Exchange Market Pressure and Monetary Policy: A Case Study of Pakistan

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Abstract

Exchange Market Pressure refers to money market disequilibrium that arises due to non-zero excess demand for domestic currency in the foreign exchange market. Exchange rate changes reflect the extent of market pressure in the absence of Central Bank intervention. It is argued that nominal exchange rate changes have consequences for domestic macroeconomic variables. These include domestic output growth, increase in domestic prices, balance of trade, firms' price-setting behaviour in high inflation countries, foreign debt burden of the country, balance of payments and the stability of the domestic financial system. It has been observed that the Central Banks generally intervene in the foreign exchange market to avoid these undesirable consequences of exchange rate changes. In this thesis, we construct exchange market pressure and intervention index for Pakistan using Weymark's (1995) approach. The basic objective is to identify whether it is downward or upward pressure that has remained dominant over the entire sample period. Based on intervention index values, we evaluate the Central Bank's monetary policy over the given sample period. In addition, we also calculate the actual exchange rate and predicted exchange rate using one period lagged exchange rate. We check whether monetary policy is successful in its objective of reducing exchange rate volatility. Finally, we also evaluate the determinants of exchange market pressure in a panel of ten countries. The first empirical chapter utilises difference data and the two-stage least square approach. In the second empirical chapter we adopt Johansen's (1988) cointegration approach. Both of these provide evidence of downward pressure and active Central Bank intervention. Furthermore, these chapters show that the Central Bank's foreign exchange intervention policy is fairly successful in achieving its objective of reducing exchange rate volatility. The initial empirical chapters use a fixed parameter approach. This has the disadvantage that it does not allow the estimated parameters to take account of structural changes. A third empirical chapter addresses this issue and uses the Kalman Filter Time Varying Parameter approach. This has

the advantage of allowing the parameters to take account of the effects of structural changes on parameter constancy. The results show unstable estimated parameters. The constructed exchange market pressure and intervention index show downward pressure and the active Central Bank intervention. Thus, this chapter further confirms our earlier findings of downward pressure and active Central Bank intervention. However, despite unstable estimated parameters, Central Bank intervention policy is successful in reducing exchange rate volatility which is unexpected. In the earlier empirical chapters, we assumed direct Central Bank intervention. However, there may be the case that Central Bank may use interest rate for fending off speculative attack. In such a case it is better to include interest rate as component of exchange market pressure to truly reflect the extent of foreign exchange market disequilibrium. Last empirical chapter overcomes this issue and uses Eichengreen et al. (1996) approach for constructing exchange market pressure. It consists of percent changes in exchange rate, relative interest rate differential and relative percent changes in foreign exchange reserves. Furthermore, in this chapter, we evaluate the determinants of exchange market pressure in a panel of ten countries. The results indicate the relevancy of some macroeconomic variables and measures of openness.

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Declaration

I hereby confirm that the work here in this thesis is the result of four year of my hard work and has not been submitted for any other degree at Glasgow University or any other institution.

Signature

Muhammad Akram Gilal

Chapter One

1.1 Introduction

In this thesis, we examine Exchange Market Pressure in the Foreign Exchange Market. We consider, although not exclusively, Exchange Market Pressure in Pakistan and evaluate the monetary authority's response to prevailing market pressure. In particular, we focus upon whether the Pakistani currency has on average experienced pressure to depreciate or not over recent decades. We also consider what fraction of pressure the Pakistan Central Bank relieves through the purchase or sale of foreign exchange reserves. We also examine whether the Central Bank in Pakistan is successful in achieving its desired objective of reducing exchange rate volatility. Furthermore, we evaluate the determinants of Exchange Market Pressure in a panel of ten countries.

The collapse of the Bretton Wood fixed exchange rate system ushered in a substantial change in the international financial architecture. Alternative systems introduced included hard pegs, and floating and intermediate exchange rate arrangements. Hard pegs are also known as currency union, referring to one country adopting another country's currency, either as part of wider currency union or dollarising by formally entering into currency union. A floating exchange rate can refer to either a free float or a managed float. In this system, although a Central Bank freely intervenes in a foreign exchange market to avoid undesirable exchange rate fluctuations, it does not commit itself to any particular exchange rate level. An intermediate system consists of fixed exchange rate, crawling peg, exchange rate band, and crawling band. All these exchange rate arrangements involve Central Bank foreign exchange intervention to reduce pressure on the domestic currency. Fischer (2001) shows that the number of countries with an intermediate exchange rate declined from 98 in 1992 to 63 in 1999. Despite the falling number in the 1990s, there remain a considerable number of countries with an intermediate exchange rate system.

Exchange rate changes have important implications for key macroeconomic variables that include domestic output, unemployment, inflation, and balance of payments. Nominal exchange rate changes are fully reflected in domestic price changes, if Purchasing Power Parity (PPP) holds. This implies that a rise in the exchange rate (or domestic currency depreciation) increases domestic price of tradable goods in the consumer basket. Even if PPP does not hold, we could still expect some pass through from exchange rate changes to domestic prices. A nominal exchange rate plays an important role in price-setting behaviour in high inflation countries (Taylor, 2000). In a high inflation environment, firms pass on to customers the increase in cost that results from exchange rate changes. This further increases the domestic price level. Furthermore, the depreciation of one country currency results in the collapse of exchange rate regime of the second country; for example, in East Asian currency crises. Gerlach and Smets (1995) argue that a depreciation of one country's currency increases its competitiveness against its trading partners. This increases the trade deficit of the second country, reduces the foreign exchange reserves of the Central Bank and thus puts pressure on its exchange rate regime to collapse. Second, a currency depreciation for one country makes its exports cheaper in a second country. This reduces the overall price level and thus decreases demand for real money balances in the second country. Given that money supply is fixed, this leaves the second country's residents with excess monetary balances which they swap for foreign currency. This depletes the foreign exchange reserve of a second country's Central Bank and thus moves it from having no speculative attack equilibrium to one where it is profitable for speculators to launch speculative attacks (Eichengreen et al. 1996).

Nominal exchange rate changes are associated with movements in the real exchange rate when Purchasing Power Parity does not hold.[1] The real exchange rate determines both

[1] Nominal exchange rate is defined as the number of units of domestic currency per units of foreign currency. Hence. a rise in the exchange rate is also a domestic currency depreciation.

internal and external equilibrium and resource allocation in the economy.[2] Furthermore, changes in the real exchange rate determine a country's external competitiveness and thus the country's trade balance through its effect on import and export prices.

Exchange rate changes have an important effect on the balance sheet of domestic agents particularly firms and financial institutions, (see Krugman, 1999). Exchange rate shocks do not turn into a recession in economies with sound firm, household and financial sector balance sheets (Mishkin, 1998). Economies with weak balance sheets are more vulnerable to a speculative attack which translates into a severe recession. Foreign currency denominated debt of firms and financial institutions play an important role in the transmission of exchange rate shocks. Negative exchange rate shocks increase foreign currency liabilities and debt servicing of firms and financial institutions. This deteriorates their balance sheet and results in the collapse of financial institutions and firms. This leads to output loss and an increase in the unemployment rate.

1.2 Exchange Market Pressure

Two important concepts in this thesis are Exchange Market Pressure and Intervention. Exchange Market Pressure refers to foreign exchange market disequilibrium that arises due to non-zero excess demand for domestic currency in the foreign exchange market. It is reflected in exchange rate changes in the absence of Central Bank intervention; for example through changes in foreign exchange reserves or interest rate. In this study, we define Exchange Market Pressure as the exchange rate change that would have occurred in the absence of Central Bank intervention given the expectation generated by the actual exchange rate policy implemented. Frequently, a Central Bank intervenes in the foreign exchange market to avoid

[2] Real exchange rate can be defined as the relative price of tradable to nontradable goods. Alternatively, it can be defined as the nominal exchange rate adjusted for relative price differential (Edwards, 1989).

the undesirable influence of exchange rate changes on domestic macroeconomic variables.[3] In such a case, actual exchange rate movements do not fully reflect the extent of foreign exchange market pressure. The sum of exchange rate and foreign exchange reserve changes can better measure the prevailing pressure in the foreign exchange market when the Central Bank uses only foreign exchange reserves changes for relieving pressure on the currency. However, when a Central Bank intervenes indirectly by changing interest rate with the sole objective of influencing market pressure, then exchange rate, foreign exchange reserve and interest rate changes better reflect the extent of foreign exchange market pressure. An intervention index based on given exchange market pressure definition can be defined as the fraction of pressure that the Central Bank relieves either by selling or purchasing foreign exchange reserves or changing the interest rate or any combination of these.

Exchange Market Pressure measurement has remained an important part of the empirical literature on speculative attacks and currency crises. Blanco and Garber (1986) constructed a macroeconomic model that consists of real money demand, purchasing power parity and uncovered interest rate parity and applied this to the Mexican experience under a fixed exchange rate regime. They showed that devaluation occurs when foreign exchange reserves reach critical level and the shadow exchange rate exceeds the fixed exchange rate level.[4] The empirical Exchange Market Pressure and intervention index literature uses excess demand for domestic currency in examining the role that Central Bank allows market forces to play in determining the domestic currency value in the foreign exchange market. These studies include Girton and Roper (1977), Roper and Turnovsky (1980) and Weymark (1995). All these approaches are model-dependent because the components of Exchange Market Pressure

[3] Foreign exchange market intervention can be either sterilised or unsterilised. Sterilised foreign exchange intervention offsets the effects of foreign exchange reserve changes on domestic monetary base. On the other hand, unsterilised foreign exchange intervention does not offset the effects of foreign exchange intervention on domestic monetary base. It results changes in domestic monetary base equal to foreign exchange reserve changes.

[4] The critical foreign exchange reserve level refers to a level when Central Bank stops intervening in the foreign exchange market.

are derived using a macroeconomic model. These have the advantage of setting out a clear analytic framework that is based upon existing theory. In contrast, Eichengreen et al. (1996) Exchange Market Pressure is a model independent because neither the components of Exchange Market Pressure nor the weights assigned to them are derived from any macroeconomic model. So, for example, it is an entirely empirical matter whether foreign exchange reserves or the interest rate are important in calculating Exchange Market Pressure.

Girton and Roper (1977) use the monetary approach to the balance of payments and derived exchange market pressure index which is simple sum of exchange rate and foreign exchange reserves changes. Since both exchange rate and foreign exchange reserve changes are equally weighted; therefore, the construction of Exchange Market Pressure is only dependent upon the index's components and does not require the estimation of the macro model. Roper and Turnovsky (1980), on the other hand, used an *IS-LM* framework and derived an optimum trade-off that monetary authorities face between domestic credit and exchange rate when stabilising domestic output. The weights assigned to the components are based upon the estimated parameters. Weymark (1995) made a notable contribution to the theory of Exchange Market Pressure. Although Weymark's (1995) Exchange Market Pressure is dependent upon actual exchange rate and foreign exchange reserve changes, the weights assigned to foreign exchange reserve changes are derived from an estimated macro model. Thus, to produce an exchange market pressure index, we need to estimate a model and hence derive weights assigned to components of the index. This converts foreign exchange reserve changes into equivalent exchange rate units. Thus, using equivalent weights ensures that the exchange market pressure index is not dominated by the most volatile component.[5]

Exchange market pressure is not directly observable. It can be measured through the channels that are used for restoring foreign exchange market equilibrium. In Girton and

[5] Roper and Turnovsky (1980) and Weymark (1995) require the estimation of six and two parameters respectively from stochastic macro mode for assigning weights to the components of exchange market pressure.

Roper's (1977), Roper and Turnovsky's (1980) and Weymark's (1995) studies, it is assumed that a Central Bank uses either the exchange rate or foreign exchange reserves or both for restoring foreign exchange market equilibrium. Thus, these studies assume direct intervention which takes place through the sale or purchase of foreign exchange reserves. However, interest rate is another policy instrument that the Central Bank may use for restoring foreign exchange market equilibrium (see for example Edison, 1993 and Dominguez and Kenen, 1992 for the interest rate policies pursued by the European Monetary System member countries to keep their exchange rates within the bands prescribed by the Exchange Rate Mechanism). Therefore, the studies that do not include the interest rate as a component of exchange market pressure may not fully reflect the extent of foreign exchange market disequilibrium. Since the Central Bank changes the interest rate to fend off the pressure, Eichengreen et al. (1996) use interest rate as an additional component of exchange market pressure index.

Contrary to Girton and Roper (1977), Roper and Turnovsky (1980) and Weymark (1995), Eichengreen et al. (1996) use the inverse of variance approach for assigning weights to the components of exchange market pressure. This approach has the advantage of assigning low weight to more volatile components and ensures that exchange market pressure is not dominated by more volatile components. An underlying intuition behind using the inverse of the variance approach is that the linear combination of exchange market pressure index components will yield an index dominated by more volatile components (Eichengreen et al. 1994). In our case, foreign exchange reserve changes are several times more volatile than exchange rate changes which in turn are more volatile then interest rate changes. Therefore, an unweighted exchange market pressure index will be driven by more volatile components (in our case foreign exchange reserve changes). The inverse of variance approach therefore assigns low weight to more volatile component and ensures equal weight for all components of the Exchange Market Pressure Index.

An important element of this thesis is the behaviour of macroeconomic policy in Pakistan. Pakistan's exchange rate regime has evolved through different phases. After the founding of the country, Pakistan adopted the policy of fixed exchange rate and fixed the parity of its currency against US dollar at rupee 3.32 in 1948. This was occasionally revised, for example in 1973 to rupees 9.9 to the US dollar. This parity remained fixed until 8th January, 1982, when Pakistan switched from a fixed to a managed float exchange rate system. Since then the Pakistan rupee has depreciated by more then 500% to 59.72 per US dollar in 2005. On the other hand, the country's foreign exchange reserves have increased from US $553 million in 1976 to US $10, 599, thus growing by 1800%. Therefore, one of the puzzles that this thesis aims to consider is why the exchange rate has depreciated by such an enormous extent given that country's foreign exchange reserves have also shown tremendous growth.

One of the elements of this thesis is to adopt Weymark's (1995) approach for constructing exchange market pressure and intervention index for Pakistan. This approach is adopted because it enables us to verify what fraction of pressure Central Bank relieves through the purchase and sale of foreign exchange reserves. Furthermore, Weymark (1995) argues that Girton and Roper's (1977) and Roper and Turnovsky's (1980) exchange Market Pressure indices measure foreign exchange market disequilibrium by the simple sum of exchange rate and foreign exchange reserve changes under fixed and float systems. On the other hand, foreign exchange reserve changes and exchange rate changes fully reflect the extent of foreign exchange market disequilibrium in a managed float or an intermediate exchange rate arrangement. Thus, under a managed float or intermediate exchange rate system, measurement of foreign exchange market disequilibrium involves converting foreign exchange reserve changes into equivalent exchange rate units and then combining them with observed exchange rate units

Weymark (1998) further argues that model-independent approaches to exchange market pressure are difficult to interpret in terms of their general usefulness. This is because neither the components of exchange market pressure nor the weights assigned to them are derived from a stochastic macroeconomic model. Furthermore, the volatilities of the exchange rate, foreign exchange reserve and interest changes not only depend on the structure of the economy but also on the intervention activity of the Central Bank. In such a case, volatility smoothing approaches cannot be expected to assign equal weights to all components of exchange market pressure index. Weymark (1998) further argues that a poor understanding of market participant's expectation formation process and failure to model this process correctly is the primary cause of poor performance of exchange rate models linking macrocosmic variables with exchange rate determination at short and intermediate horizon.

1.3 Thesis Structure

The plan of thesis is as follows. In the second chapter, we set out and contrast empirical exchange market pressure models. In the third chapter, we discuss the empirical exchange market pressure literature and see whether the determinants of exchange market pressure confirm their theoretical predictions. Chapters Four to Seven are the core of the thesis and use Weymark's (1995) approach. Chapter Eight, on the other hand, uses Eichengreen et al.'s (1996) statistical approach for Exchange Market Pressure.

In terms of the main empirical chapters in this thesis, Chapter Four uses difference data and the instrumental variable technique for constructing exchange market pressure and the intervention index for Pakistan using Weymark's (1995) approach.[6] Difference data enables us to avoid the spurious regression problem that arises when both dependent and independent variables, although independent of each other, are trended together. This gives a high

[6] Weymark (1995) used differenced data and the instrumental variable technique to construct exchange market and intervention index for Canada.

correlation among them. The instrumental variable, on the other hand, is used to avoid the endogenity problem. This arises due to the simultaneous determination of the dependent variable and one or more of the independent variables. In such a case, classical linear regression approaches do not yield unbiased estimates of the variables of interest. This problem is overcomed by the use of instrumental variables that are correlated with the endogenous variable but not correlated with the error term. This yields unbiased estimates of parameters of interest. In our case, we estimate the weight assigned to the foreign exchange reserve using interest rate and exchange rate coefficients. We estimate these parameters using real money demand and price equation. It is argued that real money balances and interest rate are simultaneously determined. This results in a simultaneity problem which we address using the instrumental variable technique.

Much of the empirical literature in international finance has gone beyond simple differencing of the data to deal with potential spurious relationships and we next utilise these methods. In Chapter Five we use Johansen's (1988) and Johansen and Juselius' (1990) cointegration approach. It is argued that although differencing satisfies stationary properities, it results in the loss of vital information about the long-term relationship if the variables of interest are cointegrated. A linear combination of non-stationary variables can give a non-stationary relationship. However, it may be the case that a linear combination of non-stationary variables yields a stationary relationship when there is evidence of cointegration. Such an outcome provides evidence of the presence of a long-term relationship. We test the presence of such a relationship using Johansen's (1988) and Johansen and Juselius' (1990) multivariate cointegration approach. It has an advantage that it not only allows us to test the presence of more than one cointegrating vector but also to test the validity of economic theories by imposing restrictions on the parameters of interest. Furthermore, the results remain invariant with respect to the direction of normalisation.

Our first two empirical chapters, Chapter Four and Five use a fixed parameter approach for constructing exchange market pressure and an intervention index for Pakistan. However, a fixed parameter approach is criticised because it does not allow the parameters to vary to take account of the effects of structural changes over time. Furthermore, it is considered as one of the important factors in the poor performance of exchange rate models. Chapter Six overcomes this issue by using the Kalman filter time varying parameter approach. It takes account of the effects of structural changes that have occurred over the given sample period on parameter constancy. These changes include Pakistan's switch from fixed exchange rate to managed float on 8th January, 1982, the introduction of interest free banking system in 1981 and subsequent replacement of interest rate bearing deposits with a system based on principle of profit and loss sharing from July 1st, 1985 (Khan 1994; Ahmad and Khan, 1990), the denationalisation of public sector banks, the imposition of sanctions in the wake of nuclear explosions and lifting of these sanction and inflow of foreign capital due to Pakistan's decision to cooperate with the international community in its war against terrorism after the September 11th terrorist attack on US. Consequently, the macro model parameters that are useful for constructing exchange market pressure and intervention index may change over time.

The last three chapters assume direct Central Bank intervention, which takes the form of the sale and purchase of foreign exchange reserves. Eichengreen et al. (1996) argue that interest rate changes are another mechanism by which the Central Banks can restore foreign exchange market equilibrium. In such a case, studies that ignore the interest rate do not fully reflect the extent of foreign exchange market pressure. Eichengreen et al. (1996) constructed such an exchange market pressure index that includes exchange rate change, relative interest rate and relative percent changes in foreign exchange reserves as its components. It uses the inverse of the variance approach for assigning weights to the components of exchange market pressure. This approach has the advantage of assigning low weight to more volatile component and thus ensures that more volatile components do not dominate the exchange market pressure index. Furthermore, it does not require the macroeconomic assumptions made by Girton and Roper's (1977) and Weymark's (1995) models.

Furthermore, in this chapter, we consider the determinants of exchange market pressure in a panel of ten countries. For example, we examine whether more open economies have greater exchange market pressure. Other issues that we address in Chapter Seven include the relevance of policy variables, openness of economy and macroeconomic variables as determinants of Exchange Market Pressure in panel framework. Particularly, we test which of these variables explains Exchange Market Pressure. Models based on a panel framework use repeated observations on the same variable. The use of a panel has the advantage of enabling researchers to estimate the complicated models. Chapter Eight summarises the study and provides policy implications.

