

Monetary Policy Reaction Function and Sterilization of Capital Inflows: An Analysis of Asian Countries

Muhammad Saim Hashmi (Corresponding author)

School of Economics, Huazhong University of Science and Technology

Wuhan 430074, China

E-mail: msaimhashmi@gmail.com

Changsheng Xu

Professor, School of Economics, Huazhong University of Science and Technology

Wuhan 430074, China

Muhammad Mahroof Khan

School of Economics, Huazhong University of Science and Technology

Wuhan 430074, China

E-mail: khanhust@yahoo.com

Mohsin Bashir

School of Management, Huazhong University of Science and Technology

Wuhan 430074, China

E-mail: uaf_mohsinpk@yahoo.com

Faheem Ghazanfar

School of Economics and Management, China University of Geosciences

Wuhan 430074, China

E-mail: faheemghazanfar@yahoo.com

Received: February 28, 2011 Accepted: April 30, 2011 doi:10.5539/ass.v7n9p19

Abstract

The study was mainly focused on estimation of monetary policy reaction function and degree of sterilization for the sample comprising of Pakistan, Korea, Philippines and Japan by using quarterly data ranging from 1980-1 to 2007-2. The study has used Johansen multivariate co integration technique. We conclude that over the period of study all the central banks of these countries have conducted a strong sterilization policy, but not fully sterilized the capital inflow. These countries have used the sterilization policy, though it is different in magnitude for different countries. Results show that in all the economies whether they are agriculture or non-agriculture they sterilized their capital inflows in the long run. Short run adjustment towards the long run equilibrium shows high value of adjustment for Korea and Philippines while for Pakistan its coefficient shows very little adjustment. On the other hand Korea and Philippines has shown comprehensive adjustment policies towards long term adjustment.

Keywords: Sterilization, Monetary policy reaction function, Capital flows

1. Introduction

Two main economic events have been dominant in the emerging market economies during and after 90's is the substantial increase in capital inflows compared to the 80's, and the repeated balance of payments crises associated with the sudden reversals of these flows. Capital flows to Latin America, which averaged less than \$ 20 billion a year in the 80's and approximately \$ 11 billion during its second half, increased to \$ 70 billion a year during the 90's (IMF, 1999). In developing Asia capital flows increased from an average of \$14.9 billion a year in the 1985-89 period to \$ 40 billion a year from 1990 to 1994 (Calvo *et al.*, 1994). The volatility of capital flows has also increased. Sudden swings in capital flows have been followed in most cases by sharp balance of payments crises and deep economic contractions (Calvo, 1998).

Last decade has passed since the revival of international capital flows to many developing countries. About US\$460 billion of foreign capital has flowed to developing countries in Asia and Latin America in the early 90's or about three-and-a-half times the US\$133 of the late 80's, when there was a debt crisis and many of these countries had little or no access to international capital markets. These huge inflows in recent years may cause serious problem and choices for appropriate economic policy.

According to Calvo, et al (1994a, b) recent surge in capital inflows was initially attributed to domestic developments, such as the sound policies and stronger economic performance of these countries. Large capital inflows are often linked with a fast monetary expansion, inflationary pressures, real exchange rate appreciation, and widening current account deficits. In later period it was clear that these capital flows were universal, affecting countries with very different characteristics. During this time short-term interest rates in the United States were declining gradually and by late 1992 it was at its lowest level since the early 1960s. Further, a recession in several industrial countries made profit opportunities in developing countries appear relatively more attractive. While this turn of events was indication as good news in most developing countries, policymakers there became concerned about its sustainability. This capital flow to these countries was a blessing to them because developing countries face the problem of capital accumulation. This proved to be an opportunity for developing countries to use this capital flow for their development.

In the light of this capital flows to the developing countries, it became interesting to study the behavior of these countries that how they managed to tackle these capital inflows. Capital recipient countries were also under pressure because of exchange rate appreciation, widening of balance of payment deficit and inflation. There are many ways to handle this phenomenon; the most commonly used is sterilization policy. Sterilization is defined as the sale of domestic assets by central bank in order to off set an increase in the monetary base due to purchase of foreign assets. Under different exchange rate regime there are different policy tools to deal with such case. In managed floating exchange rate system, the central bank may respond to exchange market equilibrium by changing either the international reserves or the exchange rates.

Many developing countries responded the situation in different ways or according to situations of their economy and try to get benefits from increasing capital inflows in recent years. Mostly this is regarded as a very welcome phenomenon, raising levels of investment and encouraging economic growth. But increase in capital inflows can have two types of effects, a tendency for the local currency to gain in value, reducing the competitiveness of export industries, and giving rise to inflation. Capital inflows result in a buildup of foreign exchange reserves. As these reserves are used to buy domestic currency, the domestic monetary base expands without a corresponding increase in production, which would result in inflation.

This paper is an attempt to study the huge capital inflows and experience of some selected sample of the Asian countries, that how these selected countries managed to tackle this huge capital inflow. The sample consists of Pakistan, Japan, Korea and Philippines. The selection of this sample is mainly attributed to the availability of quarterly data over the specific time period for certain variables. This sample consists of industrial countries, agriculture economies, developing and developed countries. The study will focus on the estimation of the monetary policy reaction function and the degree of sterilization for selected sample.

