	-0.309095	-1.750429	-0.614541	-2.862935	-1.640634	-9.160113
β_2	0.08538	1.599008	-0.011107	-0.900806	-0.011584	-0.417177	-0.001513	-0.275492	-0.004274	-0.099911
β_3	-2.504357	-6.704061	0.504076	2.280557	-3.207428	-8.700834	-1.826077	-4.470395	-2.510172	-8.852323
β_4	-0.110839	-3.916628	-0.054776	-15.24806	-0.216782	-11.11293	-0.019269	-0.846264	-0.100133	-3.692236
β_5	0.805353	0.417237	2.257107	1.392897	-4.641329	-3.239521	0.105499	0.137748	-0.438202	-0.995382
β_6	-7.247476	-5.092317	-3.119618	-3.14977	-2.06629	-2.253505	0.118801	0.216507	-2.598663	-3.891199
C	7.370659	16.35213	4.796784	26.69742	12.69304	46.49105	8.630307	23.33465	7.153477	30.17659

$$E.R_t = \alpha_0 + \beta_1 * RIR_t + \beta_2 * RIL_{t-1} + \beta_3 * TOT_t + \beta_4 * TR_t + \beta_5 * d(TB_t) + \beta_6 * NKI_t + \varepsilon_t$$

Note:

$E.R_t$ is exchange rate, measured as natural log of nominal exchange rate expressed in direct quotation in time t

RIR_t is relative interest rate in time t

RIL_{t-1} is lagged period relative inflation level

TOT_t is terms of trade in period t

$D(TB_t)$ is change in trade balance ratio

NKI_t is net capital inflows and

ε_t is error term

4.2 Results of Johansen's Cointegration

Before employing Johansen's cointegration technique, relative inflation level has been measured by relative C.P.I, which has been estimated by dividing the C.P.I of United States with C.P.I of respective sample economies. As formal investigation of variables has indicated that all economic series used in this study contain unit root at levels i.e. they are non-stationary and become stationary in first difference form, therefore, long run relationship among variables has been explored by employing Johansen's cointegration technique. Tables 3 to table 7 report the results of Johansen's cointegration test for Pakistan, India, Indonesia, Korea and Sri Lanka respectively. Johansen cointegration has been employed under different assumptions of intercept and deterministic trends. These assumptions include no intercept or trend in cointegrating equations and VAR, intercept but no trend in cointegrating equation and no intercept in VAR and intercept and trend in cointegrating equation and no trend in VAR. Table 3 indicates that at 5% significance level, there are three cointegrating equations in Pakistan. Likelihood ratio reports three cointegrating equations in case of India reported in table 4. Table 5 reports the results of Johansen's cointegration test in Indonesia. LR test indicates that there are three cointegrating equations in case of Indonesia. Table 6 reports the results of Johansen's cointegration in case of Korea. In this table, LR indicates the existence of two cointegrating equations. While table 7 reports the results of cointegration in case of Sri Lanka. In this table LR indicates the existence of three cointegrating equations among variables. Thus table 3 to table 7 report the existence of long run relationship among exchange rate and economic variables used in the study.

Table 3: Results of Johansen's Cointegration: Pakistan

Eigen Value	L. R Stat	5 % Critical Values	1 % Critical Values	Number of CEs
0.402356	158.4322	124.24	133.57	None **
0.33278	113.6482	94.15	103.18	At most 1 **
0.325109	78.44488	68.52	76.07	At most 2 **
0.25721	44.23614	47.21	54.46	At most 3
0.128556	18.36734	29.68	35.65	At most 4
0.067589	6.395801	15.41	20.04	At most 5
0.003527	0.307377	3.76	6.65	At most 6

Table 4: Results of Johansen's Cointegration: India

Eigen Value	L. R Stat	5 % Critical Values	1 % Critical Values	Number of CEs
0.413788	153.1617	124.24	133.57	None **
0.289336	101.8907	94.15	103.18	At most 1 *
0.260493	69.10139	68.52	76.07	At most 2 *
0.168087	40.13127	47.21	54.46	At most 3
0.136499	22.46467	29.68	35.65	At most 4
0.078293	8.375725	15.41	20.04	At most 5
0.005703	0.549038	3.76	6.65	At most 6