1.4 Contribution to the literature

In this thesis, we evaluate the exchange market pressure on Pakistan rupee in post 1976 period. We examine whether it is upward or downward pressure that has remained dominant over the entire sample period. Based on exchange market pressure index, we evaluate monetary authority response function by constructing intervention index. The intervention index values reflect the extent that Central Bank allows to market forces in the determination of domestic currency value in the foreign exchange market. This has important policy implication. The Central Banks that target exchange rate stability loose monetary independence. Furthermore, we evaluate the determinants of exchange market pressure in a panel of ten countries. We check whether exchange market pressure can be explained by a range of macroeconomic variables, policy variables and measures of trade openness. Based on these findings, we recommend which variables Central Banks should keep in check if they want to avoid pressure on their currencies.

Chapter Two

Exchange Market Pressure Models

In the literature, there are two main approaches to exchange market pressure, namely the model-dependent and model-independent. The difference between the two is that the model-dependent approach uses a stochastic macro model for either deriving the components of exchange market pressure or weights assigned to them or both. On the other hand, the model-independent approach does not use a macro model for deriving the components of exchange market pressure or weights assigned to them. In this chapter, we discuss model-dependent theoretical models of Exchange Market Pressure and determine how they differ from each other in deriving either the components of pressure index or weights assigned to them or both.

The chapter is outlined as follows. In section 2.1 we derive Girton and Roper's (1977) exchange market pressure index using the monetary approach to balance of payments. In section 2.2 we discuss Roper and Turnovsky's (1980) exchange market pressure model and show how both these indices differ from each other in deriving exchange market pressure components and the weights assigned to them. Section 2.3 uses a stochastic macro model to derive Weymark's (1995) exchange market pressure and provide a theoretical justification as to how it differs from Girton and Roper (1977) and Roper and Turnovsky (1980) in deriving market pressure components and weights assigned to them. Furthermore, based on the exchange market pressure index, we derive an intervention index which we define as the fraction of pressure that Central Bank relieves through the purchase and sale of foreign exchange reserves. Section 2.4 uses a short-term wealth augmented monetary model of market pressure for deriving Pentecost et al.'s (2001) exchange market pressure. Furthermore, this section shows how Pentecost et al.'s (2001) market pressure index differs from the preceding indices. Section 2.5 concludes.

2.1 Girton and Roper's (1977) Monetary Model of Exchange Market Pressure

The first model we consider is by Girton and Roper (1977). Girton and Roper (1977) derived a model of Exchange Market Pressure using the monetary approach to exchange rate and monetary approach to balance of payments. They focused their attention on the monetary independence that Canadian monetary authorities enjoy as they pursue a fixed exchange rate regime. This is based on domestic and foreign monetary conditions and is given as:

$$M_t^d = P_t Y_t^{\beta} \exp^{(-\alpha i_t)} \tag{2.1}$$

$$M_t^{d*} = P_t^* Y_t^{*\beta*} \exp^{(-\alpha i_t^*)} \tag{2.2}$$

$$M_t^s = F_t + D_t \tag{2.3}$$

$$M_t^{s*} = F_t^* + D_t^* \tag{2.4}$$

Equation 2.1 denotes domestic money demand. It shows that the demand for nominal money balances (M_t^d) is influenced by domestic real income (Y_t) and interest rate (i_t). A rise in P_t and Y_t lead to an increase in demand for nominal money balances. This is because as domestic price and income increase, people need more money for financing their increased transactions. On the other hand, the interest rate represents an opportunity cost of holding money. Therefore, as the opportunity cost of holding money increases, people prefer to hold nominal money balances in terms of assets that earn the interest rate instead of cash balances. This decreases the demand for nominal money balances. Equation 2.3 shows the sources of domestic money supply in the economy. It reveals that domestic money supply (M_t^s) is created by either increase in domestic credit (domestic component of base money measured in domestic currency, D_t) or through the purchase and sale of foreign exchange reserves (F_t) or both. * denotes foreign counterparts of domestic variables.

Money market equilibrium conditions imply that any change in money supply must be equal to money demand. Therefore, we take the log and first difference of both sides of equation (2.1) and (2.2):

$$\Delta m_t^{\ s} = \Delta d_t + \Delta f_t = \Delta p_t + \beta\ \Delta y_t - \alpha\ \Delta i_t = \Delta m_t^{\ d} \qquad (2.5)$$

$$\Delta m_t^{s*} = \Delta d_t^{\ *} + \Delta f_t^{\ *} = \Delta p_t^{\ *} + \beta^* \Delta y_t^{\ *} - \alpha^* \Delta i_t^{\ *} = \Delta m_t^{d*} \qquad (2.6)$$

The left-hand side of equation 2.5 represents the sources of domestic money creation and the right-hand side indicates the determinants of money demand in the economy. It shows that the domestic money supply changes due to changes in domestic credit ($\Delta d_t = \frac{\Delta D_t}{B_{t-1}}$) and changes in foreign exchange reserves ($\Delta f_t = \frac{\Delta F_t}{B_{t-1}}$). B_t denotes domestic monetary base. On the other hand, the right hand side of equation 2.5 shows the sources of change in money demand that include changes in domestic price, domestic real income and interest rate. We assume that money multiplier is constant and equal to unity. The money market equilibrium condition requires that log money supply change (Δm_t^s) should be equal to log changes in money demand (Δm_t^d).

Subtracting the foreign money market equilibrium condition (eqn: 2.6) from the domestic money market equilibrium condition (eqn: 2.5) yields:

$$\Delta m_t^s - \Delta m_t^{s*} = \Delta d_t + \Delta f_t - \Delta m_t^* = \Delta p_t - \Delta p_t^* + \beta \Delta y_t - \beta^* \Delta y_t^* - \alpha \Delta i_t + \alpha^* \Delta i_t^* \qquad (2.7)$$

Girton and Roper (1977) did not assume that absolute Purchasing Power Parity holds. Absolute Purchasing Power Parity holds only if deviations from its absolute version are stationary. The non-stationary real exchange rate imply that absolute version of PPP does not hold. The relative version of Purchasing Power Parity is given as:

$$\Delta p_t = \Delta p_t^{\ *} + \Delta s_t + \Delta q_t \tag{2.8}$$

where Δs_t denotes logged change in nominal exchange rate defined as the number of units of domestic currency per unit of foreign currency. Hence a rise in the exchange rate denotes the depreciation of domestic currency. In the case of stationary real exchange rate (q_t), we can define in equation 2.8 that changes in foreign price and nominal exchange rate are equally reflected in domestic price changes. We re-write equation 2.8 as:

$$\Delta s_t + \Delta q_t = \Delta p_t - \Delta p_t^* \tag{2.9}$$

Substitution of equation (2.9) in (2.7) yields:

$$\Delta d_t + \Delta f_t - \Delta m_t^* = \Delta s_t + \Delta q_t + \beta \Delta y_t - \beta^* \Delta y_t^* - \alpha \Delta i_t + \alpha^* \Delta i_t^* \tag{2.10}$$

Re-arranging the above equation yields:

$$\Delta s_t = \Delta q_t - \Delta d_t - \Delta f_t + \Delta m_t^* + \beta \Delta y_t - \beta^* \Delta y_t^* - \alpha \Delta i_t + \alpha^* \Delta i_t^* \tag{2.11}$$

Δq_t denotes deviation from absolute Purchasing Power Parity. If absolute version of Purchasing Power Parity is assumed to hold, then Δq_t will automatically disappear. However, Girton and Roper (1977) eliminate deviation from Purchasing Power Parity (Δq_t) by assuming them to be a linear function of domestic credit and foreign money growth (Haache and Townend, 1981):

$$\Delta q_t = \theta \Delta d_t - \theta^* \Delta m_t^* \qquad \theta, \theta^* \geq 0 \tag{2.12}$$

Substituting equation (2.12) for deviation from purchasing power parity in equation (2.11) gives:

$$\Delta s_t = \theta \Delta d_t - \theta^* \Delta m_t^* - \Delta d_t - \Delta f_t + \Delta m_t^* + \beta \Delta y_t - \beta^* \Delta y_t^* - \alpha \Delta i_t + \alpha^* \Delta i_t^* \tag{2.13}$$

Re-arrange the above equation:

$$\Delta s_t = -(1-\theta)\Delta d_t + (1-\theta^*)\Delta m_t^* - \Delta f_t + \beta\Delta y_t - \beta^*\Delta y_t^* - \alpha\Delta i_t + \alpha^*\Delta i_t^* \quad (2.14)$$

Equation 2.14 shows that the domestic credit and foreign money supply are no longer minus and plus unity. Since θ is unrelated to that part of growth of money supply that results from foreign exchange reserve changes, the coefficient of Δf_t is still minus unity (Haache and Townend, 1981). Therefore, we can write equation 2.14 as:

$$\Delta s_t + \Delta f_t = -(1-\theta)\Delta d_t + (1-\theta^*)\Delta m_t^* + \beta\Delta y_t - \beta^*\Delta y_t^* - \alpha\Delta i_t + \alpha^*\Delta i_t^* \quad (2.15)$$

The sum of exchange rate and foreign exchange reserve changes appears on the left-hand side of the equation 2.15. This suggests that we can measure exchange market pressure ($\Delta s_t + \Delta f_t$) without estimating any structural macro model.

It is assumed that perfect capital mobility holds and is given as:

$$\Delta s_{t+1} = \Delta i_t - \Delta i_t^* = -\delta\Delta d_t + \delta^*\Delta m_t^* \quad (2.16)$$

Equation 2.16 is a parity condition which states that the differential between domestic and foreign interest rates is fully reflected in expected exchange rate units. The violation of this parity provides opportunity to foreign exchange arbitrageurs to make a profit.

Substituting equation (2.16) in equation (2.15) gives:

$$\Delta s_t + \Delta f_t = -(1-\theta)\Delta d_t + (1-\theta^*)\Delta m_t^* + \beta\Delta y_t - \beta^*\Delta y_t^* + \alpha\delta\Delta d_t - \alpha^*\delta^*\Delta m_t^* \quad (2.17)$$

$$\Delta s_t + \Delta f_t = -(1-\alpha\delta-\theta)\Delta d_t + (1-\alpha^*\delta^*-\theta^*)\Delta m_t^* + \beta\Delta y_t - \beta^*\Delta y_t^* \quad (2.18)$$

Assuming that: $\phi_1 = (1-\alpha\delta-\theta)$ and $\phi_2 = (1-\alpha^*\delta^*-\theta^*)$

Substitution of these values for the coefficients of changes in domestic credit and foreign monetary aggregates yields Girton and Roper’s (1977) equation of exchange market pressure:

$$\Delta s_t + \Delta f_t = -\phi_1\Delta d_t + \phi_2\Delta m_t^* + \beta_1\Delta y_t - \beta_2\Delta y_t^* + v_t \quad (2.20)$$

$\Delta s_t + \Delta f_t$ in equation 2.20 denotes Girton and Roper’s (1977) Exchange Market Pressure index. It is equally applicable to all exchange rate regimes. It shows that under a floating exchange rate system, exchange rate changes (Δs_t >0) reflects the extent of foreign exchange market disequilibrium and foreign exchange reserves are held constant ($\Delta f_t = 0$). On the other hand, foreign exchange reserves (Δs_t >0) absorb the entire pressure under a fixed exchange rate and the exchange rate is held fixed (Δs_t =0). However, under a managed float or intermediate exchange rate system both exchange rate (Δs_t >0) and foreign exchange reserve changes (Δs_t >0) restore foreign exchange market equilibrium.

The right-hand side of equation 2.20 indicates the determinants of Exchange Market Pressure. It shows that an increase in domestic credit (Δd_t) and foreign income (Δy_t^*) either decreases the value of domestic currency or reduces the country's foreign exchange reserves or both and hence increases pressure. On the other hand, a rise in domestic income or foreign money either increases domestic currency value against foreign currency or increases foreign exchange reserve or both under managed float and hence reduces market pressure. Furthermore, Girton and Roper's Exchange Market Pressure assigns equal weights to both exchange rate and foreign exchange reserves changes. Hence, it does not require estimating any structural exchange rate model or adopting any statistical approach for assigning weight to the components of Exchange Market Pressure. It can easily be constructed by summing up exchange rate and foreign exchange reserve changes.

2.2 Roper and Turnovsky's (1980) Model of Exchange Market Pressure

Roper and Turnovsky (1980) derived the optimum trade-off that monetary authorities face between foreign exchange reserve and exchange rate changes for stabilising domestic output in a stochastic IS-LM frame work that includes a foreign sector. The stochastic IS-LM framework that is used for deriving optimum trade-off is extended and includes the foreign sector. It is given as:

$$y_t = b_1 y_t - b_2 i_t - b_3 s_t + u_{1t} \quad (2.21)$$

$$m_t = a_1 y_t - a_2 i_t + u_{2t} \quad (2.22)$$

$$i_t = i_t^* + E_t \Delta s_{t+1} \quad (2.23)$$

$$E_t \Delta s_{t+1} = \theta(\bar{S} - S_t) \quad 0 \leqq \theta \leqq 1 \quad (2.24)$$

$y_t =$ domestic output in period *t.*

$i_t =$ domestic interest rate in period *t.*

$s_t =$ exchange rate level denoting the numbers of units of domestic currency per unit of foreign currency.

$\bar{S}$ = equilibrium exchange rate level.

s_{t+1} = expected exchange rate level in the next period. .

$m_t =$ Money Stock or base money measured in logarithms.

$u_{1t} = u_{2t} = v_t =$ Stochastic disturbances.

We assume that all parameters in equation (2.21) are positive except b_1 that satisfies additional restriction $0 < b_1 < 1$.

Equation 2.21 describes a goods market equilibrium condition. It states that depreciation of domestic currency (i.e. a rise in s_t) makes exportable goods cheaper relative to foreign goods and hence increases domestic output level (y_t). This explains negative sign for exchange rate in *IS* equation. Similarly, a rise in interest rate (i_t) is associated with decline in domestic output level through the investment channel. Equation 2.22 explains domestic money market equilibrium conditions. It shows that domestic nominal money balances (m_t) are positively and negatively correlated with domestic income and interest rate respectively. Equation 2.23 assumes perfect capital mobility. It states that domestic interest rate is equal to foreign interest rate (i_t^*) plus expected exchange rate changes ($E_t \Delta s_{t+1}$). Equation 2.24 describes the evolution of expected exchange rate. It asserts that if the current exchange rate is above the long-term equilibrium rate then one period ahead exchange rate is expected to depreciate and vice versa.

If we denote the deviations from long-term equilibrium exchange rate by $s_t = (\bar{S} - S_t)$ this enables us to write equation 2.24 as: $E_t \Delta S_{t+1} = \theta s_t$. Given this expression of expected exchange rate changes, we can re-write equation 2.23 as:

$$i_t = i_t^* + \theta s_t \tag{2.25}$$

Substituting equation 2.25 in equation 2.21 gives:

$$y_t = b_1 y_t - b_2 i_t^* - b_2 \theta s_t - b_3 s_t + u_{1t} \tag{2.26}$$

$$(y_t - b_1 y_t) = -b_2 i_t^* - b_2 \theta s_t - b_3 s_t + u_{1t} \tag{2.27}$$

$$(1 - b_1) y_t = -b_2 i_t^* - b_2 \theta s_t - b_3 s_t + u_{1t} \tag{2.28}$$

$$y_t = \frac{-b_2 i_t^* - b_2 \theta s_t - b_3 s_t + u_{1t}}{(1 - b_1)} \tag{2.29}$$

Similarly substituting interest rate expression $i_t = i_t^* + \theta s_t$ in equation (2.22) yields:

$$m_t = a_1 y_t - a_2 (i_t^* + \theta s_t) + u_{2t} \tag{2.30}$$

$$m_t = a_1 y_t - a_2 i_t^* - a_2 \theta s_t + u_{2t} \tag{2.31}$$

Solving equation (2.29) and (2.31) for m_t:

$$m_t = \frac{a_1(-b_2 i_t^* - b_2 \theta s_t - b_3 s_t + u_{1t})}{(1 - b_1)} - a_2 i_t^* - a_2 \theta s_t + u_{2t} \tag{2.32}$$

$$m_t = \frac{-a_1 b_2 i_t^* - a_1 b_2 \theta s_t - a_1 b_3 s_t + a_1 u_{1t}}{(1 - b_1)} - a_2 i_t^* - a_2 \theta s_t + u_{2t} \tag{2.33}$$

By re-arranging the above equation:

$$m_t = -\left[\frac{a_1(b_3 + b_2\theta)}{(1-b_1)} + a_2\theta\right]s_t - \frac{(a_1b_2 + a_2)i_t^*}{(1-b_1)} + a_1u_{1t} + u_{2t} \quad (2.34)$$

The negative exchange rate sign confirms to what the theory suggests. Monetary authorities can change the exchange rate by changing the foreign exchange reserves against domestic currency (decreasing m_t). We can re-write equation 2.34 as:

$$s_t - \frac{(a_1b_2 + a_2)i_t^*}{(1-b_1)} + a_1u_{1t} + u_{2t} = -\frac{(1-b_1)}{a_1(b_3 + b_2\theta) + a_2\theta}m_t \quad (2.35)$$

Re-arranging the above equation yields:

$$s_t = -\frac{(1-b_1)}{a_1(b_3 + b_2\theta) + a_2\theta}m_t + \frac{(a_1b_2 + a_2)i_t^*}{(1-b_1)} + a_1u_{1t} + u_{2t} \quad (2.36)$$

Therefore, Roper and Turnovsky's model yields model-dependent Exchange Market Pressure given as: $EMP_t = \Delta s_t + \eta\Delta m_t$

where $\partial\Delta e_t / \partial\Delta m_t = \eta$ and

$$\eta = -\frac{(1-b_1)}{a_1(b_3 + b_2\theta) + a_2\theta}$$

Contrary to Roper and Girton's (1977) model that assigns equal weight to exchange rate and foreign exchange reserve changes, Roper and Turnovsky's model requires estimating six parameters from the *IS-LM* framework, as outlined above, for assigning weight to foreign exchange reserve component of Exchange Market Pressure. These include income elasticity of money demand a_1, interest elasticity of money demand a_2, sensitivity of output to its own level b_1, interest elasticity of domestic output b_2, output sensitivity to exchange rate changes b_3 and deviation of exchange rate from its long-term equilibrium level θ. Hence we need to estimate three equations for deriving weights to be assigned to foreign exchange reserve components of exchange market pressure index. This will ensure that exchange market pressure index is not dominated by more volatile component.

2.3 Weymark's (1995) Model

Prior to Weymark's (1995) model, Girton and Roper (1977) and Roper and Turnovsky (1980) constructed exchange market pressure indices. Girton and Roper (1977) assign equal weights to exchange market pressure index components and is a simple sum of exchange rate and foreign exchange reserves changes. On the other hand, Roper and Turnovsky (1980) use stochastic *IS-LM* framework for deriving weights to the components of exchange market pressure index. However, none of these indices show what fraction of pressure Central Bank relieves through the purchase and sale of foreign exchange reserves.

Weymark (1995) addressed this issue. Based on estimated exchange market pressure index, she constructed an intervention index that shows what fraction of pressure Central Bank relieves through the purchase and sale of foreign exchange reserve. Weymark (1995) developed a small, open economy model of Exchange Market Pressure. This consists of nominal money demand, price equation, uncovered interest rate parity, money supply process and monetary authority response function to exchange rate fluctations. It is given as:

$$m_t^{\,d} = p_t + b_1 y_t - b_2 i_t + v_t \tag{2.37}$$

$$p_t = a_0 + a_1 p_t^{\,*} + a_2 s_t \tag{2.38}$$

$$i_t = i_t^{\,*} + E_t S_{t+1} - s_t \tag{2.39}$$

$$m_t^{\,s} = m_{t-1}^{\,s} + \Delta d_t + \Delta f_t \tag{2.40}$$

$$\Delta f_t = -\overline{\rho}_t \Delta s_t \tag{2.41}$$

where:

m_t = refers to money stock in period *t*

p_t = domestic price level in period *t*

y_t = real domestic income in period *t*

i_t = domestic interest rate level in period *t*

v_t = stochastic money demand disturbance in period *t*

s_t = nominal exchange rate refers to the number of units of domestic currency per unit of foreign currency.