2. Literature Review

The theoretical framework for analysis and relationship between capital inflows, sterilization and monetary response is a combination of two approaches usually found in the literature related to the empirical analysis of this phenomenon. The estimation of the sterilization coefficient, as in much of the existing research, is based on the estimation of the monetary policy reaction function as in Cumby and Obstfeld (1989). They derived the monetary policy reaction function by assuming that the central bank neutralizes the monetary effects of capital inflows from abroad by changing its domestic or net assets. While in the literature, the estimation of the offset coefficient is mostly based on the theoretical framework set by Kouri and Porter (1974). They derived a model of

international capital flows assuming a small open economy with a fixed exchange rate regime. A number of new research papers on this topic refer to the basic theoretical frameworks set up in these two papers (e.g. Celasun *et al.*, 1999, Siklos, 2000, Jan *et al.*, 2005 and Emir *et al.*, 2000).

Moreno (1996), using four-variable vector autoregression model, explored the response of monetary authorities in Korea and Taiwan. This paper has developed an empirical model to analyze the monetary implications of intervention and sterilization policies in Korea and Taiwan. First conclusion of the study was that in both the economies, the sterilization is an important element of the response to shocks to foreign assets. Shocks to foreign assets were largely offset by shocks to domestic credit, and were generally associated with little net change in reserve money, especially in the case of Taiwan. The author made second conclusion that there are some differences in the responses of Korea and Taiwan that indicate that Korea may be more protected from foreign asset shocks. Shocks to foreign assets are quickly reversed in Korea, while they appear to be much more longer in Taiwan. The author says that this may reflect more persistent foreign exchange market speculation in Taiwan made possible by less restrictive capital controls. In addition, Korea has have a tendency to sterilize shocks to foreign assets more fully than has Taiwan, achieving a smaller change in exchange rate with a far smaller change in the money supply.

Frankel and Okongwu (1996) studied the major factors influencing emerging markets. Authors conclude that in the emerging-market countries U.S. interest rates are a very major determinant of financial conditions. Its effect is high and significant on portfolio capital flows and on local interest rates. The estimates for Mexico, suggests that a monetary expansion is followed by a capital outflow within the same quarter equal to 0.28 per cent of the increase in the monetary base, but it was not complete offset. This paper also finds the evidence against the view that the existence of country risk or remaining capital controls is the major reason why interest rates in recipient countries remained above U.S. interest rates in the period of 1990-94. Country risk, measured for example by the discount in the secondary debt market, is a significant determinant of country interest rates. But a decomposition of interest differentials into country premium and currency premium shows that the currency premium is generally larger. When countries have difficulty in sterilizing inflows, in the sense that the issue of domestic bonds drives up the local interest rate, the interest differential may be interpretable in large part as compensation for expected future depreciation.

Sahadevan (1999) attempts to analyze the impact of monetary policy on the behavior of rupee exchange rate and international reserves during the controlled floating of rupee in India. Study analyses the efforts made by Reserve Bank of India to offset the pressure that monetary shocks exert on exchange rates and reserves. Based on the estimates of Gorton -Roper model of exchange market pressure for the period between 1992:4 and 1999:3 by using Ordinary Least Square (OLS) method, the study examines the Reserve Bank of India's policy of maintaining exchange rate and reserves. Results indicate that Reserve Bank of India offsets though not completely the domestic monetary expansion (contraction) either by depreciation (appreciation) of rupee or by accumulating foreign exchange reserves or by some combination of both. The values of offset coefficient ranging between -0.81 and -0.93 show that the pressure on exchange rate and reserve level is partially neutralized by some other means. The controls on international trade and capital flows do provide effective protection from exchange market pressure.

Study by Siklos and Rogers (2001) provides an empirical assessment of the effectiveness of foreign exchange intervention in two small open economies. Study examine the intervention practices of the Reserve Bank of Australia and the Bank of Canada for a sample of daily data ranging from 1989 to the end of 1997. Results suggest that both central banks intervene in foreign exchange markets in response to excessive exchange rate volatility and uncertainty. In the study Volatility is measured by using the implied volatility of foreign currency futures options and uncertainty is proxied using the kurtosis of the implied risk-neutral probability density functions. The latter are derived using the implied volatility of options on foreign currency futures.

By using these techniques the authors find that central bank intervention in the foreign exchange market was largely unsuccessful in both countries though volatility and kurtosis were reasonably affected. The intervention reaction function estimates for Canada shows that the BoC and the RBA 'leaned against the wind'. The author found that foreign exchange activities of the BoC had no effect on implied volatility or uncertainty of extreme outcomes. While RBA interventions reduced implied volatilities but had no impact on kurtosis. As a result, intervention is not very ineffective at influencing the higher moments in the distribution of exchange rates.

Carlson and Hernández (2002), in an article studied the Mexican, Asian, and Russian crises of the mid- and late 1990s. Authors studied the determinants and effects of private capital flows. To test whether policy and real factors affect different types of the capital inflows, study have used panel data set. The data consist of annual

observations from 1991 to 1998 for the sample of 16 countries. Study uses a panel data regression with fixed effects for each country and the seemingly unrelated regression technique (SUR) on a pooled sample with country and year dummies.

This paper analyzes whether policies can affect the composition of capital inflows and whether different compositions worsen crises. Study found that while fundamentals matter, capital controls can affect the mix of capital inflows that countries receive. Study also finds that during the Asian crisis countries with more Yen denominated debt fared worse, while during the Mexican crisis larger short-term debt stocks increased the severity of the crisis.

Study also find that the currency value of debt, affected the severity of country's experiences during the Asian crisis, possibly because debt value was not matched to the country's exchange rate pegs and the debt was appreciating in value. Author also finds that in the Mexican crisis, there is some evidence that excessive amount of short-term debt to reserves led to the crisis. If exchange rate floats freely it will lead to increase the share of short-term debt in total capital inflows. Inversely by imposing restrictions on capital transactions, will tend to increase the share of Foreign Direct Investment.