Table 5: Results of Johansen's Cointegration: Indonesia

Eigen Value	L. R Stat	5 % Critical Values	1 % Critical Values	Number of CEs
0.484371	171.2807	124.24	133.57	None **
0.391021	109.0181	94.15	103.18	At most 1 **
0.255422	62.39673	68.52	76.07	At most 2
0.170958	34.67257	47.21	54.46	At most 3
0.085803	17.04905	29.68	35.65	At most 4
0.062619	8.616393	15.41	20.04	At most 5
0.026637	2.537862	3.76	6.65	At most 6

Table 6: Results of Johansen's Cointegration: Korea

Eigen Value	L. R Stat	5 % Critical Values	1 % Critical Values	Number of CEs
0.385361	162.9212	124.24	133.57	None **
0.350398	116.6828	94.15	103.18	At most 1 **
0.273258	75.70022	68.52	76.07	At most 2 *
0.214646	45.37774	47.21	54.46	At most 3
0.122724	22.42373	29.68	35.65	At most 4
0.086622	9.985067	15.41	20.04	At most 5
0.014395	1.377502	3.76	6.65	At most 6

LR stat indicates three cointegrating equations

Table 7: Results of Johansen's Cointegration: Sri Lanka

Eigen Value	L. R Stat	5 % Critical Values	1 % Critical Values	Number of CEs
0.396284	134.4931	109.99	119.8	None **
0.233207	86.55126	82.49	90.45	At most 1 *
0.205942	61.32509	59.46	66.52	At most 2 *
0.177801	39.41818	39.89	45.58	At most 3
0.144279	20.81972	24.31	29.75	At most 4
0.061145	6.017688	12.53	16.31	At most 5
0.00025	0.023707	3.84	6.51	At most 6

5. Conclusion

In this paper, capacity of macroeconomic fundamentals to explain exchange rate behavior has been gauged through empirical investigation. First Exchange rates of sample economies have been regressed on a set of explanatory variables proposed by different theories and secondly Johansen's cointegration has been employed. There is consensus among researchers that understanding about variables of exchange rate behavior is limited. Therefore, adhoc model has been used in this study. The regression results suggest link between macroeconomic variables and exchange rate behavior in sample economies. On the other hand, empirical investigation of exchange rate and macroeconomic fundamentals reveal that a set of common factors causes fluctuations in emerging Asian economies. Our results suggest the existence of negative relationship between nominal interest rate and exchange rate behavior in all the sample economies. Furthermore, they indicate that exchange rate between Pak Rupee and U.S Dollar is explained significantly by relative interest rate differential, foreign terms of trade, trade restrictions and net capital inflows. Regression results report that exchange rate between Indian Rupee and U.S Dollar is explained by relative interest rate differential, foreign terms of trade, trade restrictions and net capital inflows. Thus in both, Pakistan and India, the exchange rate is caused by same set of explanatory variables. The only difference is the direction of relationship of exchange rate with foreign terms of trade. In Pakistan, foreign terms of trade are negatively related with price of foreign currency, while in India it is positively related with price of foreign currency. However, in Indonesia, relative interest rate and relative inflation level do not significantly affect exchange rate between Indonesia Rupiah and U.S Dollar. Variables significantly affecting the exchange rate between Indonesian Rupiah and U.S Dollar are foreign terms of trade, trade restriction, trade balance and net capital inflows. In case of Korea, only two significant variables explaining the exchange rate behavior between Korean Won and U.S Dollar are relative interest rate and foreign terms of trade. Other variables do not significantly explain the behavior of exchange rate in Korea. Lastly, for Sri Lanka, the results are almost similar to those observed in case of

Pakistan and India. The significant variables are relative interest rate, foreign terms of trade, trade restrictions and net capital inflows. Thus exchange rate between Pak Rupee and U.S Dollar, Indian Rupee and U.S Dollar and Sri Lankan Rupee and U.S Dollar are explained by same set of explanatory variables.

Results of Johansen's cointegration technique reveal that exchange rates of all the five sample economies seem to have long run relationship with macroeconomic fundamentals. This long run relationship can be determined by three cointegrating equations in respect of exchange rate between Pak Rupee and U.S Dollar, Indian Rupee and U.S Dollar, Korean Won and U.S Dollar and Sri Lankan Rupee and U.S Dollar, while by two cointegrating equations in respect of exchange rate between Indonesian Rupiah and U.S Dollar. Supporting the findings of Wright (2003), we conclude that economic theories and macroeconomic fundamentals are not irrelevant or senseless as documented by some proponents of chartism like Rossi (2006).

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