$\Delta d_t = [h_t D_t - h_{t-1} D_{t-1}] / M_{t-1}$ where h_t is the money multiplier in period *t*, D_t domestic credit and M_{t-1} is the inherited monetary stock in *t*.

$\Delta f_t = [h_t F_t - h_{t-1} F_{t-1}] / M_{t-1}$ where F_t is the stock of foreign exchange reserves in period *t*, with h_t and M_{t-1} defined as above

$\overline{\rho}_t$ = the policy authority's time-variant response coefficient.

The asterisk denotes foreign counterparts of domestic variables. Small letters denote that all variable used are in logarithms. The notation $E_t s_{t+1}$ represents rational agents' expected value of exchange rate one period ahead based on the information currently available.

Equation 2.37 shows that domestic money demand (m_t^d) is positively and negatively associated with domestic income (y_t) and interest rate (i_t) respectively. This implies positive and negative sign for estimated real domestic income parameter ($b_1 > 0$) and interest rate parameter ($b_2 < 0$). Similarly, equation 2.38 shows that domestic prices (p_t) are influenced by foreign price (p_t^*) and exchange rate changes (s_t). However, the absolute version of purchasing power parity is assumed not to hold as it allows for systematic deviation given by a_0. If a_0=0 and $a_1 = a_2 = 1$ simultaneously then equation 2.34 breaks down to an absolute version of purchasing power parity.

Equation 2.39 is uncovered interest rate parity which holds that the domestic interest rate equals the foreign interest after adjustments for the expected change in exchange rate. Equation 2.40 defines the money supply process. It shows that the current money supply is determined by inherited money stock (m_{t-1}^{s}), and by changes in the domestic component of monetary base, namely domestic credit ($\Delta d_t = \frac{\Delta D_t}{B_{t-1}}$) and foreign exchange reserves ($\Delta f_t = \frac{\Delta F_t}{B_{t-1}}$). B_t denotes domestic monetary base. The money multiplier is assumed to be constant and intervention is assumed unsterilised.[7]

Equation 2.41 shows monetary authority's response function to exchange rate movements. The negative sign of monetary authority's response function indicates that Central Bank smooth exchange rate changes by selling and purchasing foreign exchange reserves. It purchases foreign exchange reserves (Δf_t>0) when there is pressure on domestic currency to appreciate (i.e. $\Delta s_t < 0$). On the other hand, Central Bank sells foreign exchange reserves when the domestic currency is under depreciating pressure. The monetary authority's response function takes values between $0 \le \bar{\rho}_t \le \infty$. In a country with fixed exchange rate $\rho_t = \infty$. This implies the Central Bank's infinite intervention for maintaining fixed exchange rate parity. On the other hand, under float exchange rate $\rho_t = 0$. In the intermediate exchange rate arrangements $0 < \rho_t < \infty$. In practice, the monetary authority's response function ρ_t is time-varying. It is argued that a Central Bank does not intervene each time domestic currency is under pressure. It may be the case that monetary authorities abstain from intervening in the foreign exchange market and let the exchange rate changes absorbs the entire exchange market pressure. In such a case, the monetary authority's response function equals zero ($\rho_t = 0$). On the other hand, ρ_t>0 when the Central Bank leans against the wind and purchases foreign exchange reserves when there is downward pressure on domestic currency. It may be the case that the monetary authority's response coefficient is negative ρ_t<0. This occurs when the

[7] Unsterilised intervention implies that Central Bank does not offset the effects of the purchase and sale of foreign exchange reserves on monetary base.

monetary authority leans with wind – that is, the Central Bank purchases foreign exchange reserves ($\Delta f_t > 0$) when the domestic currency is already under pressure to depreciate ($\Delta s_t > 0$) and vice versa. Substitution of equation 2.38 in equation 2.37 yields

$$m_t^d = a_0 + a_1 p_t^* + a_2 s_t + b_1 y_t - b_2 i_t + v_t \qquad (2.42)$$

Substitution of equation 2.39 in equation 2.42 yields

$$m_t^d = a_0 + a_1 p_t^* + a_2 s_t + b_1 y_t - b_2 (i_t^* + E_t s_{t+1} - s_t) + v_t \qquad (2.43)$$

$$m_t^d = a_0 + a_1 p_t^* + (a_2 + b_2) s_t + b_1 y_t - b_2 (i_t^* + E_t s_{t+1}) + v_t \qquad (2.44)$$

The monetary approach assumes continuous money market equilibrium at any period:

$$\Delta m_t^s = \Delta m_t^d = \Delta m_t \qquad (2.45)$$

$$\Delta d_t - \bar{\rho}_t \Delta s_t = a_1 \Delta p_t^* + (a_2 + b_2) \Delta s_t + b_1 \Delta y_t - b_2 \Delta i_t^* - b_2 \Delta E_t s_{t+1} + \Delta v_t \qquad (2.46)$$

Equation 2.46 shows that the exchange rate change required for restoring money market equilibrium subsequent to exogenous disturbance depends upon the monetary authority's response function $\bar{\rho}_t$. The sources of exogenous disturbance that cause domestic money market disequilibrium are foreign price change, changes in domestic income, foreign interest rate change, domestic credit, expectation about future exchange rate change, and the random money demand shock.

Re-arranging equation 2.46:

$$\Delta d_t - \bar{\rho}_t \Delta s_t - (a_2 + b_2) \Delta s_t = a_1 \Delta p_t^* + b_1 \Delta y_t - b_2 \Delta i_t^* - b_2 \Delta E_t s_{t+1} + v_t \qquad (2.47)$$

$$-(\bar{\rho}_t + a_2 + b_2) \Delta s_t = a_1 \Delta p_t^* + b_1 \Delta y_t - b_2 \Delta i_t^* - \Delta d_t + v_t - b_2 \Delta E_t s_{t+1}$$

$$\Delta s_t = \frac{1}{-(\bar{\rho}_t + a_2 + b_2)} \left[a_1 \Delta p^* + b_1 \Delta y_t - b_2 \Delta i_t^* - \Delta d_t + v_t - b_2 \Delta E_t s_{t+1} \right] \qquad (2.48)$$

$$\Delta s_t = \frac{1}{\beta_t} \left[X_t - b_2 \Delta E_t (s_{t+1}) \right]$$

where

$$\beta = -[\bar{\rho}_t + a_2 + b_2]$$

$$X_t = \left[a_1 \Delta p_t^* + b_1 \Delta y_t - b_2 \Delta i_t^* + v_t - \Delta d_t\right]$$

Equation (2.48) shows that exchange rate changes may occur due to excessive demand for money $EDM_t = \left[a_1 \Delta p^* + b_1 \Delta y_t - b_2 \Delta i_t^* + v_t - \Delta d_t\right]$ or because of agents' expectations about future exchange rate changes $b_2 \Delta E_t S_{t+1} > 0$. The actual exchange rate changes also depend on the Central Bank's choice for the value of $\bar{\rho}_t$ and also on exchange rate (a_2) and interest rate (b_2). The expression EDM_t also suggest that an increase in domestic credit will not increase pressure on domestic currency if it is equally offset by an increase in the demand for domestic monetary aggregates.

Re-arranging equation 2.48 yields:

$$(\bar{\rho}_t + a_2 + b_2)\Delta s_t = -[a_1 \Delta p_t^* + b_1 \Delta y_t - b_2 \Delta i_t^* - \Delta d_t + v_t - b_2 \Delta E_t s_{t+1}]$$

$$\bar{\rho}_t \Delta s_t + (a_2 + b_2)\Delta s_t = -[a_1 \Delta p_t^* + b_1 \Delta y_t - b_2 \Delta i_t^* - \Delta d_t + v_t - b_2 \Delta E_t s_{t+1}]$$

Substitution of $\bar{\rho}_t \Delta s_t = -\Delta f_t$ from equation 2.41 in the above equation yields:

$$-\Delta f_t + (a_2 + b_2)\Delta s_t = -[a_1 \Delta p_t^* + b_1 \Delta y_t - b_2 \Delta i_t^* - \Delta d_t + v_t - b_2 \Delta E_t s_{t+1}] \quad (2.49)$$

Re-arranging equation 2.49 yields:

$$(a_2 + b_2)\Delta s_t = [a_1 \Delta p_t^* + b_1 \Delta y_t - b_2 \Delta i_t^* - \Delta d_t + v_t - b_2 \Delta E_t s_{t+1} + \Delta f_t] \quad (2.50)$$

Multiplying both sides of equation 2.50 by $\dfrac{1}{a_2 + b_2}$ yields:

$$\Delta s_t = \frac{-[a_1 \Delta p_t^* + b_1 \Delta y_t - b_2 \Delta i_t^* + v_t - \Delta d_t - b_2 \Delta E s_{t+1} + \Delta f_t]}{a_2 + b_2} \quad (2.51)$$

and the implied exchange rate elasticity with respect to foreign exchange reserves is given as:

$$\eta = -\frac{\partial \Delta s_t}{\partial \Delta f_t} = \frac{-1}{a_2 + b_2} \quad (2.52)$$

It is assumed that exchange elasticity of domestic price (a_2) is greater than interest elasticity of money demand (b_2). This implies that the elasticity of exchange rate with respect to foreign exchange reserves is always negative (i.e. $\eta = \frac{-1}{a_2 + b_2} < 0$).

The Weymark (1995) model dependent Exchange Market Pressure is given as:

$$EMP_t = \Delta s_t + \eta \Delta f_t \qquad (2.53)$$

The construction of Exchange Market Pressure requires the estimates of η. This further requires the estimates of interest rate elasticity of real money demand (b_2) and exchange elasticity of domestic price (a_2). Thus the construction of Weymark's (1995) Exchange Market Pressure index requires only two estimates, namely interest elasticity of money demand (b_2) and exchange rate elasticity of domestic price (a_2) and contrasts with the Roper and Turnovsky (1980) model that requires estimating six parameters. .

Under fixed and floating exchange rates, the entire pressure is absorbed by exchange rate and foreign exchange reserve changes. However, under a managed float or intermediate exchange rate arrangements, monetary authorities have to decide what fraction of pressure they are willing to relieve by foreign exchange intervention. Hence under a managed float, exchange market pressure is relieved by exchange rate changes $\left(\frac{\Delta s_t}{EMP_t}\right)$ and part of it by foreign exchange reserves $\left(\frac{\Delta f_t}{EMP_t}\right)$. Therefore, the division of equation 2.53 yields:

$$1 = \frac{\Delta s_t}{EMP_t} + \frac{\eta \Delta f_t}{EMP_t} \qquad (2.54)$$

Weymark defines exchange market intervention as a fraction of pressure that the Central Bank relieves through the purchase and sale of foreign exchange reserve and is given as:

$$\omega_t = \frac{\eta(\Delta f_t)}{EMP_t} = \frac{\Delta f_t}{\left(\frac{1}{\eta}\right)\Delta s_t + \Delta f_t} \qquad (2.55)$$

The intervention index takes values between $-\infty < \omega < \infty$. In a fixed exchange rate regime $\Delta s_t = 0$ and the entire pressure is absorbed by foreign exchange reserves ($\Delta f_t = EMP_t$). In such a case ω_t = 1. On the other hand, under a flexible exchange rate regime, the entire pressure is absorbed by exchange rate changes ($\Delta s_t = EMP_t$) and foreign exchange reserve changes are held constant ($\Delta f_t = 0$). Under an intermediate exchange rate system, the time varying coefficient takes values between zero and infinity $0 < \overline{\rho} < \infty$ and therefore, intervention index takes a value between zero and unity 0< ω_t <1.

2.4 An Alternative Exchange Market Pressure Model

Pentecost et al. (2001) derived their Exchange Market Pressure index from a short-term wealth augmented monetary model of foreign exchange market. The model assumes that purchasing power parity does not hold, imperfect substitutability between domestic and foreign assets, and non-bank financial wealth as the sole determinant of demand for all assets. The model in log linear form is given as:

$$\Delta m_t - \Delta p_t = \alpha \Delta y_t + \varphi \Delta w_t + \beta \Delta i_{mt} - \gamma \Delta i_t - \delta \Delta i_t^* \qquad (2.56)$$

Δ denotes first difference operator. m_t is nominal money balances, p_t is domestic price level, y_t domestic output level, w_t non-bank private sector wealth, i_{mt} own short-term interest rate of nominal money balances. α and φ denote income and wealth elasticity of real money demand β, γ *and* δ denote elasticities of real money demand with money itself, interest rate on alternative assets (i_t) and foreign interest rate (i_t^*) respectively. Equation 2.56 shows that the demand for nominal real money balances is positively associated with domestic real income (y_t), non-bank private sector wealth (w_t) and the own rate on nominal money balances (i_{mt}). The positive association between real money demand and its own interest rate (i_{mt}) reflects the fact that money is held in the form of bank deposits that yield low but positive interest rate. Equation 2.56 further indicates that the demand for the domestic real money balances is negatively associated with interest rate on competing assets and foreign interest rate. All variables in equation 2.56 are given in log form.

Domestic credit and foreign exchange reserve changes determine the domestic money supply. After assuming a unity multiplier, we can write domestic money supply as

$$\Delta m_t^s = \Delta d_t + \Delta f_t \tag{2.57}$$

The continuous money market equilibrium condition implies the equality of changes in real money demand and supply equation. Hence we can write continuous money market equilibrium condition as:

$$\Delta m_t = \Delta d_t + \Delta f_t = \Delta p_t + \alpha \Delta y_t + \beta \Delta i_{mt} + \varphi \Delta w_t - \gamma \Delta i_t - \delta \Delta i_t^* \tag{2.58}$$

Equation 2.58 indicates the equality between changes in money supply and money demand and thus ensures continuous money market equilibrium.

The demand for real money balances in a foreign country is identical to domestic real money demand function and is given as:

$$\Delta m_t^* - \Delta p_t^* = \alpha \Delta y_t^* + \beta \Delta i_{mt}^* + \varphi \Delta w_t^* - \gamma \Delta i_t - \delta \Delta i_t^* \tag{2.59}$$

γ and δ denote semi elasticity of demand for domestic real money balances with respect to domestic and foreign interest rate. Compare to foreign bonds, domestic bonds are assumed to be closer substitutes of domestic real money balances. This ensures that the semi-elasticity of domestic real money balances with domestic interest rate is higher then the foreign interest rate $\gamma > \delta$.

The nominal exchange rate that links domestic and foreign money market is given as:

$$S_t = Q_t\left(\frac{P_t}{P_t^*}\right) \qquad (2.60)$$

Equation 2.60 shows that nominal exchange rate can be defined as real exchange rate adjusted for relative price ratio. Real factors determine real exchange rate and are therefore exogenously given. Therefore, we can write equation 2.60 as:

$$\Delta s_t = \Delta p_t - \Delta p_t^* + \Delta q_t \qquad (2.61)$$

Equation 2.61 permits the deviation from purchasing power parity (PPP)

The changes in relative output growth are reflected in changes in real money demand which in turn depend on real exchange rate and relative interest rate differential changes. Therefore, we can write this relationship as:

$$(\Delta y_t - \Delta y_t^*) = \psi \Delta q_t - \lambda(\Delta i_t - \Delta i_t^*) \qquad (2.62)$$

Equation 2.62 indicates that relative changes in output depend on real exchange rate changes and on relative interest rate differential between domestic and foreign country.

Solving equation 2.58 for Δp_t yields:

$$\Delta p_t = \Delta d_t + \Delta f_t - \alpha \Delta y_t - \beta \Delta i_{mt} - \varphi \Delta w_t + \gamma \Delta i_t + \delta \Delta i_t^* \qquad (2.63)$$

Similarly, the solution of (2.59) for Δp_t^* yields

$$\Delta p_t^* = \Delta m_t^* - \alpha \Delta y_t^* - \beta \Delta i_{mt}^* - \varphi \Delta w_t^* + \delta \Delta i_t + \gamma \Delta i_t^* \qquad (2.64)$$

Subtracting 2.64 from 2.63 yields:

$$\Delta p_t - \Delta p_t^* = \Delta d_t + \Delta f_t - \alpha \Delta y_t - \beta \Delta i_{mt} - \varphi \Delta w_t + \gamma \Delta i_t + \delta \Delta i_t^* - \left[\Delta m_t^* - \alpha \Delta y_t^* - \beta \Delta i_{mt}^* - \varphi \Delta w_t^* + \gamma \Delta i_t^* + \delta \Delta i_t\right]$$

$$\Delta p_t - \Delta p_t^* = \Delta d_t + \Delta f_t - \alpha \Delta y_t - \beta \Delta i_{mt} - \varphi \Delta w_t + \gamma \Delta i_t + \delta \Delta i_t^* - \Delta m_t^* + \alpha \Delta y_t^* + \beta \Delta i_{mt}^* + \varphi \Delta w_t^* - \gamma \Delta i_t^* - \delta \Delta i_t$$

Substituting equation 2.61 for domestic and foreign price differential in the above equation yields:

$$\Delta s_t - \Delta q_t = \Delta d_t + \Delta f_t - \alpha\Delta y_t - \beta\Delta i_{mt} - \varphi\Delta w_t + \gamma\Delta i_t + \delta\Delta i_t^* - \Delta m_t^* + \alpha\Delta y_t^* +$$
$$\beta\Delta i_{mt}^* + \varphi\Delta w_t^* - \gamma\Delta i_t^* - \delta\Delta i_t$$

Re-arranging the above equation yields:

$$\Delta s_t - \Delta f_t = (\Delta d_t - \Delta m_t^*) - \alpha(\Delta y_t - \Delta y_t^*) - \beta(\Delta i_{mt} - \Delta i_{mt}) - \varphi(\Delta w_t - \Delta w_t^*) +$$
$$(\delta - \gamma)(\Delta i_t^* - \Delta i_t) + \Delta q_t$$

Substituting equation 2.62 in the above equation yields:

$$\left[\Delta s_t + \beta(\Delta i_{mt} - \Delta i_{mt}^*) - \Delta f_t\right] = (\Delta d_t - \Delta m_t^*) - \alpha\psi\Delta q_t + \alpha\lambda(\Delta i_t - \Delta i_t^*) - \varphi(\Delta w_t - \Delta w_t^*) +$$
$$(\gamma - \delta)(\Delta i_t^* - \Delta i_t) + \Delta q_t$$

Re-arranging the above equation:

$$\left[\Delta s_t + \beta(\Delta i_{mt} - \Delta i_{mt}^*) - \Delta f_t\right] = (\Delta d_t - \Delta m_t^*) + (1 - \alpha\psi)\Delta q_t + (\alpha\lambda + \gamma - \delta)(\Delta i_t - \Delta i_t^*)$$
$$- \varphi(\Delta w_t - \Delta w_t^*) \qquad (2.65)$$

The left-hand side of equation 2.65 measures Exchange Market Pressure in a wealth-augmented monetary model. It is a simple sum of nominal exchange rate changes, changes in relative interest rate differential and foreign exchange reserve changes. It shows that interest rate is another channel that the Central Bank can use for restoring foreign exchange market equilibrium. The positive sign indicates that Central Bank can relieve Exchange Market Pressure by increasing interest rate, letting exchange rate to depreciate or by selling foreign exchange reserves or any combination of all these variables.

Equation 2.65 further shows the determinants of Exchange Market Pressure in a wealth-augmented monetary model. It indicates that Exchange Market Pressure can be explained by relative changes in monetary aggregates, real exchange rate changes, relative changes in long-term interest rate differential and relative changes in non-bank private sector wealth. It reveals that growth in domestic monetary aggregates greater than foreign country aggregates increases pressure on domestic currency to depreciate. Similarly, the factors that increase demand for domestic money relative to foreign money, such as non-bank private sector wealth, reduce pressure. As we have argued above, $\gamma > \delta$; therefore, a domestic long-term interest rate above a foreign interest rate suggests an increase in pressure.