The study by King (2002) concludes that foreign exchange intervention strategies should be chosen according to the objective for intervention. Author argues that inability of empirical studies to consider how objectives for intervention might vary over time is a shortcoming of this literature. According to study, change in objectives over time and the lack of data on why monetary authorities intervene, is a short coming of the this literature. In this study two categories of objectives are identified, policy objectives and tactical objectives. Policy objectives are longer-term in nature and concerned with the macro economy. Intervention to support policy objectives should be announced, supported by macro economic policy, coordinated with other monetary authorities.

Tactical objectives for intervention are short term and are concerned with the fluctuations of the foreign exchange market, such as the volatility or price action of the currency. Intervention to support tactical objectives should be conducted secretly, in large size and timed to take advantage of supportive economic releases. Study argue that secrecy may be desired in theory, in practice it is hard to obtain because of the dynamics of the foreign exchange markets. King (2002)

Buscaglia (2003), model a general equilibrium framework for the relationship between the sterilization of capital inflows and balance of payments crises. Study shows that, an attempt to sterilize capital inflows in an economy facing a temporary decrease in the international interest rate, leads the economy to a balance of payment crises, while a pure Currency Board would handle it in a better manners. Study raises many objections on sterilization. It argues that it worsen the finances of the public sector. The Author have also shown that in the context of perfect foresight and perfect capital mobility sterilization is not effective in reducing the current account deficit. The results of the study suggest that BOPC are caused by an effort to sterilize the capital inflows that would follow from a temporary decrease in the international interest rate. It also analyze this argument empirically, which depends on the the magnitude of the interest rate decrease and time-extension.

The study by Qayyum and Khan (2003) has estimated domestic credit policy reaction function to analyze the monetary implications of interventions and sterilization policy in Pakistan. The study has used quarterly data ranging from 1982-3 to 2001-2. Johansen multivariate co integration technique has been used in this study. The study found the central bank of Pakistan exercised the sterilization policy in Pakistan. The study estimated degree of sterilization about 72 percent in the long run. Further study applied error correction model and estimate that in the short run about 11 percent adjustments takes place towards the long run equilibrium. The results of error correction model also indicate that about 88 percent sterilization has taken place in the short run. The study also indicates that short run elastic ties are greater than the long run elastic ties.

Cardarelli *et al.* (2009), focused on a large group of emerging and advanced economies to examine the macroeconomic implications and policy responses to surges in private capital inflows over the period of 1987–2007. They found that episodes of large capital inflows to those countries are often associated with real exchange rate appreciations and deteriorating current account balances. They found that during episodes by keeping public expenditure growth steady can help limit real currency appreciation and foster better growth outcomes in their aftermath. Furthermore, resisting nominal exchange rate appreciation through sterilized intervention is likely to be ineffective when the influx of capital is persistent. Finally tightening capital controls has not in general been associated with better outcomes.

Igor Ljubaj, *et al.* (2010) explore the Croatian National Bank response to capital inflows in the period from 2000 to 2009 by estimating a sterilization coefficient, and to explore to what degree the central bank's activities in the domestic market spurred additional capital inflows by estimating an offset coefficient. They applied two stage

least square Method (2SLS) to find the relevant explanatory variables that enabled the estimation of the mentioned coefficients. According to the estimated coefficients they concluded that during the period 2000 to 2009 the Croatia national bank conducted a policy of partial sterilization of foreign inflows. Their estimated coefficients indicate that the central bank managed to preserve the relatively high autonomy and efficiency of its sterilization policy despite the liberalization of capital flows and their continued strengthening.

3. Model Specification and Data

The model for the estimation of degree of sterilization is taken from Qayyum and Khan (2003). To examine the degree of sterilization, it is necessary to drive a domestic credit policy reaction function. The reaction function can be derived from two equations, which summaries the monetary approach to balance of payments.

$$M_t^d = AY_t^{\beta_1} Q_t^{\beta_2} \exp(\beta_3 i_t + \beta_4 i_t^* + u_t) \quad (1)$$

$$M_t^s = \kappa(D + R)_t \quad (2)$$

In equation (1) M_t^d is money demand, Y represents real income, Q real exchange rate, i domestic interest rate, i^* foreign interest rate, $\beta_1, \beta_2, \beta_3, \beta_4$ are assumed to be constant elastic ties, A is scale factor.

In equation (2) Ms is money supply, k represents money multiplier, D is domestic components of monetary base and R denotes foreign components of monetary base. In equation (1) money demand M_t^d is a function of real income (Y), real exchange rate (Q), domestic interest rate (i) and foreign interest rate (i^*). The parameters $\beta_1, \beta_2, \beta_3, \beta_4$ are assumed to be constant elastic ties and A is scale factor.

So in equation (2) money supply (Ms) is composed of money multiplier (k) of domestic (D) and foreign components (R) of monetary base.

From equation (2) we obtain

$$D_t = \frac{1}{\kappa}(M_t^s) - R_t$$

Which demonstrates the link between domestic credit and foreign exchange reserves. When the central bank buys foreign currency from the foreign exchange market, R goes up. The rise in R can be sterilized by reducing the central bank's credit holdings D . if the change in R is fully matched by an offsetting change in D , there is no change in Ms . Assuming monetary equilibrium where $M^s = M^d$, we have

$$D_t = \frac{1}{\kappa}(M_t^d) - R_t \quad (3)$$

Taking logarithms of equation (3) we obtain

$$\ln D_t = \ln M_t^d - \ln \kappa - \ln R_t \quad (4)$$

Using logarithms of equation (1) and substituting in equation (4) we get the following equation

$$\ln D_t = \ln A + \beta_1 \ln Y_t + \beta_2 \ln Q_t + \beta_3 i_t + \beta_4 i_t^* - \ln \kappa - \ln R_t + u_t \quad (5)$$

we can write equation(5) in the following estimable form

$$d_t = \beta_0 + \beta_1 y_t + \beta_2 q_t + \beta_3 i_t + \beta_4 i_t^* + \beta_5 m_t + \beta_6 r_t + u_t \quad (6)$$

where lower case letters represents the logarithms of variables involved in equation (5), $\beta_0 = \ln A$ and m_t is the logarithm of money multiplier and u_t is the error term.

The co-efficient of r_t i.e. β_6 is called as the sterilization coefficient. It measures the thrust of monetary policy to sterilize the impact of international reserve flow on the monetary base. The value of sterilization coefficient ranges from 0 to -1. If the value is 0, it means no sterilization. If the value is -1 it shows full sterilization. In our model sterilization co-efficient is β_6 . If the value of sterilization coefficient β_6 is 0, then no sterilization has taken place. If $\beta_6 = -1$, sterilization is complete. But when the results of regression are such that $-1 < \beta_6 < 0$, sterilization is conducted incompletely by the central bank. Equation (6) may be subject to simultaneous bias. However, using multivariate co integration techniques, we can obtain unbiased long run elastic ties of the determinants of money demand and monetary base.

3.1 Estimation of Error-correction Model

In our above analysis if there exist long run co integration relationship between the variables, then the performance of the domestic credit policy reaction function can be improved by introducing short run dynamics into the static model. According to Granger (1987) representation theorem, if a co integration relationship exist between series of I(1) variables, then a dynamic error-correction representation also exist. The general form of the error correction model can be written as

$$\Delta d_t = \alpha + \sum_{i=1}^{k-1} \beta_i \Delta d_{t-i} + \sum_{i=0}^{k-1} \gamma_i \Delta y_{t-i} + \sum_{i=0}^{k-1} \delta_i q_{t-i} + \sum_{i=0}^{k-1} \theta_i i_{t-i} + \sum_{i=0}^{k-1} \eta_i i^*_{t-i} + \sum_{i=0}^{k-1} \tau_i \Delta m_{t-i} + \sum_{i=0}^{k-1} \lambda_i \Delta r_{t-i} + \phi \varepsilon_{t-i} + \mu_t$$

Where (i=1,2,3,4), and ϕ is the speed of adjustment.

Error correction term ε_t is given by

$$\varepsilon_t = d_t - \hat{d}_t$$

3.2 Data Description

For the empirical analysis we used the quarterly data ranging from 1980Q1 to 2007Q1. Domestic credit (d) is calculated by taking the difference between the central bank reserve money and gross foreign assets. International reserves (r) excluded gold is defined in domestic currency. For domestic interest rate (i) interbank call money rate is used and foreign interest rate (i^*) United State's Federal Fund rate is used. Real exchange rate is calculated as ($q = s + p^* - p$), where (s) is the annual average exchange rate and (p^*) is the US WPI and (p) is Pakistan's WPI. Money multiplier (m) is obtained from dividing reserve money by M2. All the data are taken from various issues of International Financial Statistics (IFS). Except domestic and foreign interest rates all other data is expressed in logarithms form.

4. Estimation Techniques and Results

To estimate the time series data we will first check the stationarity of the variables to obtain reliable estimates. To check the stationary level of the variables we apply Augmented Dickey-Fuller (ADF) test. If all the variables are I(1) stationary, we will apply co integration test to check for any long run co integration relationship between one or more variables by using Johansen (1988) and Johansen and Juselius (1990) multivariate technique. Then to get the significant values of target variables, the model will be estimated by using OLS estimation technique to estimate long run adjustments coefficients of the variables. Finally we will estimate short run error correction model by using Hendry's general to specific methodology to get short run adjustment coefficient.

4.1 Pakistan

For the purpose of estimation, the time series data should be stationary. Generally time series data on variables is non-stationary at levels (at 1% critical values). A non-stationary series becomes stationary when difference d times, is said to be integrated of order d , can be shown as $X \sim I(d)$. We have used Augmented Dickey-Fuller (ADF) test to obtain stationery value of the variables. Table 1 shows the results of Augmented Dickey-Fuller (ADF) test at levels and at first difference.

[Insert Table 1 here]

Table 1 shows that all the variables are non-stationary at levels at 1% critical value and they are stationary at I(1) at 1% critical value, it means that $(d, I^*, I, m, q, r, y) \sim I(1)$. As all the variable are I(1) stationary so there is possibility of long term co integration relationship between the variables

4.2 Japan

The Augmented Dicky Fuller test is applied on variables of Japan. All the variables for Japan tend to non stationary at levels. The results of unit root test for Japan are presented in table 2

[Insert Table 2 here]

The results of ADF test shows that all the variables are non stationary at levels and become stationary at the first difference. It means that all the variable are I(1) stationary for Japan.