2.5 Central Bank Foreign Exchange Intervention

The Central Bank can influence Exchange Market Pressure by intervening in the foreign exchange market. This could be direct or indirect intervention. Direct intervention refers to the purchase and sale of foreign exchange reserves with the sole objective of influencing exchange market pressure. On the other hand, the use of interest rate to influence the prevailing pressure is called the Central Bank's indirect foreign exchange market intervention. In this thesis, we have particularly focused on the Central Bank's direct intervention.

Direct intervention can be sterilised and unsterilised. Sterilised intervention refers to Central Bank's offsetting the effect of purchase and sale of foreign exchange reserve on domestic monetary base. In other words, under sterilised intervention, domestic monetary base remains unaffected by the Central Bank's actions in the foreign exchange market. In contrast, under sterilised intervention, the Central Bank does not offset the effects of its foreign exchange intervention on domestic monetary base. Thus domestic monetary base changes by the extent of changes in foreign exchange reserves. Since it changes domestic monetary base therefore, it is assumed that unsterilised intervention has a significant effect on exchange market pressure. On the other hand, the effect of sterilised intervention on exchange market pressure is uncertain. Since it leaves the domestic monetary base unaffected its effect on market pressure is still to be fully investigated.

In this thesis, we have focused on the Central Bank intervention in the foreign exchange market. We have then used intervention index values for evaluating the conduct of the Central Bank monetary policy over the given sample period. The objective was to check the extent that Central Bank allows to market forces in the determination of exchange rate level. We have not paid attention to whether the intervention policy pursued by the Central Bank is sterilised or unsterilised.

2.6 Conclusion

In this chapter we have discussed theoretical models of Exchange Market Pressure. They are called model-dependent models because either the components of exchange market pressure or weights assigned to them or both are derived from a stochastic macro model. The objective was to check how they differ from each other in terms of their components or weights assigned to them or both.

Girton and Roper (1977) used a monetary model of exchange rate determination and derived exchange market pressure index that is a simple sum of exchange rate and foreign exchange reserve changes. It assigns equal weights to both exchange rate changes and foreign exchange reserve changes. Hence the construction of Girton and Roper's (1977) exchange market pressure index does not require estimating any stochastic macro model for deriving weights to be assigned to components of pressure index. Roper and Turnovsky (1980) on the other hand, used an *IS-LM* framework for deriving the trade off that monetary authorities face between exchange rate and foreign exchange reserves when they stabilise domestic output. The exchange market pressure that they derive is the sum of exchange rate and foreign exchange reserve changes. However, both components are not equally weighted. The construction of Roper and Turnovsky (1980) requires estimating six parameters for weighting foreign exchange reserve changes.

Contrary to Girton and Roper (1977) and Roper and Turnovsky (1980), Weymark (1995) constructed an exchange market pressure and intervention index. The intervention index is defined as the fraction of pressure that the Central Bank relieves through the purchase and sale of foreign exchange reserves. Similar to Roper and Turnovsky (1980), Weymark (1995) also used a macro model for deriving the weights assigned to foreign exchange reserve changes. Contrary to Roper and Turnovsky (1980), Weymark (1995) requires the estimation of two parameters for assigning weights to foreign exchange reserve changes.

Girton and Roper's (1977), Roper and Turnovsky's (1980) and Weymark's (1995) exchange market pressure indices are simple sums of exchange rate and foreign exchange reserve changes. However, they differ in weighting schemes. Pentecost et al. (2001), on the other hand used a wealth-augmented monetary model and derived an exchange market pressure index that is a simple sum of exchange rate, foreign exchange reserve and relative interest rate differential changes. The construction of Pentecost et al.'s (2001) exchange market pressure index requires the estimation of one parameter for assigning weight to the relative interest rate differential component in the exchange market pressure index.

Chapter Three

Empirical Exchange Market Pressure Literature

In this chapter, we discuss the studies that have used Girton and Roper (1977), Weymark (1995) and Eichengreen et al. (1996) for evaluating pressure on different countries' currencies and monetary authorities' response function. Furthermore, we also discuss the studies that have used Girton and Roper (1977) and Eichengreen et al. (1996) for evaluating the determinants of exchange market pressure in time series and panel frameworks. The objective of constructing Exchange Market Pressure and an intervention index is to check the direction of pressure and see what fraction of pressure Central Banks relieve through the purchase and sale of foreign exchange reserves. Furthermore, the objective of evaluating the determinants of Exchange Market Pressure is to determine whether they confirm their theoretical predictions. The results indicate downward pressure and active Central Bank intervention. Furthermore, we gather evidence that the determinants of market pressure confirm their theoretical predictions.

The rest of the chapter is as follows. In section 3.1 we discuss the studies that have used Girton and Roper's (1977) model and its different versions to different countries. Section 3.2 discusses the studies that have used a VAR approach while using Girton and Roper's approach. Weymark's (1995) model and its application to different countries are discussed in section 3.3. In section 3.4, attention is paid to the studies that have used Eichengreen et al. (1996) in time series and panel frameworks. Section 3.5 concludes.

3.1 Empirical Studies of variants of the Girton and Roper (1977) Model.

The first model that we discuss is Girton and Roper's (1977) theoretical model. They applied their model to post-war Canada. Its objective was to construct Exchange Market pressure index and measure the degree of autonomy that the Canadian Central Bank has in pursuing an independent monetary policy in an open economy. They equated monetary autonomy with monetary authorities' ability in diverging domestic prices and interest rates from their foreign counterparts by the use of monetary policy. Girton and Roper (1977) measured the monetary independence with the domestic credit parameter in their estimated regression equation. A lower domestic credit estimated coefficient suggests that monetary authorities can use domestic credit as instrument of monetary policy for influencing domestic macroeconomic conditions. On the other hand, higher domestic credit shows that an increase in the domestic component of money supply would increase pressure on domestic currency. Such a case implies the loss of monetary independence. They regressed EMP_t on Canadian dollar on changes in domestic credit (Δd_t), growth of US money supply (Δm_t^*), domestic output growth (Δy_t) and US output growth (Δy_t^*) respectively and estimated the following equation:

$$EMP_t = \alpha \ - \beta_1 \Delta d_t + \beta_2 \Delta m_t^* + \beta_3 \Delta y_t - \beta_4 \Delta y_t^* + v_t \qquad (3.1)$$

Where EMP_t consists of Canadian exchange rate defined as number of units of Canadian per US dollar changes (Δs_t) and foreign exchange reserve changes (Δf_t) respectively. A random error term v_t is included in the equation to capture the effects of omitted variables from the equation and deviations from equilibrium. Similarly, α is an intercept that measures the extent of pressure in case all regressors included in the equation are equal to zero. Girton and Roper (1977) estimated equation 3.1 for Canada using annualised data for the period 1952 through 1974. The estimated coefficient of domestic credit in equation 3.1 was quite high, suggesting that Canadian monetary authorities when under a fixed exchange rate, had little scope for pursuing independent monetary policy. In other words, an increase in domestic credit reflected in either exchange rate changes (Δs_t) or foreign exchange reserve changes (Δf_t) or any combination of both under managed float. Other variables included in the regression equation (3.1) confirmed their theoretical predictions. Girton and Roper (1977) tested the sensitivity of exchange market pressure index to its components (whether the authorities absorb pressure in international reserve changes or exchange rate changes) by including a new variable $\vartheta = s_t / f_t$ in (3.1) and re-estimated it. The newly introduced variable was insignificant and the estimates of the rest of the variables remained unchanged. This suggests that the constructed exchange market pressure is insensitive to its components (see table 3.1). This has the policy implication that the components of Exchange Market Pressure can be used for the foreign exchange market intervention necessary for attaining certain exchange rate targets (Girton and Roper, 1977).

A modified version of Girton and Roper's (1977) model was applied to Brazil by Connolly and da Silveira (1979). This modified version depends on four essential ingredients: (a) stable money demand function, (b) money supply (c) purchasing power parity, and (d) monetary equilibrium. Unlike Girton and Roper (1977), Connolly and da Silveira assume that purchasing power parity holds continuously.[8] Based on these assumptions, they derived a single country exchange market pressure regression equation given as:

$$EMP_t = -\beta_1 \Delta d_t + \beta_2 \Delta p_t^* + \beta_3 \Delta y_t \qquad (3.2)$$

Connolly and da Silveira estimated equation (3.2) for two period: one for 1955-1975 and then for a shorter sub-period of fourteen years, 1962-1975 for Brazil. The sign of the estimated coefficient on the growth of domestic credit was consistent with a monetary model

[8] Purchasing power parity states that domestic prices reflect foreign prices via exchange rate changes.

of exchange market pressure and was significant in both periods. This can be interpreted as given a stable money demand function; an increase in domestic credit is associated with an outflow of foreign exchange reserve or depreciation of exchange rate or any combination of these under a managed float. Thus the domestic credit coefficient worked as an offsetting coefficient, and reflected changes in domestic credit being offset by either exchange rate changes or foreign exchange reserve changes or any combination of these. The estimates of both foreign price, β_2 and income β_3, were not significant from 1955 to 1975, but were from 1962 to 1975. This shows that an increase in these variables appreciated domestic currency, encourages capital inflow or a combination of both, and thus reduced pressure on domestic currency.

It is argued that the regression equation that uses the exchange rate or foreign exchange reserves changes as the sole dependent variable assumes a fixed and flexible exchange rate regime. Connoly and da Silveira (1979) verified the performance of the model that uses simultaneous changes in exchange rate and foreign exchange reserve changes by comparing its results with those that are obtained using exchange rate and foreign exchange reserve changes as the sole dependent variable. The results of the regression equation that used exchange rate and foreign exchange reserve changes compared to those obtained using the sum of exchange rate and foreign exchange reserve changes were poor for the entire sample period and worst for the sub-sample. This confirmed the opinion that under a managed float, simultaneous changes in exchange rate and foreign exchange reserve changes better explain exchange market pressure then exchange rate or foreign exchange reserve changes alone. They also tested the sensitivity of exchange market pressure to its components by including

$\vartheta_t = (s_t - 1)/(f_t - 1)$ exchange rate to foreign exchange reserve ratio.[9] The basic objective of including this ratio as an additional variable was to check what fraction of pressure the monetary authorities relieve by exchange rate and foreign exchange reserve changes respectively. The higher value of the estimated coefficient of ϑ_t implied that monetary authorities preferred exchange rate changes in relieving pressure. On the other hand, lower value is associated with foreign exchange reserve absorbing a major portion of exchange market pressure. The estimated coefficient of ϑ_t was insignificant and other coefficients remained unchanged. The insignificant estimate of ϑ_t implied that the monetary authorities did not distinguish between exchange rate and foreign exchange reserves in relieving exchange market pressure (see Table 3.1 for details).

The modified version of Girton and Roper (1977) given in equation 3.2 is further applied by Modeste (1981) for evaluating the Argentinean monetary experience during the 1970s. All variables except foreign price confirmed their theoretical predictions. However, the estimated coefficient of foreign price was insignificant and yet the F – statistic of 9.41 indicate that the three variables together explained substantial variation in exchange market pressure.[10] Modeste (1981) further tested the sensitivity of exchange market pressure to its components by including $\vartheta_t = (s_t - 1)/(f_t - 1)$ as an additional regressor. The estimated coefficient of ϑ_t was insignificant and the estimated parameters for the remaining variables remained unchanged. This supports the view that monetary authorities did not distinguish between exchange rate and foreign exchange reserve changes in restoring foreign exchange market equilibrium. Modeste (1981) further tested the efficacy of monetary model of exchange market pressure using exchange rate and foreign exchange reserves as the sole dependent

[9] Girton and Roper (1977) used $\vartheta = s_t / f_t$ for testing the sensitivity of Exchange Market Pressure to its components. It is discontinuous for values of f_t equals to zero.

[10] The F-test is used to test the null that all estimated parameters in the regression equation are zero. Its rejection implies that one of these estimates is non-zero and thus explains some variation in the dependent variable.

variables. The use of exchange rate and foreign exchange reserves as the sole dependent variable implies flexible and fixed exchange rate system. The estimates of exchange market pressure using either exchange rate or foreign exchange reserve changes as sole dependent variable were inferior to those obtained from the regression equation that used the sum of exchange rate and foreign exchange reserve changes as the dependent variables. This confirm the view that under managed float, both exchange rate and foreign exchange reserves instead of exchange rate and foreign exchange reserves alone better explain market pressure for Argentina in 1970s. These finding confirm the superiority of monetary model in explaining market pressure under a managed float.

The studies discussed above focused on the relationship between exchange market pressure and its determinants. It is important for the parameters to be stable over time for the formulation of effective policy. Hodgson and Schneck (1981) addressed this issue and tested the stability of Exchange Market Pressure and its monetary determinants for Canada, France, West Germany, Belgium, the Netherlands and Switzerland. They used quarterly data from 1959:02 to 1976:01 and two stage least square approach for carrying out their analysis. For the United Kingdom, the sample period was 1964:02 to 1976:01, due to the absence of some data before 1964. Hodgson and Schneck tested the stability of the relationship between Exchange Market Pressure and its determinants using the following equation:

$$EMP_t = \alpha + \beta_1 \Delta s_{t+1} + \beta_2 \Delta y_t + \beta_3 \Delta p_t + \beta_4 \Delta a_t + \beta_5 \Delta d_t$$

$$\beta_6 \Delta y_t^* + \beta_7 \Delta p_t^* + \beta_8 \Delta a_t^* + \beta_9 \Delta d_t^* + \beta_{10} f_t^* + v_t \tag{3.3}$$

The new variables introduced in equation 3.3 are Δs_{t+1} and Δa_t. The former denote future spot rate of the same maturity as domestic and foreign interest rate and the latter is the deposit expansion multiplier. The future spot rate reflects the linkage between domestic and foreign economies through the asset market. It reflects the effects of interest rate differential between domestic and foreign countries on exchange market pressure. The deposit expansion multiplier is the inverse of reserve requirements. It reflects the influence of an increase in checkable deposits resulting from the changes in the reserves of the commercial banks on exchange rate and reserve changes. The world counterparts of the domestic variables are denoted by *. The world variables are weighted average of the corresponding variables for the individual countries. The weights are the ratio of individual money stocks to world money stocks. The world is defined as the sample countries plus United States, Japan and Italy.

Expected signs of the coefficients are:

$\beta_2, \beta_7, \beta_8, \beta_9, \beta_{10} > 0$ and $\beta_4, \beta_5, \beta_6, \beta_7 < 0$

The sign of β_1 is uncertain. It reflects the effect of interest rate differential between domestic and foreign country on exchange market pressure through uncovered interest rate parity. This could be either positive or negative. The positive effect of future spot exchange rate is in conformity with the Chicago theory that assumes flexible prices. As a consequence, changes in nominal interest rate reflect changes in expected inflation rate. Therefore, an increase in domestic interest rate relative to foreign interest rate reflect an increase in domestic inflation and hence an increase in pressure on domestic currency to depreciate.

On the other hand, negative future spot rate is in accord with Keynes theory which assumes sticky prices, at least in the short run. Thus the assumption of sticky prices suggests a rise in interest rate as a consequence of contraction in domestic money supply without matching fall in domestic prices. A domestic interest rate higher than the foreign interest rate attracts capital inflows and thus puts pressure on domestic currency to appreciate. Thus Keynes theory suggests a negative relationship between future spot rate and exchange market pressure. The results indicate that money demand variables were generally insignificant. On the other hand, money supply variables like domestic credit and home money multiplier were significant with signs as predicted by theory. The stability test however, suggested a weak relationship between exchange market pressure and its monetary determinants.[11]

The estimated parameters of domestic income (Δy_t), foreign price (Δp_t^*), foreign deposit expansion multiplier (Δa_t^*) and expansion in the domestic credit of foreign country (Δd_t^*) results either an increase in foreign exchange reserve or appreciation of domestic currency or both and thus reduce pressure on domestic currency. On the other hand, the estimated coefficients of changes in domestic price (Δp_t), domestic deposit expansion multiplier (Δa_t), domestic credit (Δd_t) and foreign income (Δy_t^*) exert pressure on domestic currency to depreciate and that an increase in these variables either reduces domestic countries holding of foreign exchange reserves, depreciates the value of domestic currency or both.

A slightly altered formulation of Connolly and da Silveira's (1979) version of Girton and Roper's (1977) model was adopted by Kim (1985) for examining Korean foreign exchange market conditions for the period March 1980 to July 1983. He estimated the following equation:

$$EMP_t = -\beta_1 \Delta d_t + \beta_2 \Delta p_t^* + \beta_3 \Delta y_t - \beta_4 \Delta mm_t \qquad (3.4)$$

In addition to standard variables, Kim includes Δmm_t in the equation for capturing the effects of money multiplier changes on Exchange Market Pressure.[12] The negative estimates of domestic credit and money multiplier confirmed theoretical predictions that an increase in these variables increased pressure on domestic currency to depreciate. This can be interpreted as, when the nominal cash balances of the domestic residents increase, they swap them for foreign currency. This increases pressure on domestic currency to depreciate. On the other

[11] Zettelmeyer (2004) evaluated the impact of monetary policy shocks on exchange rate in Australia, Canada and New Zealand during the 1990s. They identified monetary shocks with the reaction of three months market interest rate to policy announcements that were not themselves endogenous to economic news on the same day and found a negative association between interest rate hike and exchange market pressure.

[12] The money multiplier reflects the total change in the money supply that results from an increase of one unit of money in the economy.

hand, positive estimates of foreign price and domestic income support the view that an increase in both these variables attracts either an inflow of foreign exchange reserves or exchange rate appreciation or any combination of both. Kim reestimated equation 3.4 by including $\vartheta_t = (s_t - 1)/(f_t - 1)$ as an additional regressor. The objective was to test the sensitivity of exchange market pressure to its components. The estimate of coefficient on this variable was insignificant and other variables remained unaffected. This suggests that monetary authorities did not distinguish between exchange rate and foreign exchange reserve in relieving pressure. Finally, Kim estimated equation 3.4 using foreign exchange reserves as the sole dependent variable. The estimated coefficient of variation and significance of foreign price increased substantially while that of domestic income and domestic credit reduced slightly. Kim interprets this finding as the Korean monetary authorities preferring to utilise foreign exchange reserves in relieving pressure. This may reflect the Korean monetary authorities' fear that exchange rate movements may unduly influence domestic prices and the debt burden of the country.

The monetary models that used exchange rate changes as the sole dependent variable failed to explain short-term movements of Canadian-US dollar exchange rate in the 1970s (Backus, 1984; Lafrance and Racette, 1985). This cast doubt on the validity of the monetary approach as an explanation of the short run movements of Canadian-US exchange rate after the breakdown of Bretton Wood system. Burdekin and Burkett (1990) argued that the studies that use exchange rate as the sole dependent variable implicitly assume a fully flexible exchange rate which seems inconsistent with the actual post-Bretton Wood experience of dirty float. They therefore used simultaneous changes in exchange rate and foreign exchange reserve as the dependent variable and re-examined the performance of the Girton and Roper's (1977) monetary model for explaining short-term movements of the Canadian-US exchange rate for the period 1963:01 to 1988:01. The objective was to test whether the monetary model adequately explains short-term movements of the Canadian-US exchange rate since its floating in June 1970. The proposed dynamic specification of the Girton and Roper (1977) model included lagged dependent and independent variables. Other variables included in the model are the Canadian and US gross national product deflators and the Canadian and US three-month Treasury bill rates. The results indicate that all variables have signs consistent with the literature and were generally significantly different from zero. However, some variables were insignificant, particularly the Canadian Treasury Bill Rate.