4.3 Korea

The time series data on variables is non-stationary at levels at 1% critical values. Augmented Dickey- Fuller (ADF) test is used to determine the stationery value of the variables. Results are shown in the table 3

[Insert Table 3 here]

The above table shows that all the variables are non-stationary at levels at 5% critical value and they are stationary at I(1), it means that $(d, I^*, I, m, q, r, y) \sim I(1)$

4.4 Philippines

For the purpose of estimation, the time series data on variables is non stationery at levels at 1% critical values. The Table 4 shows the results of the variables at levels and at first difference for Philippines

[Insert Table 4 here]

The table 4 shows that all the variables are non-stationary at levels at 5% critical value and they become stationary at I(1), it means that $(d, I^*, I, m, q, r, y) \sim I(1)$ for Philippines

5. Co integration Analysis

For a time series data which is I(1) stationary, to check the co integration between the variables the Jahonsen (1988) and Johansen and Juselius(1990) multivariate technique is used. This technique uses likelihood ratio and eigenvalues to determine the co integration relationship. Likelihood ratio test uses the null hypothesis that there are at most r co integration vectors against the alternative of $r+1$ co integration vectors. The results are reported in Table 9. The value of R square shows the good fit of the model for all the countries. While Durban Watson d statistic indicates that there is no autocorrelation in the data for all the countries in the sample. F-test also validates the significance of the models for all countries. The detailed description of results is given below:

5.1 Co integration test for Pakistan

The following table shows the results of co integration analysis for Pakistan:

[Insert Table 5 here]

Results in above table reject the null hypothesis of no co integration relation ship and indicate that there is one co integration relationship exist at 5% level of significance. It means that there exists long-term relation ship between variables.

5.2 Co integration test for Japan

As all the variables of Japan are I(1) stationary so we applied co integration test to the data series. Results are reported in the following table 6.

[Insert Table 6 here]

Results in table 6 rejects the null hypothesis of no co integration between the variables and shows that there are two co integration equations at 5% significance level.

5.3 Co integration test for Korea

To test for any long run relationship among one or more variables, co integration test is applied to the data. Results are presented in the following table.

[Insert Table 7 here]

The results in above table reject the null hypothesis of no co integration and indicate that there is one co integration equation among the series of data at 5% significance level.

5.4 Co integration test for Philippines

Results of co integration analysis are reported in the following Table 8.

[Insert Table 8 here]

The above results reject the null hypothesis of no co integration for Philippines and indicate that there two co integration equation at 5% significance level.

6. Long Run Estimates of sterilization

In the following table 9 we have presented the results of co integration equations for our sample countries.

[Insert Table 9 here]

The above table presents the results obtained by regressing independent variables on domestic credit d , To get long run sterilization coefficient for the period of study.

The above table shows that all the variables are statistically significant. Sterilization coefficient of r shows that the state bank of Pakistan sterilized the foreign capital inflow approximately 0.83. It means that central bank sterilized its foreign exchange reserves approximately 83 percent over the period of study.

The results shown in the above table show that all the coefficient of variables are significant at 5% level of significance except the coefficient of domestic interest rate (i).

For Japan, the coefficient of sterilization (β_6) is estimated about -0.39193 which shows that the central bank of Japan sterilized about 61 percent of its capital inflows over the period of study.

For Korea, except for the coefficient of variable q all the coefficients of variables in the above table are statistically significant at 5% level of significance. The coefficient of sterilization is -0.74382 indicating that the degree of sterilization in Korea is 0.26. or Korea sterilized its foreign capital inflows by 26%.

Finally for Philippines, the above table the coefficient of sterilization is estimated about -0.43608 and is statistically significant. It means that the central bank of Philippines sterilized about 56 percent of its foreign capital inflows in the long run.

7. Error correction Model for domestic credit reaction function

The above model shows the static behavior of the variable over the data period. To introduce short run dynamics in the model and to estimate short run adjustment coefficients for all sample countries we estimated an error correction model. According to Granger (1987) representation theorem, if there exist co integration relationship between $I(1)$ series of variables, then a dynamic error-correction representation also exist. By using Hendry's general to specific methodology, the following results have been obtained.

[Insert Table 10 here]

The value of R square shows the fit of the models is good for all the countries. While Durban Watson d statistic indicates that there is no autocorrelation in the data for all the countries in the sample. The detailed description of results is given below:

In the table 10 almost all the variables are statistically significant at 5% level of significance except the coefficients of q with all its lags, $y(-1)$, and $I^*(-2)$. For Pakistan, the estimate of error correction term is 0.162523, which means that in one quarter about 16 percent adjustment takes place towards long run equilibrium. On the other hand the coefficient of foreign exchange reserves is -0.104523 , which shows that the state bank of Pakistan sterilizes 88 percent of its capital inflows in the short run.

The short run adjustment coefficient is estimated by estimating error correction model for Japan. In the table above, the adjustment coefficient is statistically insignificant. Other wise it indicate that there is very little (0.0000107) adjustment takes place in every quarter towards long run equilibrium. Short run coefficient of foreign exchange reserves is estimated about -0.589545 , which means that central bank of Japan sterilized its foreign exchange inflows by 59% in the short run.

The estimate of Error correction Model for domestic credit reaction function for Korea shows that short run adjustment coefficient, $E(-1)$, is -0.969789 which shows that 97% adjustment towards long run equilibrium in a quarter took place. The coefficient of foreign exchange reserves is estimated about -0.75894 , which shows that the central bank of Korea sterilized about 24 percent of its foreign capital inflows in the short run.

For Philippines, the results above show that in the short run adjustment coefficient is about 0.985045. It means that about 99 percent adjustment toward the long run equilibrium takes place in one quarter. The coefficient of

foreign exchange reserves is -0.44455, which implies that central bank of Philippines, sterilized about 56 percent of its foreign capital inflows in the short run.

8. Summary and Conclusions

The study was mainly focused on estimation of monetary policy reaction function and degree of sterilization for the sample comprising of Pakistan, Korea, Philippines and Japan by using quarterly data ranging from 1980-1 to 2007-08. The study has used Johansen multivariate co integration technique. We conclude that over the period of study all the central banks of these countries have conducted a strong sterilization policy, but not fully sterilized the capital inflow. These countries have used the sterilization policy, though it is different in magnitude for different countries.

[Insert Table 11 here]

Summary of results in above Table 11 shows that sterilization coefficient over the sample period, for the selected countries, varies from 0.26 to 0.83. While in the short run it ranges from 0.24 to 0.88. Pakistan has sterilized most of its foreign capital inflows, as its coefficient of sterilization is highest in the long run (0.83) and in the short run (0.88). While the sterilization coefficient for Korea indicate that Korea has sterilized very less of its foreign capital inflows as its coefficient of sterilization estimated is 0.26 and 0.24 in the short and long run respectively. The short run adjustment coefficient to the long run equilibrium is lowest in Pakistan (0.16) and highest in the case of Philippines (0.99).

In the long run, the response of the industrial economy like Japan shows that it has sterilized about 61 percent of its foreign capital inflows, while in the cluster of non-industrial countries also showed a mixed response to the capital inflows in the long run. The degree of sterilization for Pakistan is estimated about 83 percent, while for Korea and Philippines it is about 26 percent and 57 percent respectively. It indicates that in all the economies whether they are agriculture or non-agriculture they sterilized their capital inflows in the long run.

Short run adjustment towards the long run equilibrium shows high value of adjustment for Korea and Philippines while for Pakistan it shows very little adjustment. For Pakistan it exhibits very short term policies to control for its monetary base. There may be some policy issues to expand the monetary base as it could be seen from current huge inflationary pressure on the economy. On the other hand Korea and Philippines has shown a comprehensive adjustment policies towards long term adjustment or it have long term monetary policy stances.

References

- Calvo, Guillermo A., Leonardo Leiderman, and Carmen Reinhart. (1993). Capital Inflows and Real Exchange Rate Appreciation in Latin America. The Role of External Factors. IMF Staff Papers, Vol. 40, March 1993.
- Calvo, Guillermo A., Leonardo Leiderman, and Carmen Reinhart. (1994). Inflows of Capital to Developing Countries in the 1990s: Causes and Effects. Working Paper 301, Office of the Chief Economics, Inter-American Development Bank.
- Celasun, O., C. Denizer, and D. He. (1999). Capital Flows, Macroeconomic Management and Financial System, Turkey 1989-97, World Bank.
- Cumby, Robert and Maurice Obstfeld. (1983). Capital Mobility and the Scope for Sterilization: Mexico in the 70's, in Financial Policies and the World Capital Market: the Problem of Latin American Countries, Pedro Aspe, Rudiger Dornbusch and Maurice Obstfeld, editors.
- Dominguez, Kathryn and Jeffrey Frankel. (1993b). Does Foreign-Exchange Intervention Matter? The Portfolio Effect. *American Economic Review*, 83 (5), 1356-69.
- Emir, O. Y., A. Karasoy, and K. Kunter. (2000). Monetary Policy Reaction Function in Turkey. Central Bank of the Republic of Turkey, October 2000.
- Guillermo A. Calvo, Leonardo Leiderman, and Carmen M. Reinhart. Inflows of Capital to Developing Countries in the 1990s: Causes and Effects. Inter-American Development Bank Working Paper 302.
- Igor Ljubaj, Ana Martinis and Marko Mrkalj. (2010). Capital Inflows and Efficiency of Sterilization Estimation of Sterilization and Offset Coefficients. Croatian National Bank.
- International Monetary Fund. (Various issues). *International Financial Statistics (IFS)*.
- Jan A., A. Elahi, and M. A. Zahid. (2005). Managing Foreign Exchange Inflows: An Analysis of Sterilisation in Pakistan. *The Pakistan Development Review*, 44:4, pp. 777-792.

Jeffrey A. Frankel and Chudozie Okongwu, (1996). Liberalized Portfolio Capital Inflows in Emerging Markets: Sterilization, Expectations, and the Incompleteness of Interest Rate Convergence. Department of Economics, University of California, Berkeley,

Johansen, S. (1988). Statistical Analysis of Cointegration Vector. *Journal of Economic Dynamics and Control*, 12, 231-254. doi:10.1016/0165-1889(88)90041-3, [http://dx.doi.org/10.1016/0165-1889\(88\)90041-3](http://dx.doi.org/10.1016/0165-1889(88)90041-3)

Johansen, S., and K. Juelius. (1990). Maximum Likelihood Estimation and Inference of Cointegration—with Application to the Demand for Money. *Oxford Bulletin of Economics and Statistics*, 52, 169-210. doi:10.1111/j.1468-0084.1990.mp52002003.x, <http://dx.doi.org/10.1111/j.1468-0084.1990.mp52002003.x>

K.G. Sahadevan, (1999). Foreign Exchange Market Intervention and Neutralization: the Indian experience under controlled floating of rupee. Indian Institute of Management, Prabandh Nagar, Off Sitapur Road, Lucknow – 226 013, INDIA.

Kaminsky, Graciela and Karen Lewis. (1996). Does foreign exchange intervention signal future monetary policy. *Journal of Monetary Economics*, 37: 285-312. doi:10.1016/S0304-3932(96)90038-0, [http://dx.doi.org/10.1016/S0304-3932\(96\)90038-0](http://dx.doi.org/10.1016/S0304-3932(96)90038-0)

Kouri, P., and R. Porter. (1974). International Capital Flows and Portfolio Equilibrium. *Journal of Political Economy*, Vol. 82, pp. 443-467. doi:10.1086/260207, <http://dx.doi.org/10.1086/260207>

Marcos A. Buscaglia. (2003). Sterilization of Capital Inflows and Balance of Payments Crises. IAE School of Management and Business. Mariano Acosta y Ruta Nac. 8, Casilla de Correo 49. B1629WWA Pilar, Provincia de Buenos Aires, Argentina.