A modified version of Girton and Roper's (1977) monetary model of Exchange Market Pressure as given in equation 3.4 was further applied by Thornton (1995) to Costa Rica. Costa Rica is a small economy in which foreign prices and monetary conditions are taken as given. In addition, Costa Rica's domestic currency and foreign exchange reserves witnessed significant changes over the given sample period. This made Costa Rica a suitable country for testing the validity of Girton and Roper's (1977) monetary model of Exchange Market Pressure.

The estimated parameters were in conformity with their theoretical predictions. The negative estimate of domestic credit and money multiplier implied that an increase in domestic credit increased pressure on domestic currency to depreciate. On the other hand, positive signs of foreign price and domestic income suggest that an increase in these parameters is associated with decrease in pressure on domestic currency. Thornton (1995) further tested the sensitivity of exchange market pressure to its components by including the ratio of the exchange rate to foreign exchange reserves $\vartheta_t = (s_t - 1)/(f_t - 1)$. The estimated coefficient on this variable was insignificant and other estimates remained unchanged. This suggests that monetary authorities did not distinguish between exchange rate and foreign exchange reserve changes in relieving pressure. Finally, Thornton (1995) reestimated the model using foreign exchange reserves as the sole dependent variable. The overall estimates of the model improved substantially, which the author interprets as the Central Bank of Costa Rica preferring foreign exchange reserve in relieving pressure. This may reflect the monetary authorities' fear that exchange rate changes might influence domestic price levels.

All the studies discussed above, except Burdekin and Burkett (1990), estimated Girton and Roper (1977) and its modified version without allowing for a dynamic response. Mah (1998) on the other hand, adopted a dynamic approach and re-examined Connolly and da Silveira's (1979) version of Girton and Roper's model as given in equation 3.2 for Korea. The dynamic equation that Mah proposed included lagged values of the independent variables. The estimated coefficients showed signs consistent with their theoretical predictions. Furthermore, the estimated parameters were significantly different from zero suggesting that dynamic specification of equation 3.2 explained exchange market pressure for Korea adequately.

All the studies discussed above use Girton and Roper's (1977) model to examine individual country Exchange Market Pressure. Bahmani-Oskooee and Bernstein (1999) on the other hand, employed Girton and Roper's (1977) model for investigating EMP_t for Canada, France, Germany, Italy, Japan, UK and the US. They estimated three different specifications of this equation. In addition to the benchmark model as given in equation 3.4, they estimated it using exchange rate foreign exchange reserve ratio $\vartheta_t = (s_t - 1)/(f_t - 1)$ as an additional independent variable. The basic objective of including this ratio was to test the sensitivity of exchange market pressure to its component. The third specification used foreign exchange reserve changes instead of composite index that includes exchange rate and foreign exchange reserves as the dependent variable. The estimates of benchmark equation were poor. The domestic credit coefficient was insignificant for all countries except Canada and the UK. However, when the same equation is estimated using ϑ_t as an additional regressor, results were substantially improved. The estimate of ϑ_t is significant and of negative sign, suggesting that most of the pressure in these countries is absorbed by changes in foreign exchange reserves rather than exchange rate changes. Finally, the specification of equation 3.4 that used foreign exchange reserves instead of composite variables, including exchange rate and foreign exchange reserve changes yield the estimates of variables of interest in accord with literature. One implication of these findings is that the exchange rate regime of these countries was close to fixed instead of freely floating.

Contrary to the studies discussed above, Pollard (1999), tested Wohar and Lee's (1992) formulations of the Girton–Roper (1977) model using data from Barbados (1968 - 1991), Guyana (1964 - 1985), Jamaica (1964 - 1993), and Trinidad and Tobago (1967 - 1993). The basic objective of the paper was to identify the international variables that develop pressure on Caribbean countries' currencies. Wohar and Lee's (1992) formulation of the Girton and Roper model is given as:

$$EMP_t = -\beta_1 \Delta mm_t - \beta_2 \Delta d_t + \beta_3 \Delta m_t^* + \beta_4 \Delta q_t + \beta_5 \Delta y_t - \beta_6 \Delta y_t^* - \beta_7 \Delta er_t + v_t \qquad (3.5)$$

q_t and er_t denotes deviation from the purchasing power parity and interest rate differential between domestic and foreign country.

Wohar and Lee (1992) proposed an alternative to this model which is given as:

$$EMP_t = -\beta_1 \Delta mm_t - \beta_2 \Delta d_t + \beta_3 \Delta p_t^* - \beta_4 \Delta i_t^* + \beta_5 \Delta q_t + \beta_6 \Delta y_t - \beta_7 \Delta er_t + v_t \qquad (3.6)$$

The difference between the two equations is the way foreign disturbance enters into the economy. In equation 3.5, foreign money supply and income are the sources of foreign disturbance. On the other, foreign price and interest rate are the important sources of foreign disturbances in equation 3.6.

The estimates of both domestic credit and money multiplier are significant and are negatively signed, which is in conformity with the literature. Similarly, the estimate of differential between domestic and foreign price is positive and is significant, suggesting that purchasing power parity does not hold for Caribbean countries. Similarly, the coefficient of domestic income, although of positive sign, is not significantly different from zero.

The results further showed that growth in US money supply significantly increased pressure for Barbados and Guyana and was therefore identified as a major source of foreign disturbance for these countries. On the other hand, US inflation significantly increased pressure for Jamaica and Trinidad and was therefore identified as an important source of foreign disturbance for these countries. For Jamaica, the US interest rate was identified as a source that contributed to the build up of pressure on its currency. Finally, Pollard tested the composition of Exchange Market Pressure to its components by including another variable $\vartheta_t = (s_t - 1)/(f_t - 1)$ in the regression equation. The estimated coefficient on this ratio was insignificant for Jamaica and Trinidad & Tobago. However, for Barbados and Guyana the estimate was significant and of positive and negative sign. This suggests that in Barbados, the monetary authorities preferred exchange rate changes for relieving pressure. On the other hand, the negative estimate of this ratio implies that monetary authorities in Guyana intervened in foreign exchange market and relieved most of the pressure by selling and purchasing foreign exchange reserves.

Contrary to above studies, Taslim (2003) applied Girton and Roper's (1977) framework to study Australian exchange market pressure and reserve transactions during 1975-1997. The results indicate substantial reserve transactions even after the switch to a floating exchange rate in December, 1983. This shows that Australian monetary authorities permitted little flexibility to exchange rate in adjusting towards its underlying market equilibrium rate. An implication of the continued intervention is that monetary policy is unlikely to be fully independent of balance of payments adjustments.

Most of the studies that we have discussed have used domestic and foreign macroeconomic variables as Exchange Market Pressure determinants. Conversely, Hallwood and Marsh (2004) used expected exchange rate changes within the bands $E\Delta x_{t+1}$ and expected exchange rate depreciation from the central parity Ec_{t+1} along with macroeconomic variables as the determinants of Exchange Market Pressure. They evaluated Exchange Market Pressure against pound during the inter-war period when it operated a peg to gold and consequently to the US dollar and estimated an Exchange Market Pressure model in the following form:[13]

$$EMP_t = \alpha - \beta_1 d_t + \beta_2 d_t^* + \beta_3(\Delta y_t - \Delta y_t^*) - \beta_4 \Delta q_t - \beta_5 E\Delta x_{t+1} - \beta_6 E(\Delta c_t) + v_t \qquad (3.7)$$

EMP_t refers to Girton and Roper's (1977) measure of Exchange Market Pressure index. Its lower value implies greater pressure against pound because there is some reduction in the domestic reserves relative to foreign reserves and exchange rate depreciation.

We include $E\Delta x_{t+1}$ and Ec_{t+1} as additional regressors. The rationale for including the real exchange rate is to evaluate the effect of deviation from purchasing power parity on the level of exchange market pressure. An over-valued real exchange rate reduces domestic exporters' competitiveness in the international market and hence puts downward pressure on domestic currency. The deviations from central parity (c_t) and movements of exchange rate within the band (x_t) reflect the effect of expected exchange rate change on the level of exchange market pressure. Uncovered interest rate parity suggests that expected exchange rate reflects the differential between domestic and foreign interest rate therefore, we include deviations from central parity (c_t) and movements of exchange rate within the band (x_t) to evaluate the effect of interest rate differential on exchange market pressure. The asterisk denotes foreign counterparts of domestic variables.

The main finding of the paper is that devaluation expectation as denoted by deviations from central parity (c_t) and movements of exchange rate within band (x_t) and UK

[13] Hallwood and Marsh (2004) used monthly data between May 1925 and August 1931 and McCallum-Wicken's instrumental variable technique, which uses instruments for endogenous variables.

macroeconomic fundamentals have significant power in explaining pressure. This has important implications in that disciplined management of macroeconomic fundamentals may not be enough to maintain a currency peg over a time. A foreign disturbance can put pressure on domestic currency and results in the collapse of a fixed exchange rate regime.

Foreign debt is an important factor that determines pressure on domestic currency. However, its effect on market pressure has not been evaluated in the empirical studies discussed above. There are two channels through which an increase in foreign debt increases pressure. It is argued that the debt burden contributes to market pressure in the form of increased debt and debt servicing payments. This is a direct effect of debt burden on market pressure. Indirectly, debt burden reduces productivity in the economy. With unchanged demand, a drop in the production increases prices of domestic goods and services. With unchanged world price level, increase in domestic prices increases pressure on domestic currency to depreciate. This makes it necessary to evaluate the effects of debt burden on the build up of exchange market pressure.

Guyana’s debt showed great fluctuations for the period 1968 to 2000. In 1968, it constituted approximately 30 percent of Guyana’s domestic income and had increased to more than 800 percent of domestic income by 1991. It fell to 180.5 percent of domestic income in 2000 due to debt relief given by the donor community. This makes it necessary to consider the impact of foreign debt burden on the build up of foreign exchange market pressure for Guyana. Modeste (2005) evaluated the impact of the foreign debt burden on Guyana market pressure using following equation:

$$EMP_t = \alpha - \beta_1 d_t - \beta_2 B_t^* + \beta_3 p_t^* - \beta_4 rpo_t - \beta_5 uncer_t + \beta_5 X_{t-1} \qquad (3.8)$$

We include the foreign debt burden (B_t^*), relative price of crude oil (rpo_t), macroeconomic uncertainty ($uncer_t$) and lagged real exports (X_{t-1}). Lagged real exports are used to allow for a delay in the response of productivity changes to growth in real exports. It is assumed that productivity growth is influenced by foreign debt burden, relative price of crude oil, macroeconomic uncertainty, and lagged growth in real exports and is therefore replaced by these variables in equation 3.8. The results confirm theoretical predictions. Empirical evidence shows that domestic credit, foreign debt burden, relative crude oil price and macroeconomic uncertainty are positively correlated with exchange market pressure. On the other hand, growth in foreign price (p_t^*) and lagged real exports ($\exp_{t-1}$) reduce pressure on Guyanian dollar to depreciate.[14]

The studies discussed above confirm monetary approach to Exchange Market Pressure which argues that a rise in the domestic component of a monetary base would reduce either the foreign exchange reserve or the depreciation of currency. The results obtained in these studies further support this interpretation. Particularly, domestic credit is consistently negatively related to Exchange Market Pressure, and is significant, apart from in Bahmani Oskooee and Bernstein (1999). This suggests that a rise in domestic credit results either in exchange rate depreciation or depletion of foreign exchange reserves or any combination of these. This has the important policy implication for the Central Bank having to give up its monetary independence of attaining domestic objectives when it targets exchange rate stability. The estimate of money multiplier has also the same interpretation. Furthermore, the estimates of foreign price and domestic income are consistent with their prediction. An increase in domestic income and foreign price reduce pressure on domestic currency. All these findings are consistent with the monetary model of exchange market pressure.

[14] Burket and Richard (1993) evaluated the impact of global and regional developments and found that the shocks emanating in the region had greater power in explaining Paraguayan pressure.

Table 3.1 Summary of Early Empirical Evidence on Girton and Roper (1977) Exchange Market Pressure Model.

Authors	Country	Period	d_t	mm_t	m_t^*	p_t^*	y_t^*	y_t	q_t	er_t	i_t^*
Girton and Roper(1977)	Canada [c]	1952A - 1974A	-0.96 [a]		1.14 [a]		-2.84 [a]	2.80 [a]			
Connolly and da Silveira (1979)	Brazil [c]	1955A - 1975A	-0.85 [a]			1.2		2.78			
Modeste (1981	Argentina [c]	1972Q2 - 1978Q3	-1.46 [a]			1.1		0.87 [a]			
Kim (1985) [c]	Korea	1980M2 - 1983M7	-0.69 [a]	-0.56 [a]		0.95		0.06 [a]			
Thornton(1995) [c]	Costa Rica	1986M1 - 1992M12	-0.92 [a]	-0.85 [a]		4.3 [a]		0.43 [a]			
Bahmani-Oskooee and Bernstein (1999)	Canada [c]	1973Q1 - 1993Q3	-1.37 [a]	-1.46 [a]		1.36 [a]		0.06 [a]			
Bahmani-Oskooee and Bernstein (1999)	France [c]	1973Q1 - 1993Q3	-0.42 [a]	-0.44 [a]		-0.06		-1.26			
Bahmani-Oskooee and Bernstein (1999)	Germany [c]	1973Q1 - 1993Q3	-0.43 [a]	-1.30 [a]		-0.33		-0.30			
Bahmani-Oskooee and Bernstein (1999)	Italy [c]	1973Q1 - 1993Q3	0.04	-0.55 [a]		0.31		0.31			
Bahmani-Oskooee and Bernstein (1999)	Japan [c]	1973Q1 - 1993Q3	-0.99 [a]	-1.29 [a]		0.18		0.37 [a]			
Bahmani-Oskooee and Bernstein (1999)	UK [c]	1973Q1 - 1993Q3	1.15 [a]	-1.45 [a]		1.13 [a]		-0.13			
Bahmani-Oskooee and Bernstein (1999)	US [c]	1973Q1 - 1993Q3	-0.26 [a]	-0.23 [a]		-0.01		-0.07			
Polard (1999)	Barbados [c]	1968A - 1993	-1.04 [a]	-1.38 [a]	0.61 [a]		0.31	2.033 [a]	0.29	0.01	
Polard (1999)	Guyana [c]	1964A-1985A	-1.02 [a]	-0.83 [a]	1.59 [a]		-0.05	0.51	1.05 [a]	-0.12 [a]	
Polard (1999)	Jamaica [c]	(1964A-1993A)	-0.97 [a]	-1.07 [a]		1.88 [a]		1.35 [a]	1.06 [a]	0.14	- 0.36 [a]
Polard (1999)	Trinidad &Tobago	1967A-1993A	-1.01 [a]	-1.09 [a]		2.14 [a]		1.12 [a]	1.16 [a]	-0.08	-0.02

Note: d_t, mm_t, m_t^*, p_t^*, y_t^*, y_t, q_t, er_t and i_t^* denotes domestic credit, money multiplier, foreign money supply, foreign price, foreign income, domestic income, deviations from purchasing power parity, interest differential between domestic and foreign country and foreign interest rate. c denotes that this regression uses independent variable $\vartheta_t = (e_t - 1)/(f_t - 1)$. The coefficients of ϑ_t are not reported due to space constraint. The above empirical studies use Ordinary Least Square as estimation method. a denotes that estimated parameters are significantly different from zero.

3.2 Exchange Market Pressure Studies Based on VAR approach

In economics, it is common to have variables that not only explain some dependent variables but are also explained by the dependent variables. Such a situation is characterised as simultaneous equation bias. This issue is generally dealt with by the use of the instrumental variables technique which uses instrumental variables for endogenous variables. Furthermore, it splits variables between exogenous and endogenous variables. Sims (1980) criticised this approach and advocated equal treatment of all variables in the presence of simultaneous equation bias. That all variables should be treated as endogenous. It was in this spirit that Sims (1980) developed the Vector Auto Regression (VAR) Approach. Since its development, the VAR approach has been frequently used in empirical international finance literature.

The theoretical literature on currency crises emphasises macroeconomic variables and shifts in market expectations about the macroeconomic fundamentals as important determinants. Karfakis and Moschos (1999) used the VAR framework to examine the macroeconomic fundamentals that explain Exchange Market Pressure for Greece, using quarterly data from 1975Q1 to 1995Q4. The Granger causality results thus obtained show that real overvaluation of the drachma, the reserve adequacy ratio, the current account balance and the net capital movements have predictive power in explaining Greece exchange market pressure for the given period. On the other hand, variance and historical decomposition results show that shocks associated with real over valuation, reserve adequacy ratio, and net capital movements were the most important sources of foreign exchange market pressure in Greece. These findings have the implication that monetary authorities should monitor the signals given by these variables if they want to avoid pressure on the Greek drachma.

The independence of monetary authorities in formulating effective monetary policy depends on the exchange rate regime. In a fixed exchange rate regime, monetary authorities target the domestic currency value and market determines its quantity. Thus under a fixed exchange rate, monetary authorities lose monetary independence as they cannot use monetary instruments for attaining domestic objectives. On the other hand, a floating exchange rate buys monetary independence but monetary authorities have to give up the freedom of fixing the value of domestic currency in the foreign exchange market. In a managed float system, monetary authorities can simultaneously target the exchange rate stability and domestic objectives. Kamaly and Erbil (2000) used Exchange Market Pressure and a VAR approach for gauging the monetary independence for Middle East and North African (MENA) region countries (Egypt, Tunisia and Turkey) that maintained a managed float.[15] The authors were primarily interested in gauging the degree of monetary independence and the monetary authorities' response to exchange market pressure for MENA region.

The small estimates of domestic credit and interest rate differential may imply a higher degree of monetary independence for Turkey. This is also evident from exchange rate changes that dominate foreign exchange reserve changes. This provides support that the Turkish economy is more open and Turkish monetary authorities can use monetary policy for targeting domestic objectives. On the other hand, the large estimates of domestic credit and interest rate for Egypt and Tunisia suggest a low degree of monetary independence. The authors' interpretation of this finding is that in an environment of low monetary independence, monetary authorities have to vigorously change its monetary instruments for them to have a desirable effect on exchange market pressure.

Contrary to Kamaly and Erbil (2000) who tested the independence of monetary authorities, Tanner (2001) examined the responses of monetary authorities to Exchange Market Pressure for Brazil, Chile, Mexico, Indonesia, Korea and Thailand in VAR framework.

[15] The authors provide two reasons to justify the use of VAR: (a) it circumvents the endogenity problem, and (b) it provides an effective tool to analyse how a system reacts to shocks in one of its components through Impulse Response Function.

Particularly, Tanner was interested in identifying whether monetary authorities sterilised their foreign exchange market intervention. The results indicate that contractionary monetary policy reduced pressure. However, Mexican and East Asian countries' monetary authorities sterilised their foreign exchange market intervention and thus increased domestic credit in the event of a speculative attack on their currencies.

Tanner (2002) further extended his previous work (Tanner, 2001) and reexamined the relationship between exchange market pressure and monetary variables for 32 emerging markets in Western Hemisphere, Asia and Europe. Vector Autoregression Approach has the advantage of examining the relationship between exchange market pressure and monetary policy in both directions. In this study, Tanner (2002) used a modified exchange market pressure index that consisted of three elements, namely a real money demand, money supply and real exchange rate, as its components.[16] The VAR estimates of exchange market pressure indicate a positive association between domestic credit and exchange market pressure, a finding consistent with traditional monetary theory. The negative estimate of interest rate differential for the majority of the countries also confirms their theoretical predictions. This suggests that an increase in interest rate differential reduces pressure on domestic currency. Shocks to exchange market pressure increase domestic credit and thus confirmed the view that domestic monetary authorities sterilised their foreign exchange market intervention.