Mark Carlson and Leonardo Hernández. (2002). Determinants and Repercussions of the Composition of Capital Inflows. International Finance Discussion Papers, Number 717, January 2002, Board of Governors of the Federal Reserve System.

Menzie D. Chinn and Michael P. Dooley (1997). Financial Repression and Capital Mobility: Why Capital Flows and Covered Interest Rate Differentials Fail to Measure Capital Market Integration. Monetary and Economic Studies/December, University of California, Santa Cruz, and National Bureau of Economic Research.

Michael R. King. (2003). Effective Foreign Exchange Intervention: Matching Strategies with Objectives. Bank of Canada, International Finance.

Qayyum Abdul and Muhammad Arshad Khan. (2003). Capital Flows and Money Supply: The Degree of Sterilisation in Pakistan. *The Pakistan Development Review*, Pakistan Institute of Development Economics, Vol. 42(4), 975-985.

Ramon Moreno. (1996). Intervention, sterilization, and monetary control in Korea and Taiwan. *Economic Review*, Federal Reserve Bank of San Francisco, 23-33.

Roberto Cardarelli, Selim Elekdag, and M. Ayhan Kose. (2009). Capital Inflows: Macroeconomic Implications and Policy Responses. IMF Working Paper WP/09/40, Asia and Pacific Department and Research Department, International Monetary Fund.

Siklos, P. L. (2001). Capital Flows in a Transitional Economy and the Sterilization Dilemma: The Hungarian Experience, 1992-97. *Policy Reform*, Vol. 3, 373-392. doi:10.1080/13841280008523411, <http://dx.doi.org/10.1080/13841280008523411>.

State Bank of Pakistan (various issues).

Table 1. Unit root tests for Pakistan with no intercept & no trend

Variable	ADF Statistics at level	ADF Statistics at Ist difference	Stationarity level
D	0.313652	-11.50048	I(1)
I*	-2.044412	-8.690175	I(1)
I	-1.329426	-13.23882	I(1)
M	0.198384	-11.37810	I(1)
Q	-0.608593	-6.493757	I(1)
R	1.280481	-8.790565	I(1)
Y	0.734055	-20.91835	I(1)

Critical value at 5%=-1.9437, Critical value at 1%=-2.5888, The critical values are given by Mackinnon (1991)

Table 2. Unit root tests for Japan with no intercept & no trend

Variable	ADF Statistics at level	ADF Statistics at Ist difference	Stationary level
D	0.7089	-15.2829	I(1)
I*	-2.0585	-8.7371	I(1)
I	-2.0741	-8.3972	I(1)
M	-0.6087	-14.2327	I(1)
Q	-0.8559	-7.5183	I(1)
R	4.9850	-5.7677	I(1)
Y	7.0551	-4.7019	I(1)

Critical value at 5%=-1.9437, Critical value at 1%=-2.5888, The critical values are given by Mackinnon (1991)

Table 3. Unit root tests for Korea with no intercept & no trend

Variable	ADF Statistics at level	ADF Statistics at Ist difference	Stationarity level
D	0.029443	-11.62484	I(1)
I*	-2.105822	-8.931002	I(1)
I	-1.972400	-7.669510	I(1)
M	1.072188	-11.37109	I(1)
Q	1.356671	-7.127252	I(1)
Y	2.213028	-16.78486	I(1)
R	3.532507	-8.909572	I(1)

Critical value at 5%=-1.9437, Critical value at 1%=-2.5888, The critical values are given by Mackinnon (1991)

Table 4. Unit root tests for Philippines with no intercept & no trend

Variable	ADF Statistics at level	ADF Statistics at Ist difference	Stationarity level
D	-1.319953	-9.966841	I(1)
I*	-2.105822	-8.931002	I(1)
I	-1.303822	-11.55090	I(1)
M	0.106228	-9.536210	I(1)
Q	-0.609141	-7.777341	I(1)
R	1.109264	-12.84024	I(1)
Y	1.609095	-15.61886	I(1)

Critical value at 5%=-1.9437, Critical value at 1%=-2.5888, The critical values are given by Mackinnon (1991)

Table 5. Results of Co integration Analysis for Pakistan (Series: d, i^*, i, m, q, y, r)

Eigenvalue	Likelihood Ratio	5%critical value	1% critical value	Hypothesized No of CE(s)
0.617605	174.4607	109.99	119.80	None**
0.340762	90.82757	82.49	90.45	At most 1
0.215091	54.57719	59.46	66.52	At most 2
0.163431	33.50687	39.89	45.58	At most 3
0.124267	17.982	24.31	29.75	At most 4
0.038339	6.437644	12.53	16.31	At most 5
0.034301	3.036535	3.84	6.51	At most 6

H_0 : No cointegration exists between variables

*(**) denotes rejection of the hypothesis at 5%(1%) significance level, No intercept no trend in the data

Table 6. Co integration test for Japan

Series: (d, i^*, i, m, q, y, r)

Eigenvalue	Likelihood Ratio	5%critical value	1% critical value	Hypothesized No of CE(s)
0.4935	168.9931	109.99	119.80	None**
0.4046	107.7714	82.49	90.45	At most 1**
0.2243	61.0956	59.46	66.52	At most 2
0.1776	38.2383	39.89	45.58	At most 3
0.1531	20.6461	24.31	29.75	At most 4
0.0586	5.6926	12.53	16.31	At most 5
0.0029	0.2597	3.84	6.51	At most 6