Pooled estimates further support individual country vector auto regression estimates. They show a positive association between domestic credit and exchange market pressure. However, pooled estimates of interest rate differential provide inconclusive evidence. The

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[16] Tanner (2002) uses modified exchange market pressure given as: $emp_t = d_t - m_t + \lambda_t$. Here λ_t denotes foreign price (p_t^*) and deviations from purchasing power parity (z_t). Thus exchange market pressure increases with fall in real money demand (m_t), increase in domestic component of money supply (d_t) or real exchange rate depreciates or foreign inflation falls (λ_t)

augmented model that includes fiscal policy variable estimated for the subset of the countries further provides evidence of the positive association between domestic credit and Exchange Market Pressure.[17]

The East Asian financial crises affected the countries of region to varying degrees and the Philippine was no exception to this. The standard International Monetary Fund prescription was the same as that embodied in monetary model of Exchange Market Pressure - to reduce domestic credit instead of targeting any exchange rate level (Boorman et al. 2000). Gochoco-Bautista and Bautista (2005) examined whether the prescription suggested by the International Monetary Fund contributed to strengthening the Philippine peso during the period. Particularly they focused on whether the monetary authorities' response of contracting domestic credit reduced pressure on the Philippine peso. They used Tanner's (2000, 2001) VAR method and obtained results that supported the traditional view of a positive association between domestic credit and Exchange Market Pressure. This supports the view that increase in domestic credit expansion either depreciates domestic currency or depletes the foreign exchange reserves of Central Bank or both. The results provide further evidence that in the non-crisis period, monetary authorities sterilised reserve outflow, fearing that unsterilised foreign exchange intervention would cause bankruptcy of the domestic financial system. However, in the crisis period, monetary authorities abstained from sterilizing foreign reserve outflow and followed a tight monetary policy in the face of exchange market pressure. Furthermore, in a non-crisis period, an increase in interest rate differential reduced pressure. Conversely to that, in a crisis period, an increase in interest rate differential increased pressure, suggesting a perverse effect. This has an important policy implication in that in the crisis

[17] Younus (2005) used Engel and Granger's (1987) two-step procedure and Vector Error Correction Model for evaluating the impact of domestic credit on exchange market pressure for Bangladesh. They found that an increase in domestic credit increases exchange market pressure, which is reflected either in exchange rate depreciation or foreign exchange reserves depletions or any combination these.

period, the use of interest rate as an instrument of monetary policy will not yield the desired results.

The empirical studies on Exchange Market Pressure that use a VAR approach tends to omit the output growth variable. However, the domestic output growth is considered to be an important determinant of Exchange Market Pressure. In the Girton and Roper (1977) model, growth in domestic output reduces pressure on the domestic currency. Furthermore, the second generation currency crises models argue that output growth might inversely affect the devaluation expectation and hence reduce pressure on the domestic currency. Due to its enormous importance, Garcia and Malet (2007) used a VAR framework and included domestic output as an additional determinant in examining Exchange Market Pressure for Argentina from 1993-2004.

The results indicate a positive relationship between domestic credit and market pressure – a finding consistent with the monetary approach to balance of payments. Shocks to Exchange Market Pressure indicate that Argentinean monetary authorities sterilised reserve outflow with a view to providing enough liquidity to the domestic financial system. Second, this study finds a positive association between interest rate and Exchange Market Pressure. This suggests that interest rate rather than reducing pressure alerted domestic investors to the eventual need for depreciation and thus increased pressure. Third, the study provides evidence that increase in output reduced pressure on Argentinean currency. This finding confirms the second generation currency crises model's theoretical prediction that worsening fundamentals increase pressure on a fixed exchange rate regime to collapse.[18]

The empirical literature that analysed exchange market pressure in a VAR framework delivers consistent results. It indicates that an increase in domestic credit increases pressure on domestic currency. This has an important policy implication for countries that target the

[18] Kumah (2007) examined exchange market pressure and its dynamics for the Kyrgz Republic using the Markov Regime switching approach and found that contractionary monetary policy helps reduce pressure.

exchange rate stability, in that they would have to give up the independence of using monetary policy instruments for attaining domestic objectives such as output growth and stable prices. The interest rate effect in some studies is contrary to what the theoretical literature suggests and seems to be insignificant. A positive interest rate coefficient implies that monetary authorities cannot use the interest rate as a policy instrument for reducing pressure. On the other hand, a negative relationship between exchange market pressure and domestic output is confirmed in Garcia and Malet (2007). All these studies suggest that monetary authorities cannot use the interest rate as a policy instrument in a crisis period. However, if the policy authorities wish to reduce pressure, they have to control domestic credit growth and formulate policies conducive to domestic output growth.

3.3 Empirical Studies of the Weymark (1995) Model

Prior to Weymark (1995), Frenkel and Aizenman (1982) derived an index that measures the extent of foreign exchange market intervention. It takes the value of zero and one for two extreme exchange rate regimes, flexible and fixed. Based on Frenkel and Aizenman's (1982) index, Weymark (1995) proposed an index of exchange market pressure which she later used for developing a quantitative measure of the degree of exchange market intervention. It indicates the fraction of pressure that a Central Bank relieves through the purchase and sale of foreign exchange reserves. Weymark (1995) argues that the intervention index values can be used as a tool for analysing the monetary policy being implemented.

Using a simple macroeconomic model with rational expectations, Weymark (1995) constructed a quarterly measure of exchange market pressure and intervention index for Canada between 1975 and 1991. A subset of these calculated values was then used to analyse the Bank of Canada's conduct of exchange rate policy over the period 1981–1984. The Exchange Market Pressure indicated upward pressure on Canadian dollar between 1975Q2 to

1984Q4. In the post-1984 period there was downward pressure. The intervention index mean value indicated that on average, the intervention activities of the Central Bank of Canada removed approximately 96% of the pressure by purchasing and selling foreign exchange reserves. Exchange rate changes relieved the remaining market pressure. Poso and Spolander (1997) used the Weymark (1995) model for analysing the Bank of Finland's conduct of monetary policy during the markka's recent float from September 1992 to October (1996). The average exchange market pressure was more often negative than positive. The intervention index mean value of 0.99 indicated that the Bank of Finland removed almost all the pressure by purchasing and selling foreign exchange reserves and permitted limited flexibility for the exchange rate to adjust towards its underlying free float equilibrium value.

A Weymark-type model was also applied to Chile and Greece by Kohlschen (2000) and Apergis and Eleftheriou (2002), respectively. Kohlschen (2000) modified Weymark's (1995) model slightly and applied exchange market pressure and intervention index to analyse pressure on the Chilean peso from 1990 to 1998.[19] He slightly modified the index with reserve requirement and gathered the evidence that supported the Chilean peso's experiencing upward pressure. Furthermore, the intervention index values suggest that the Central Bank of Chile substantially intervened in the foreign exchange market and prevented the Chilean peso from appreciation for most of the time.

An approach slightly modified from Weymark's (1995) model was also applied by Apergis and Eleftheriou (2002) to analyse Greek monetary authorities' response to Exchange Market Pressure from 1975 to 1998. They assumed the absence of a well-developed financial system and therefore, the absence of perfect substitutability between domestic and foreign assets. In other words, they assumed that uncovered interest parity condition does not hold.

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[19] In the early 1990s, Chile witnessed a surge in capital inflows equivalent to 10% of GDP, due to lax US monetary policy. In order to avoid a conflict between capital inflows and domestic objectives, the Chilean Central Bank initially imposed a one-year non-interest bearing reserve requirement on selected capital inflows. Initially, it was set up to 10% and was increased to 30% in May 1992.

The mean of the exchange market pressure was positive from 1975Q4 to 1989Q4. On the other hand, in the post-1990 period, exchange market pressure was negative, indicating appreciating pressure on Greek drachma. In the pre- and post-1989 period, the intervention index means were 0.89 and 0.97 respectively. This indicates that in the pre-1989 period, policy makers let the exchange rate to depreciate to boost the exports. However, in the post- 1989 period, particularly after 1992, the Bank of Greece frequently intervened in the foreign exchange market to stabilise the value of domestic currency as part of the Maastricht criteria regarding the limitations of inflationary pressures.[20]

Some studies use both model-dependent and model-independent approaches when considering exchange rate arrangements. Jeisman (2005) used the model-dependent approach proposed by Weymark (1995) and the model-independent approach of Eichengreen et al. (1996) for measuring exchange market pressure and intervention index for Australia over the post-float period. The resulting exchange market pressure and intervention indices thus enabled the author to determine how well the two methodologies explained the conduct of the Australian Reserve Bank momentary policy over the given period. The empirical evidence shows that the Central Bank assisted pressure on the Australian dollar to depreciate and reversed appreciating pressure. Contrary to Jeisman (2005), Leu (2009) found that in the post-float period, the monetary authority followed a leaning against the wind policy – that is, the Australian Reserve Bank sold (purchased) foreign exchange reserves when the Australian dollar was under pressure to depreciate (appreciate). The difference in the results could be due to the use of different econometric approach. Jeisman (2005) uses the two-stage least square

[20] Chen, Shiu-Sheng and Taketa (2007) assessed the validity of Weymark's (1995) index of foreign exchange market intervention using general changes in foreign exchange reserves and pure intervention data. The intervention index that uses general changes in foreign exchange reserve suggests strong intervention. On the other hand, the intervention index constructed using pure intervention data indicates that Japanese moentary authorities have not frequently intervened in the foreign exchange market over the sample period thus investigated.

approach, while Leu (2009) used Johansen's cointegration approach for constructing Exchange Market Pressure and intervention index for Australia.[21]

Since its development, Weymark's (1995) approach has been applied by a number of researchers for evaluating the external position and conduct of monetary policy for a number of countries. All these studies indicate that the countries thus evaluated were either faced with downward or upward pressure. However, almost all studies confirm some form of Central Bank leaning against the wind in that the Central Bank frequently intervened in the foreign exchange market and relieved depreciating pressure by selling foreign exchange reserves and vice versa. This confirms the view that the Central Banks of the countries thus evaluated allowed a limited role to market forces in determining the value of domestic currency in the foreign exchange market, a finding consistent with the fear of floating.

3.4 Empirical Studies of Eichengreen et al's (1996) model

Before Eichengreen et al. (1996), Girton and Roper (1977), Roper and Turnovsky (1980) and Weymark (1995) derived Exchange Market Pressure indices that are simple sum of exchange rate and foreign exchange reserve changes. However, all these studies differ in assigning the weights attached to Exchange Market Pressure components. Girton and Roper (1977) assigns equal weight to both exchange rate and foreign exchange reserve changes. On the other hand, Roper and Turnovsky (1980) and Weymark (1995) derived the weight using a stochastic macro model. All these studies assumed direct foreign exchange market intervention that the Central Bank relieves pressure by purchasing and selling foreign exchange reserves. However, it may be the case that Central Bank relieves pressure by changing interest rate. In such a case, interest rate constitutes another monetary instrument that Central Bank may use for restoring foreign exchange market equilibrium. In such a case, the

[21] We also use two-stage least square and Johansen's cointegration approach to determine if the results differ or complement each other.

studies that ignore interest rate do not fully reflect the extent of foreign exchange market disequilibrium.

Eichengreen et al. (1996) used a statistical approach and constructed an exchange market pressure index consisting of percentage change in exchange rate, relative interest rate differential and percentage change in relative foreign exchange reserves. They used the inverse of the variance approach for assigning weights to the components of exchange market pressure. This approach assigns low weight to more volatile component and thus ensures that all variables are equally weighted.

First generation currency crisis models argue that inconsistency between domestic macroeconomic policies and the exchange rate regime often results in the collapse of the fixed exchange rate regime. Particularly they argue that increased monetising of budget deficit results in speculative attacks and thus the collapse of the fixed exchange rate regime (Krugman, 1979). Bird and Mandilaras (2006) examined the relationship between fiscal deficit and Exchange Market Pressure for Latin America & Caribbean (LAC) and East Asia & Pacific (EAP) regions in a panel framework. The results indicate significant effect of fiscal deficit on exchange market pressure for Latin America & Caribbean (LAC) countries but not for East Asia & Pacific (EAP) countries. The difference in the results is due to low savings, lack of investor's confidence and high and volatile inflation rate in LAC compare to EAP countries. These findings have the implication that the same policy prescription cannot be followed in both regions to avoid currency crises.

Moreover, foreign debt is an important factor in causing exchange market pressure. There are two channels through which an increase in foreign debt increases pressure. Ricardian equivalence points towards a strong association between an increase in taxes and an increase in debt. It argues that current higher debt suggest a future increase in taxes. Given a future rise in taxes, rational agents would save the amount equal to foreign debt to offset the effects of expansionary macroeconomic policies in future. This will not affect investors' confidence and thus cause pressure on a highly indebted country to rise.

On the other hand, Keynes argues that domestic economic agents are myopic. They base their consumption on disposable instead of permanent income. In such a case they do not save the amount required for financing future expansionary macroeconomic policies. In such a situation a rise in foreign debt will increase pressure on domestic currency. Mandilaras and Bird (2008) tested which of the above effects of debt burden on exchange market pressure held true for Latin American countries from 1970 to 2000. They used Eichengreen et al's (1996) approach for constructing exchange market pressure. However, they assigned weights to the components of exchange market pressure by the ratio of inverse of variance of each component to the sum of inverse of variance of all components. They used four proxies of Exchange Market Pressure for checking the robustness of their results. The first proxy used exchange rate changes, relative interest rate differential and relative foreign exchange reserve changes. The second specification used exchange rate and foreign exchange reserve as components of exchange market pressure. The third specification uses exchange rate changes to denote market pressure. In the fourth specification, the authors assumed that purchasing power parity holds and used inflation differential to denote devaluation expectations. The results indicate that an increase in foreign debt increases pressure on currency to depreciate in foreign exchange market. This finding appears to be robust across different proxies used for denoting Exchange Market Pressure.

Finally, Turkey experienced currency crises in 1994 and 2000-2001 as well as unsuccessful speculative attacks that were fended off by the monetary authorities. This makes Turkey a suitable country to examine the relationship between exchange market pressure and macroeconomic fundamentals. Katircioglu and Feridun (2011) evaluated this relationship and found the relevancy of fiscal and current account balance, domestic credit and excess real money balances to be important macroeconomic determinants of exchange market pressure in Turkey. These findings suggest that the monetary authorities in Turkey should constantly monitor the growth of these variables if they want to avoid pressure on Turkish currency.

3.5 Conclusion

In this chapter, we reviewed the empirical studies that have applied Girton and Roper (1977), Weymark (1995) and Eichengreen et al. (1995) to the experience of different countries. The empirical studies that use Girton and Roper (1977) and Eichengreen et al. (1995) are primarily interested in evaluating the determinants of Exchange Market Pressure both in time series and panel frameworks. On the other hand, the studies that have used Weymark's approach to different countries were primarily concerned with determining the direction of the pressure and monetary authorities' response function. They focused on whether downward or upward pressure was dominant over the given sample period and what fraction of the pressure a Central Bank relieves through the purchase and sale of foreign exchange reserves.

The empirical studies that use Girton and Roper's (1977) model provide evidence that confirms the predictions implied by the monetary approach to Exchange Market Pressure. This indicates that in a fixed exchange rate regime, an increase in domestic credit increases pressure on domestic currency to depreciate. This has an important policy implication in that when a Central Bank targets exchange rate stability, it has to relinquish its independence in using monetary policy instruments for stabilising domestic output or prices or both. The empirical evidence further shows that an increase in domestic prices further increases pressure on domestic currency to depreciate. However, an increase in domestic output and foreign prices are associated with downward pressure on domestic currency. All these findings are consistent with the predictions of the monetary model of exchange market pressure. Similarly, the studies that use Eichengreen et al. (1995) indicates that fiscal deficit, foreign debt burden, current account deficit are important determinants of exchange market pressure in a panel framework.

The studies that applied Weymark's (1995) approach to different countries provide evidence that it is either upward or downward pressure that has remained dominant over the entire sample period. Furthermore, they indicate that the Central Bank actively intervened in the foreign exchange market and allowed limited flexibility to exchange rate to adjust to the equilibrium value as suggested by the market forces. In the chapters that follow, we use Weymark's (1995) approach and determine whether it is downward or upward pressure that has remained dominant on the Pakistan rupee over the given sample period. Furthermore, based on the exchange market pressure index, we construct an intervention index and use its value for analysing monetary authorities' responses to foreign exchange market disequilibrium.

Chapter Four

Exchange Market Pressure and the Degree of Exchange Market Intervention: The Case of Pakistan

Abstract

In this chapter, we construct an Exchange Market Pressure and intervention index for Pakistan using the Weymark (1995) approach. We then use the constructed intervention index for evaluating Central Bank of Pakistan's exchange rate policy over the period 1976:Q1 to 2005:Q2. The empirical evidence suggests that on average there was downward pressure on Pakistan's currency and active Central Bank intervention. The intervention index shows that Central Bank used both exchange rate and foreign exchange reserve changes for restoring foreign exchange market equilibrium, which is consistent with a managed float exchange rate regime. Thus our characterisation of the exchange rate regime based on Central Bank intervention is in conformity with International Monetary Fund Report on Exchange Rate Arrangements and Exchange Restrictions instead of Reinhart and Rogoff (2004).

4.1 Introduction

After the collapse of the Bretton Wood system, most industrialised countries adopted a system of flexible exchange rate. They argued that the adoption of such a regime would reduce exchange rate volatility. In practice, few of them allowed market forces to determine the value of their currencies. The International Monetary Fund Annual Report (1998) on Exchange Rate Arrangements and Exchange Restrictions shows that by the end of 1997 forty- six of 184 countries allowed their currencies to be determined by market forces. Even then, they frequently intervened in foreign exchange market and stabilised their currencies (Spolander, 1999). The remaining countries either fixed or allowed limited flexibility for their currencies.

Countries often adopt extreme ends of the spectrum of exchange rate arrangements namely fixed or flexible exchange rates. Frankel (1999) and Fischer (2001) support the bipolar view and argue that the countries that adopt either fixed or flexible rates are less prone to an exchange rate crisis. They report IMF official exchange rate classification and exchange rate arrangements and suggest abolishing the intermediate exchange rate arrangements.[22] Calvo and Reinhart (2002) examined actual exchange rate practices of thirty- nine countries and found increased interest rate and foreign exchange rate volatility - a phenomenon attributable to increased exchange rate stabilisation and foreign exchange intervention by monetary authorities. Levy-Yeyati and Sturzenegger (2005) constructed de facto classification of an exchange rate regime that reflects actual instead of announced exchange rate policies. They found wide differences in de facto and de jure exchange rate policies. Particularly, the countries that claim to float frequently intervene in the foreign exchange market for stabilising the external value of their currencies. Furthermore, they found that the countries that declare

[22] Fischer (2001) report International Monetary Fund Annual Report (2000). The report provides evidence of vanishing intermediate exchange rate regime. According to this report, in 1991 there were 16 percent hard pegs, 62 percent intermediate and 23 percent independent float. In 1999 their number reached to 24 percent currency peg, 34 percent intermediate and 42 percent independent float. Frankel (1999, p. 7 footnote) also reports an IMF classification that breaks down as: 25 pegged to a single currency, 13 pegged to composite, 6 crawling pegs, 12 horizontal bands, 10 crawling bands, and 26 managed floats.

they have flexible rates behaved like fixers in an attempt to avoid exposure of their currencies to speculative attacks. They named this kind of exchange rate arrangement ‘hidden pegs’. These studies show that there are wide differences between de facto and de jure exchange rate practices. They further provide evidence that the countries that declare fixed or flexible exchange rate regime, in fact follow intermediate or managed float exchange rate policy. It is therefore, largely an empirical matter to assess a country’s exchange rate regime, rather than trust public policy pronouncements from a Government or Central Bank.

Frenkel and Aizenman (1982) first constructed an index that measures the extent of foreign exchange intervention. It may be viewed as the fraction of the money market disequilibrium that exchange rate changes eliminate. Under the two extreme systems of fixed and flexible exchange rate systems, it takes values of zero and one. In contrast to Frenkel and Aizenman, Weymark (1995) derived an intervention index based on the Girton and Roper (1977) approach. It defines an intervention index as the fraction of pressure that Central Bank relieves by changing foreign exchange reserves. It takes a value of zero and one under the system of fixed and pure float exchange rate system and values between zero and one for intermediate and managed float exchange rate arrangements.