H_0 : No cointegration exists between variables

*(**) denotes rejection of the hypothesis at 5%(1%) significance level, No intercept no trend in the data

Table 7. Co-integration test for Korea

Series: (d, i^*, i, m, q, y, r)

Eigenvalue	Likelihood Ratio	5%critical value	1% critical value	Hypothesized No of CE(s)
0.631176	246.3588	109.99	119.8	None**
0.550987	151.6023	82.49	90.45	At most 1
0.306432	75.53553	59.46	66.52	At most 2
0.250341	40.77443	39.89	45.58	At most 3
0.090441	13.40147	24.31	29.75	At most 4
0.041797	4.395877	12.53	16.31	At most 5
0.00357	0.339784	3.84	6.51	At most 6

H₀: No cointegration exists between variables

*(**) denotes rejection of the hypothesis at 5%(1%) significance level, No intercept no trend in the data

Table 8. Co integration test for Philippines

Series: (d, i^*, i, m, q, y, r)

Eigenvalue	Likelihood Ratio	5%critical value	1% critical value	Hypothesized No of CE(s)
0.323099	117.4309	109.99	119.8	None *
0.308557	85.04186	82.49	90.45	At most 1 *
0.232592	54.41699	59.46	66.52	At most 2
0.18112	32.44382	39.89	45.58	At most 3
0.126046	15.85898	24.31	29.75	At most 4
0.054785	4.676616	12.53	16.31	At most 5
1.99E-06	0.000165	3.84	6.51	At most 6

H₀: No co integration exists between variables, *(**) denotes rejection of the hypothesis at 5%(1%) significance levelTable 9. Results of Regression estimates (Dependent variable d)

Variables	Pakistan	Japan	Korea	Philippines
C	-4.018 (-2.39)	-8.087 (-6.15)	0.500 (1.73)	3.327 (5.24)
I^*	-0.023 (-3.32)	0.002 (1.28)	-0.005 (-2.67)	0.006 (0.84)
I	0.016 (2.54)	0.000 (0.17)	-0.001 (-1.59)	0.000 (0.55)
M	1.099 (2.38)	1.642 (19.95)	0.719 (10.28)	1.754 (17.48)
Q	-1.355 (-2.66)	-0.329 (-4.45)	0.056 (0.54)	0.106 (0.41)
Y	2.508 (12.43)	2.303 (4.54)	0.680 (17.16)	8.000 (0.82)
R	-0.167 (-3.18)	-0.391 (-9.36)	-0.743 (-34.26)	-0.436 (-9.66)
R Square	0.90	0.97	0.99	0.97
$D.W.$ Stat	1.70	2.17	1.84	1.93
F-statistic	139.50 (0.00)	491.17 (0.00)	1820.81 (0.00)	375.09 (0.00)

Note: t-value is given in parenthesis

Table 10. Error Correction Estimates

Variable	Pakistan	Japan	Korea	Philippines
D(-2)	1.080 (7.77)	0.434 (4.91)	0.038 (3.29)	0.973 (211.49)
D(-3)	-0.283 (-1.94)	0.189 (4.14)		
E(-1)	0.162 (1.27)	0.000 (0.00)	0.969 (77.03)	0.985 (125.76)
I*(-1)	0.005 (1.05)		-0.005 (-26.89)	0.002 (8.81)
I*(-2)	-0.003 (-0.69)	0.002 (1.62)		
I*(-3)	0.006 (1.35)			-0.002 (-5.25)
I*(-4)	-0.004 (-1.16)		-0.000 (-1.85)	-0.000 (-0.95)
I	0.003 (1.56)		-0.001 (-8.73)	
I(-1)		0.011 (1.98)		0.000 (7.35)
I(-2)		-0.014 (-2.48)		-0.000 (-8.19)
M(-1)	0.959 (3.64)	1.723 (20.27)	0.719 (80.97)	1.749 (228.41)
M(-2)	-1.296 (-4.02)	-0.696 (-4.08)	-0.043 (-2.77)	-1.705 (-186.03)
M(-3)	0.298 (1.07)		-0.013 (-2.07)	
Q(-1)	0.214 (0.50)	-0.322 (-1.51)	0.049 (3.00)	0.105 (6.15)
Q(-2)	0.231 (0.42)		-0.085 (-4.27)	-0.111 (-6.53)
Q(-3)	-0.272 (-0.74)		0.055 (3.75)	
R(-1)	-0.104 (-3.25)	-0.589 (-5.08)	-0.758 (-152.6)	-0.444 (-144.9)
R(-2)	0.106 (2.80)	0.318 (2.77)	0.044 (3.91)	0.430 (112.79)
R(-3)	-0.034 (-1.02)			
Y(-1)	-0.175 (-0.52)	0.990 (4.17)	0.651 (74.86)	7.988 (11.96)
Y(-2)	0.208 (1.74)			-0.008 (-11.17)
Y(-3)	0.296 (2.43)			
C	-1.687 (-1.63)	-2.661 (-2.47)	0.577 (17.11)	0.122 (4.33)
R-squared	0.99	0.98	0.99	0.99
D-W. stat	1.85	1.97	1.76	2.37

Note: t-value is given in parenthesis

Table 11. Summary of results

Countries	Long run sterilization coefficient	Short run sterilization Coefficient	Short run adjustment coefficient
Pakistan	0.83	0.88	0.16
Japan	0.61	0.59	Insignificant
Korea	0.26	0.24	0.97
Philippines	0.56	0.56	0.99