This chapter focuses upon the exchange rate system in Pakistan. Pakistan’s exchange rate system has evolved through different phases. Prior to 8th January, 1982, Pakistan followed a fixed exchange rate arrangement. Since then, Pakistan’s exchange rate system is characterised as managed float (Ahmad and Khan, 1990). In this system, simultaneous changes in exchange rate and foreign exchange reserve changes capture the extent of foreign exchange market disequilibrium.

In this chapter, we adopt the Weymark (1995) approach for constructing exchange market pressure and intervention indices for Pakistan. Particularly, we check the direction of pressure and evaluate the monetary authority’s response by constructing an intervention index.

This approach has the advantage of allowing us to evaluate the monetary authority's response to market pressure by constructing an intervention index. We then use the intervention index values to confirm whether Pakistan's exchange rate arrangements are in conformity with International Monetary Fund's Annual Reports on Exchange Rate Arrangements and Exchange Rate Restrictions or Reinhart and Rogoff's (2002) exchange rate classification. The International Monetary Fund's Annual Reports on Exchange Rate Arrangements and Exchange Rate restrictions characterise Pakistan's exchange rate regime as pegged to the US dollar for the period 1976 to 1982. A post-1982 exchange rate regime of the country is characterised as managed float except for the year 1999. For 1999, the country's exchange rate regime is characterised as multiple one.[23] On the other hand, Reinhart and Rogoff (2002), using de facto exchange rate policy, characterise Pakistan's exchange rate regime as pegged to US dollar for the period 1971 to 1982. For the post-1982 period, it characterises Pakistan's exchange rate regime as a de facto crawling peg to the US dollar with a band width of +/- 2%. Using the intervention index mean value, we test whether our characterisation of the exchange rate regime is in conformity with the IMF classification or that of Reinhart and Rogoff (2004).

The results indicate dominant downward pressure and active Central Bank intervention. Most of the interventions leaned against the wind and removed most of the downward pressure on domestic currency. The intervention index mean value suggest that on average Central Bank relieved sixty-one percent of the pressure by selling foreign exchange reserves. Exchange rate changes absorbed the remaining pressure. Since both exchange rate and foreign exchange reserve changes restored foreign exchange market equilibrium therefore, we characterise the country's exchange rate regime as managed float. Thus our

[23] Pakistan introduced a multiple exchange rate system on 22nd July, 1998 due to sanctions that were imposed on the country in the wake of its nuclear explosions. The multiple exchange rate system comprised of (a) official exchange rate, (b) floating inter-bank rate (FIBR) and composite rate. State Bank of Pakistan determined official exchange rate while the floating inter bank rate was determined by the market forces. The composite rate was based on certain specified ratio of official rate and floating inter-bank rate which was initially fixed at 50-50 (50% official and 50% FIBR) and was changed to 20:80 on 21st December, 1998 and further to 5:95 percent on 11th March, 1999 (State Bank Annual Reports 1998-1999, p. 130).

characterisation of the exchange rate regime based on the Central Bank's intervention index mean value confirms International Monetary Fund's Annual Reports on Exchange Rate Arrangements and Exchange Rate Restrictions rather than Reinhart and Rogoff's (2002) classification.

The rest of the paper is organised as follows. Section 4.2 reviews related past studies on exchange market pressure. Section 4.3 addresses the theoretical model of a small open economy that engages in stabilising exchange rate fluctuation and in Section 4.4 we analyse data using descriptive statistics and graphical evidence. Section 4.5 contains our main empirical results. These include unit root tests in section 4.5.1, estimation of the model and construction of exchange market pressure and intervention index in section 4.5.2 and 4.5.3 respectively. Section 4.6 concludes.

4.2 Literature Review

In this section, we review the theoretical models and their empirical application to different countries and regions. Particularly we focus on theoretical models and show how they differ from each other.

Before Girton and Roper's (1977) paper, Whiteman et al. (1975) argued that under a managed float, the effective exchange rate and foreign exchange reserve changes reflect the extent of money market disequilibrium although no one has yet constructed a single composite index that measures it. Girton and Roper (1977) derived such a measure of market pressure and named it Exchange Market Pressure (EMP). It measures the extent of domestic money market disequilibrium that arises due to non-zero excess demand or supply of domestic currency in the foreign exchange market. It is restored by adjustments in exchange rate or foreign exchange reserve changes or any combination of both of them. Since its development, the Girton and Roper (1977) model has been applied by a number of researchers to number of developed and developing countries. Girton and Roper's (1977) model and its modified versions have been applied to Brazil's experience over 1955-1975 by Connolly and Da Silveira (1979), sterling's effective exchange rate over the period 1964 -1978 by Hacche and Townend (1981), Korea's experience by Kim (1985), Costa Rica's experience by Thornton (1995), by Burdekin and Burkett (1990) to Canada, by Mah (1998) to Korea, by Pollard (1999) to Barbados, Jamaica, and Trinidad & Tobago, by Hallwood and Marsh (2003) to the pound sterling during the inter-war period, 1925-31, and by Modeste (2005) to Guyana.

Roper and Turnovsky (1980) carried forward Girton and Roper's (1977) work. Based on the assumptions of fixed prices and perfect capital mobility, they derived the optimum trade-off that monetary authorities face between exchange rate (Δs_t) and foreign exchange reserve (Δf_t) changes for relieving pressure on the domestic currency. They allowed the intervention to take the form of changes in exchange rate and foreign exchange reserves with both of them not equally weighted.

Contrary to exchange market pressure indices discussed above, Eichengreen et al. (1995) derived a model independent exchange market pressure index that includes the percentage change in exchange rate, relative percentage change in bilateral interest rates and foreign exchange reserves differential.[24] They assigned weights to the components of exchange market pressure by equalising their conditional volatilities. The Exchange Market Pressure index provided by Eichengreen et al. (1995) is called a model-independent index because neither the components of exchange market pressure nor the weights assigned to them are derived from a structural model of the economy.

[24] Eicehngreen et al. exchange market pressure index is given as:
$\%\Delta s_t + 7[\%\Delta(i_t - i_t^*) - .08[\%\Delta(f_t - f_t^*)$

In contrast to Eichengreen et al. (1995), Pentecost et al. (2001) derived a measure of exchange market pressure from a short-term wealth augmented monetary model of foreign exchange market.[25] It includes exchange rate changes, foreign exchange reserve and relative short term money market interest rate differential between domestic and foreign country as its components. They used a principal component approach for assigning weights to the components of exchange market pressure.[26]

Weymark (1998) criticised the model-independent exchange market pressure index due to difficulty in its interpretation. She argued that the components which Eichengreen et al. (1996) uses relieve exchange market pressure on the domestic currency. The magnitude of interest rate and foreign exchange reserve changes are determined by the structure of the economy and Central Bank intervention activity, rather than a volatility-smoothing technique that ensures the components of Exchange Market Pressure are equally weighted. Therefore, it is necessary that exchange market pressure indices must be derived from a model that reflects the economy for their proper interpretation (Weymark, 1998).

Weymark (1995) further argued that Girton and Roper (1977) were primarily concerned with the monetary independence enjoyed by the monetary authorities in Canada. They equated monetary independence with the relationship between domestic credit and exchange market pressure. The significant correlation between these variables suggests that the monetary authorities in Canada are not independent in formulating monetary policy. Similarly, Roper and Turnovsky (1980) were concerned with deriving the optimum trade-off faced by the monetary authorities between exchange rate and foreign exchange reserves for eliminating exchange market pressure. Thus the exchange market pressure indices derived by Girton and Roper (1977) and Roper and Turnovsky (1980) do not constitute a model

[25] Pentecost et al. (2001) exchange market pressure index is given as:
$$[s_t + \beta(\Delta i_m - \Delta i_m{}^*) - f_t] = (d_t - m_t{}^*) + (1 - \alpha\phi)q_t + (\alpha\lambda + \gamma - \gamma)(\Delta i_t - \Delta i_t{}^*) - \vartheta(w_t - w_t{}^*)$$
[26] Principal Component Analysis is a common technique for finding patterns in data and expresses the data in such manners that highlight their similarities and differences (see Pentecost et al. (2001).

independent definition of exchange market pressure. Therefore, Weymark (1995) defined exchange market pressure in general terms as the excess demand for domestic currency in the international market that would be relieved by exchange rate changes in the absence of foreign exchange market intervention, given the expectations about the actual exchange rate policy implemented.

Based on a model-independent definition of exchange market pressure, Weymark (1995) constructed an exchange market pressure index that includes exchange rate and foreign exchange reserve changes. The weights assigned to the components of exchange market pressure are derived from a small open economy stochastic macroeconomic model. Contrary to other indices that simply measure exchange market pressure, Weymark (1995) also constructed an intervention index defined as the fraction of the pressure that Central Bank relieved through the purchase and sale of foreign exchange reserves.

4.3 A Model

In order to measure exchange market pressure upon the Pakistan currency and also the foreign exchange intervention policy of the State Bank of Pakistan, we adopt the approach of Weymark (1995). Weymark's simple model is based on money demand, price, interest rate, money supply and monetary authorities' response function and is given as:

$$m_t^{\,d} = p_t + b_1 y_t - b_2 i_t + v_t \qquad b_1 > 0 \text{ and } b_2 > 0 \tag{4.1}$$

$$p_t = a_0 + a_1 p_t^{\,*} + a_2 s_t \qquad a_1, a_2 > 0 \tag{4.2}$$

$$i_t = i_t^{\,*} + E_t s_{t+1} - s_t \tag{4.3}$$

$$m_t^{\,s} = m_{t-1}^{\,s} + \Delta d_t + \Delta f_t \tag{4.4}$$

$$\Delta f_t = -\bar{\rho}_t \Delta s_t \tag{4.5}$$

Asterisks denote foreign counterparts of domestic variables and the notation Es_{t+1} represents the rational agents' expected value of exchange rate at time $t+1$, conditional on the information available in period *t*. All variables are logged.

Equation 4.1 describes domestic real money demand function. It states that the demand for nominal monetary aggregates $(m_t{}^d)$ is a positive function of domestic prices (p_t) and real income (y_t) and a negative function of interest rate (i_t). The positive relation between income (y_t) and nominal money demand $(m_t{}^d)$ is based on the assumption that as income increases, people demand more money for financing their transactions. The interest rate represents an opportunity cost of holding money. As the opportunity cost of holding money increases, people prefer to hold their cash balances in assets that earn interest rate. This reduces demand for domestic money balances. Equation 4.1 also has a stochastic money demand disturbance (v_t). Equation 4.2 is the Purchasing Power Parity (PPP) condition. It states that the domestic prices (p_t) are an increasing function of both exchange rate (s_t) and foreign price level $(p_t{}^*)$. The spot exchange rate is defined as the number of units of domestic currency per unit of foreign currency. Hence an increase in exchange rate suggests that the domestic currency depreciates. Parameter a_0 denotes deviations from purchasing power parity. If $a_0 = 0$ and $a_1 = a_2 = 1$ simultaneously, the price equation breaks down in absolute PPP, suggesting that exchange rate and foreign price changes are reflected equally in domestic prices.

Equation 4.3 is Uncovered Interest Parity and suggests that returns on both domestic and foreign assets are set equal. In case of difference between the domestic and foreign interest rate, exchange rate changes to bring equality on asset returns. Equation 4.4 defines the evolution of the money supply process. It states that money supply depends on inherited money stock m_{t-1}^{s}, changes in domestic credit (Δd_t) and foreign exchange reserves (Δf_t).[27] Equation (4.5) shows that the Central Bank responds to exchange rate fluctuation. For example, as the domestic currency depreciates $(\Delta s_t > 0)$, the Central Bank sells foreign exchange reserves $(\Delta f_t < 0)$. Similarly, when a country has an appreciating currency, the reserves of the Central Bank rise $(\Delta f_t > 0)$.

We now seek to use the simple model to obtain exchange market pressure and intervention indices. Substitution of equation (4.2) and (4.3) into (4.1), taking the difference of the resulting equation, combining it with the central bank's response function and re-arranging the resulting equation yields an equation for the changes in the exchange rate:

$$\Delta s_t = \frac{-\{(a_1\Delta p_t^* + b_1\Delta y_t - b_2\Delta i_t^* + v_t - \Delta d_t - b_2\Delta ES_{t+1}) + \Delta f_t\}}{a_2 + b_2} \tag{4.6}$$

Taking the partial derivative of exchange rate change with respect to foreign exchange reserve changes is given by equation 4.7:

$$\eta = -\frac{\partial \Delta s_t}{\partial \Delta f_t} = \frac{-1}{a_2 + b_2} \tag{4.7}$$

The exchange rate elasticity with respect to foreign exchange reserves (η) is of negative sign. It shows that both foreign exchange reserves and exchange rate changes move in the opposite direction. An increase in foreign exchange reserve causes the exchange rate to appreciate, and vice versa.

The log linear small open economy model given above allows us to construct exchange market pressure (EMP_t) index given as:

$$EMP_t = \Delta s_t + \eta \Delta f_t \tag{4.8}$$

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[27] Changes in the domestic credit $\Delta d_t = [h_t D_t - h_{t-1} D_{t-1}] / M_{t-1}$ where h_t is the money multiplier in period t, D_t denotes domestic credit, and M_{t-1} the inherited money stock. Changes in foreign exchange reserves = Δf_t = $[h_t F_t - h_{t-1} F_{t-1}] / M_{t-1}$ where F_t is the stock of foreign exchange reserves in period t.

The EMP_t index measures the extent of exchange rate changes required for removing exchange market pressure in the absence of Central Bank intervention. It takes a negative or a positive sign. A negative sign implies strengthening pressure and vice versa. A zero value of exchange market pressure suggests the absence of market pressure. This index contrasts with the Girton and Roper (1977) approach that assigns equal weights to Δs_t and Δf_t hence η = 1. Equation 4.8 further shows that as a_2 and b_2 rises, less EMP_t is relieved by Δf_t (i.e. $\eta \to 0$). That is, as the semi-elasticity of real money demand to interest rate rises and the response of domestic prices to exchange rate increases, η approaches to zero and the Central Bank either allows exchange rate changes or the interest rate to restore foreign exchange market equilibrium.

Based on exchange market pressure index, Weymark (1995) constructed foreign exchange market intervention index. It measures the fraction of total pressure on the currency that Central Bank relieves through the purchase of foreign exchange reserves. Hence, the intervention index is the ratio of reserve changes to pressure, adjusted for parameter η. When monetary authorities engage only in direct exchange market intervention, the intervention index (ω_t) is given as:

$$\omega_t = \frac{\eta \Delta f_t}{EMP_t} = \frac{\eta \Delta f_t}{\Delta s_t + \eta \Delta f_t} \tag{4.9}$$

Dividing the numerator and denominator of the right hand side of the equation 4.9 by $1/\eta$ gives:

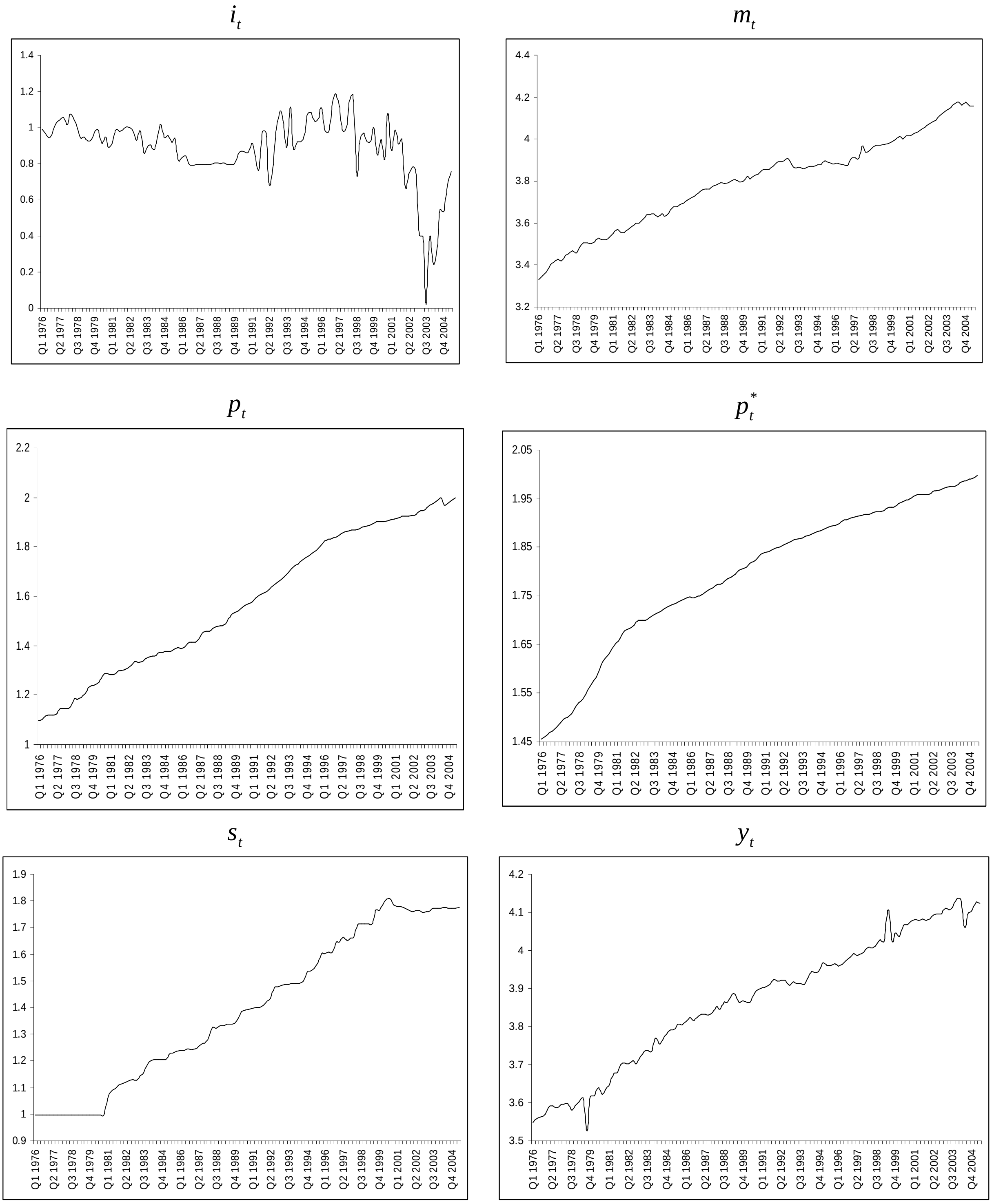
$$\omega_t = \frac{\Delta f_t}{\frac{1}{\eta}\Delta s_t + \Delta f_t} \tag{4.10}$$

The intervention index takes values between $-\infty < \omega_t < \infty$. Its values can be interpreted as follows: when ω_t = 0, the Central Bank abstained from intervening in the foreign exchange market and exchange rate changes absorbed the entire pressure. This is consistent with a flexible exchange rate regime. On the other hand, $\omega_t = 1$ suggests that foreign exchange reserve changes absorbed the entire pressure and exchange rate remained unchanged. This suggests fixed exchange rate arrangements. When the intervention index takes values between $0 < \omega_t < 1$, we call it a managed float. This is because both the exchange rate and foreign exchange reserve absorb the prevailing pressure. $\omega_t < 0$ indicates the Central Bank's leans with the wind. That is for example, the Central Bank purchases foreign exchange reserves when there is a pressure on the domestic currency to depreciate. Typically a Central Bank will only engage in leaning with the wind to attain an exchange rate level rather than to resist exchange rate volatility. We adjust the exchange market pressure and intervention index with η. It converts foreign exchange reserve changes into equivalent exchange rate changes. The underlying intuition of adjusting foreign exchange reserve changes with η is to avoid exchange market pressure and intervention index being dominated by more volatile component.

4.4 Data

In order to construct an exchange market pressure and intervention index for Pakistan, we use logged quarterly data for the period 1976:Q1 to 2005:Q2. The data on interest rate, domestic and foreign price and spot exchange rate were taken from International Monetary Fund, *International Financial Statistics*. Quarterly money supply data were taken from the Thomson Data stream and denote m_1 monetary aggregate. The State Bank of Pakistan provided quarterly data on nominal GDP. The series displayed strong evidence of seasonality particularly for real GDP and money supply which were adjusted using X – 12 ARIMA seasonal adjustment programme. Call money rate refers to the rate of interest (i_t) that lending institutes charge to brokerage firms when extending loans for financing their clients' financial

Figure 4.1 Data in levels



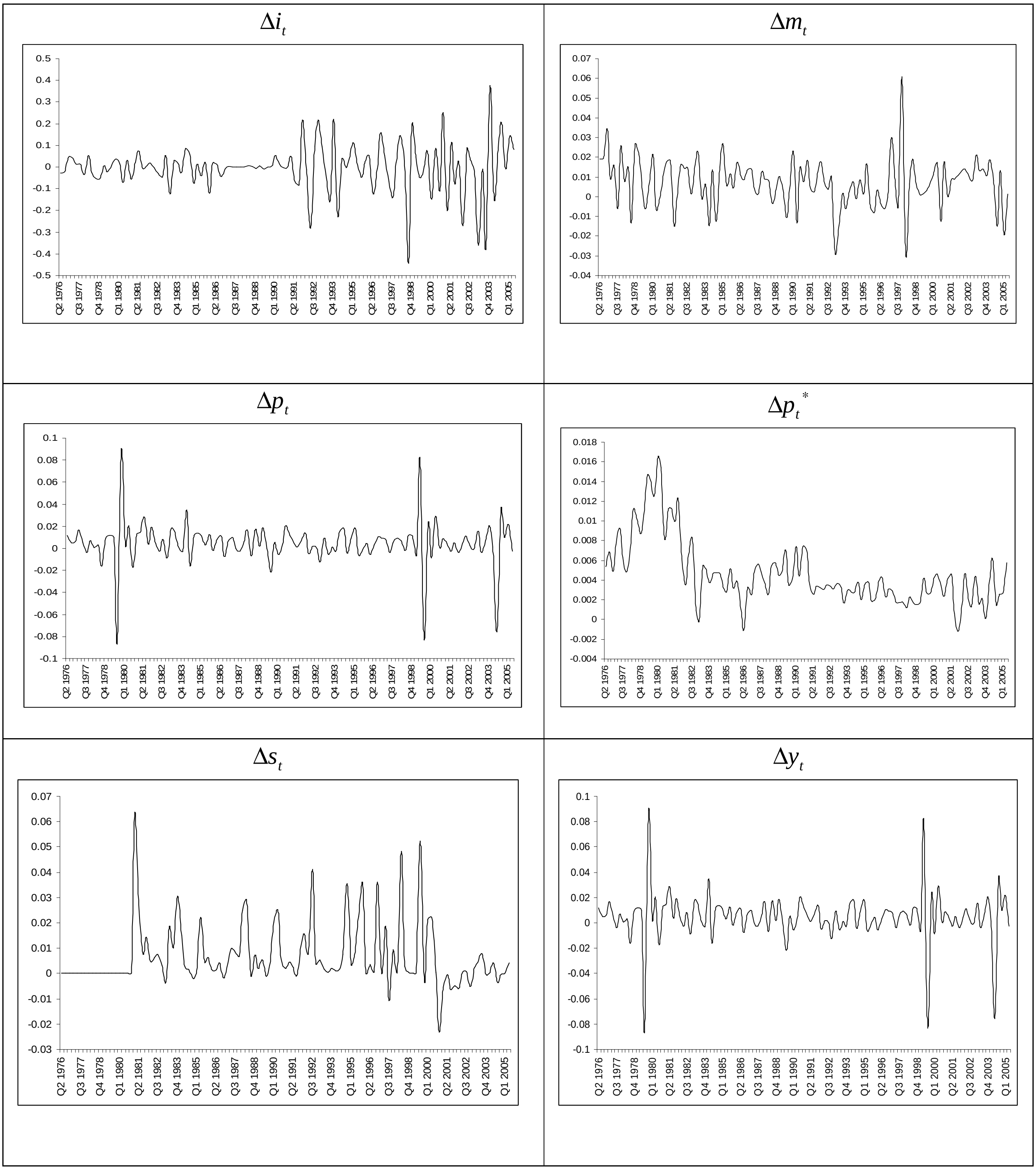
Notes: These graphs represent data for Pakistan's interest rate, money supply, prices, US prices, bilateral nominal exchange rate with the US dollar and real income. Sample period is from 1976 to 2007.

needs. Similarly, the exchange rate (s_t) refers to number of units of domestic currency in terms of US dollars. Consumer price indices for both Pakistan (p_t) and the US (p_t^*) reflect the cost of acquiring a fixed basket of goods and services by the average consumer. Money (m_1) refers to currency plus demand deposits. Foreign exchange reserves (f_t) refer to total reserves minus gold. Real income is y_t and refers to nominal income adjusted using Pakistan's consumer price index.

Figure 4.1 contains the graphs of data in log levels. Following the approach of Weymark (1995), the graphs reveal that real money, domestic price level, foreign price and real domestic income display an increasing trend over the entire sample period. The call money rate plot reveals much persistence. From 1982 to 2001, the exchange rate shows that the Pakistan rupee consistently lost its value against US dollar. Subsequent to 2001, the exchange rate did not rise so rapidly. This occurred due to an increase in the country's foreign exchange reserves following the lifting of sanctions imposed in the wake of nuclear explosions, increased worker's remittances, rescheduling of external debt, substitution of hard loans into soft ones, and Pakistan's cooperation with international community in its war against terrorism. Domestic real income also shows increasing trend except for the year 1998 to 2001. The fall in domestic real income for the period 1999 to 2000 could be due to sanctions imposed on the country in the wake of its nuclear explosions. The data are apparently non-stationary in levels and therefore may have implications for the statistical properities of our estimators. Therefore, we formally investigate non-stationarities using statistical tools.

Figure 4.2 contains graphs of first difference data on all these variables. The plots do not display any systematic pattern which is in conformity with the non-stationarity of the

Figure 4.2 Data in first difference



Notes: These graphs represent data for Pakistan's interest rate, money supply, prices, US prices, bilateral nominal exchange rate with US dollar and real income. Sample period is from 1976 to 2007 stochastic process. This finding is further supported by the values obtained for both Augmented Dicky-Fuller and Phillips-Perron unit root test values using log differenced data and are given in section 4.5.1.

4.5 Empirical Results

4.5.1 Unit Root Tests

In this section, we examine the time series properties of the variables used in the analysis. The empirical work based on time series data assumes that the underlying stochastic process is stationary. This implies that its mean, variance and auto covariance (at various lags) remains time-invariant no matter at what point we measure them. When this assumption is violated, we say that the time series is non-stationary. A non-stationarity test that has been widely used in empirical work on time series process is based on the following Augmented Dicky Fuller regression:

$$\Delta x_t = \alpha_0 + \beta_1 x_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta x_{t-i} + \varepsilon_t \tag{4.11}$$

Here x_t and ε_t denote stochastic time series process and white noise error term respectively. The unit root test implies that $\beta_1 = 0$. If calculated t–values are greater than the critical values from McKinnon (1996), we do not reject the null of data non-stationarity. Alternatively, if the calculated t–values are less than the critical ones, the null of non-stationarity of the data is rejected. Due to quarterly data, we use four lags as the maximum number of lag length (ρ). Alternatively, the lag length can be chosen so that the Information Criterion (AIC) value is minimised. After selecting the optimal lag length, we use the Augmented Dicky Fuller test for testing the presence of unit root.

Table 4.1 shows the results of ADF unit root test both in log levels and log first difference for random walk model with drift and with drift and trend. It is evident from the

Table 4.1: Unit Root Test[28]

ADF Test in Levels		
Variables	Constant	Constant and trend
i_t	-1.442 (1)	-1.673(1)
m_t	-1.750(1)	-2.950(1)
p_t	-0.287(1)	-2.534(1)
p_t^*	-2.853(1)	-3.891 ^{a} (1)
s_t	-0.453(1)	-2.496(1)
y_t	-1.399(1)	-2.571(1)
5% critical values	-2.887	-3.449
ADF Unit Root Test in First Difference		
Variables	Constant	Constant and trend
Δi_t	-10.837 ^{a} (1)	-10.810 ^{a} (1)
Δm_t	-12.268 ^{a} (1)	-12.377 ^{a} (1)
Δp_t	-2.908 ^{a} (1)	-3.033(1)
Δp_t^*	-3.791 ^{a} (1)	-4.897 ^{a} (1)
Δs_t	-9.386 ^{a} (1)	-9.531 ^{a} (1)
Δy_t	-10.287 ^{a} (1)	-10.289 ^{a} (1)
5% critical values	-2.887	-3.449

Note: superscript a indicates the significance of the variables at 5% critical values. * denotes the foreign counterparts of the domestic variables. Lag lengths in parentheses (.) are determined by the Akakike Information Criterion with maximum number of 4 lags. Variables used are defined as: i_t = Treasury Bill Rate, m_t = M1 in Pakistan, p_t = CPI in Pakistan, p_t^* = US CPI, s_t =spot exchange rate, and y_t =gross domestic product adjusted with GDP deflator. 5% one-sided critical values are taken from McKinnon (1996). Quarterly data for the period 1976:Q1 to 2005:Q2 is used. Δ denotes first difference operator.

table that log level data yield the t-values that are far greater than 5% critical ones for all variables except foreign price (p_t^*) in model with constant and deterministic trend. Therefore, we are unable to reject the null of unit root in levels for all variables, except foreign price (p_t^*) with drift and deterministic trend.

Following Weymark's (1995) empirical strategy, we first difference the data to overcome the non-stationarity issues. The difference data ADF unit root test results are, as

[28] We also tested the non-stationarity of all variables in levels using Phillips and Perron test. The results indicate that the calculated t-values are less than critical values; therefore, we can not reject the null of non-stationarity for all variables in levels. However, Phillips-Perron unit root test applied to difference data yields t-values that are greater than critical ones. Therefore, we can reject the null of non-stationarity for all variables at first difference.

expected, entirely different from those obtained in levels. The lower part of table 4.1 shows that the calculated t-values are lower than the critical ones at 5% significance levels for all variables except for domestic price with constant and deterministic trend.[29] However, first difference domestic price is stationary with drift. This shows that first difference domestic price with drift would be more appropriate specification for the estimation. Figure 4.2 further confirms our interpretation. It shows that foreign price in first difference does not show any deterministic trend and fluctuates around zero mean. Furthermore, the Phillips-Perron unit root test (given in appendix) show that all variables are stationary at first difference. All this shows that we can reject the null of non-stationarity for all variables in at least one specification.

4.5.2 Estimation of the Model

We need to estimate η, the relative weight of foreign exchange reserve (Δf_t) to construct exchange market pressure and intervention index, as discussed in section 3.3. This necessitates the estimation of parameters a_2 and b_2 from equation (4.1) and (4.2) given below:

$$m_t^{\,d} = p_t + b_1 y_t - b_2 i_t + v_t \qquad b_1 > 0 \text{ and } b_2 > 0 \qquad (4.1)$$

$$p_t = a_0 + a_1 p_t^{\,*} + a_2 s_t \qquad a_1, a_2 > 0 \qquad (4.2)$$

The basic objective of constructing an exchange market pressure and intervention index is to determine the direction of pressure and evaluate the monetary authorities' response function over the sample period.

We have used differenced data and the two-stage least square approach for obtaining interest sensitivity of money demand (b_2) and price sensitivity of exchange rate (a_2) from the estimated real money demand (eq. 4.1) and price equation (eq. 4.2). This approach is

[29] We also tested the non-stationarity of all variables using the Phillips-Perron test. The difference data results indicate that the null of non-stationarity can be rejected for all variables.

adopted to overcome the endogenity problem that arises due to simultaneous determination of the dependent variable and one or more of the independent variables. In such a situation, ordinary least square approach yields inconsistent estimates of behavioural parameters in the regression equations. Two -tage least square (2SLS) uses instruments for obtaining unbiased estimates of the endogenous variables.[30] Instrumental variable is assumed to be uncorrelated with the model's error term but correlated with the endogenous variables. It is argued that the instruments used may be strongly correlated with the endogenous variable but may be uncorrelated with the dependent variable. This may give insignificant estimates of endogenous variable(s) in the estimated regression equation. Furthermore, we do not take into account R^2 and $\overline{R}^2$ values due to lack of consensus on the unique definition of the coefficient of variation if the model is estimated by the method other than ordinary least square. Furthermore, the objective of using instrumental variable is to obtain consistent estimates of the causal effects of endogenous variables on regressand and the use of instruments instead of endogenous variables fulfil this task (Verbeek 2008, p. 150).

Table 4.2 shows the estimates of the real money demand function using log level, log first difference and Newey-West adjusted standard errors with Ordinary Least Square (OLS) and Two-Stage Least Square (2SLS) method.[31] Contrary to many researchers who have used interest rate in levels, we use it in log difference form to test the short-term dynamics of money demand function.[32] One difference between the log level and first difference models is

[30] Following Weymark (1995), we used the US CPI, three-month US Treasury Bill Rate and real domestic income as first stage instruments in the real money demand equation. For the price equation, we used US CPI, the three-month Treasury Bill rate and the lagged exchange rate as first stage instruments.

[31] Newey-West test statistic corrects standard errors in presence of autocorrelation and heteroscedasticity.

[32] Fair (1987) argued that the interest rate should be used in levels than in log form. It is because, when the interest rate changes from 0.02 to 0.03, the log of the interest rate rises from -3.91 to -3.51, which is a change of 0.40. If, on the other hand, the interest rate rises from 0.10 to 0.11, the log of the rate rises from -2.20 to -2.21 which is only a change of 0.09. One generally does not see that a one percentage point rise in the interest rate has four times the effect on the log of the desired money holdings when the change is from a base of 0.02 than when it is from a base of 0.10.

Table 4.2 Real Money Demand Estimation

Equation	Tech:	Indep: Variable	Coeff:	T-ratio	T-ratio (NW)	DW Stat	$LM_{(4)}$	$ARCH_{(4)}$	$\overline{R}^2$
1	OLS [Level]	Const	-0.711	-9.51^a	-4.91^a	0.92	13.81 (0.00)	0.44 (0.77)	0.98
		i_t	-0.144	-6.93^a	-4.54^a				
		y_t	1.191	68.03^a	33.75^a				
2	OLS [Diff]	Δi_t	-0.013	-1.12	-1.43	1.89	5.34 (0.00)	0.97 (0.43)	-0.26
		Δy_t	0.126	1.98^a	2.01^a				
3	2SLS [Level]	Const	-0.588	-5.37^a	-2.55^a	0.99	34.03 (0.00)	2.23 (0.14)	0.97
		i_t	-0.163	-4.62^a	-2.39^a				
		y_t	1.170	52.47^a	24.83^a				
4	2SLS [Diff]	Δi_t	-0.080	-1.13	-1.46	2.274	4.406 (0.354)	0.04 (0.84)	-0.46
		Δy_t	0.129	1.79	1.95^a				

Note: Level, Diff and NW refer to log level data, log differenced data and Newey – West test statistic respectively. data for the period 1976:Q1 to 2005:Q2 is used. a denotes significant t – values. $LM_{(4)}$ and $ARCH_{(4)}$ denote Godfrey Lagrange multiplier and Autoregressive Conditional Heteroscedasticity test statistics to test the n autocorrelation and heteroscedasticity in the estimated regression equation.

that former includes an intercept term while differencing removes the constant in the latter.[33]

It is evident from Table 4.2 that interest rate and real domestic income estimates are of negative and positive signs. The positive domestic real income estimate suggest that as income goes up, people demand more money to finance their transactions. On the other hand, a negative interest rate estimate suggests that with the rise in opportunity cost of holding money, people prefer to hold their cash balances in terms of assets that earn interest rate instead of holding them in cash balances. This behaviour of individuals and firms suggests a negative sign of interest rate in real money demand equation.[34]

[33] We also estimated the real money demand function using interest rate in levels. Although the estimated interest rate parameter was significant yet the coefficient is wrongly signed and is not different from zero (0.00083).

[34] Abe Shigeyuki et al. (1975), Mangla (1979), Khan (1980, 1982, 1994), Ahmad and Khan (1990), Hossain (1994), and Qayyum (2001, 2005) estimated money demand for Pakistan. Arize (1989) examined demand for money in four Asian economies: Pakistan, the Philippines, South Korea and Thailand. Bahmani-Oskooee and Rehman (2005) examined the stability of the money demand function in Asian developing countries that include India, Indonesia, Malaysia, Pakistan, the Philippines, Singapore and Thailand.

Table 4.2 further shows significant domestic real income estimates in all specifications except difference data and two-stage least square method. On the other hand, interest rate estimate is insignificant in difference data estimates. A high $\overline{R}^2$ with low Durbin-Watson statistic suggests spurious regression due to use of non-stationary data (Garnger and Newbold, 1974). This arises when both dependent and independent variable trend together which causes the apparent high correlation. It is further evident from Table 4.2 that the null of no serial correlation cannot be accepted for all specifications except difference data and 2SLS approach. Rejection of no serial correlation causes the standard errors to be underestimated and they are adjusted using Newey-West test statistic. On the other hand, we cannot reject the null of no heteroscedasticity in all specifications due to low F-statistic with the probability of obtaining it being quite high.

Table 4.2 further reveals that the estimates of real money demand function using difference data yield reduced and insignificant estimates of real domestic income and interest rate. Moreover, use of non-stationary data gives a negative coefficient of variation. However, real money demand estimates using difference data yield DW statistics that are quite high implying that null of no serial correlation can not be rejected. Because of this, we prefer difference data 2SLS estimate of interest rate for constructing exchange market pressure and intervention index. Hence we use equation [4] in Table 4.2 for our estimate of the coefficient of interest rate.[35]

The estimates of price equation using log level, log first difference data with Ordinary Least Square (OLS) and Two Stage Least Square (2SLS) are given in Table 4.3. Following Weymark (1995), the constant term is introduced in price equation, both in log level and log differenced data to denote the deviations from absolute purchasing power parity. Table 4.3

[35] It is somewhat dissatisfying that the interest rate elasticity is statistically insignificant with standard t-statistic and Newey-West test statistic. However, it is more re-assuring that specification tests suggest no residual misspecification.

Table: 4.3 Purchasing Power Parity Equation

Equation	Tech:	Idep: variable	Coeff:	T-ratio	T-ratio [NW]	D.W Stat	$LM_{(4)}$	$ARCH_{(4)}$	$\overline{R}^2$
1	OLS [level]	const	-0.297	-4.11 ^{a}	-3.01 ^{a}	0.16	153.67 (0.00)	37.07 (0.00)	0.98
		p_t^*	0.449	6.89 ^{a}	4.46 ^{a}				
		s_t	0.766	22.11 ^{a}	11.99 ^{a}				
2	OLS [Diff]	const	0.006	5.21 ^{a}	4.39 ^{a}	1.88	8.11 (0.00)	1.26 (0.29)	0.11
		Δp_t^*	0.371	1.89	1.91				
		Δs_t	-0.016	-0.32	-0.29				
3	2SLS [Level]	const	-0.266	-3.47 ^{a}	-2.51 ^{a}	0.17	98.49 (0.00)	36.37 (0.00)	0.98
		p_t^*	0.422	6.13 ^{a}	3.99 ^{a}				
		s_t	0.779	21.54 ^{a}	11.96 ^{a}				
4	2SLS [Diff]	const	0.001	0.24	0.22	1.77	5.76 (0.22)	0.11 (0.98)	-2.26
		Δp_t^*	0.287	0.79	0.58				
		Δs_t	0.828	1.81	1.65				

Note*:* Level, Diff and NW refer to log level data, log differenced data and Newey-West test statistic. Quarterly data for the period 1976:Q1 to 2005:Q2 is used. a denotes significant t – values. $LM_{(4)}$ and $F_{Het(4)}$ denotes Godfrey Lagrange multiplier and Autoregressive Conditional Heteroscedasticity test statistics to test the n autocorrelation and heteroscedasticity in the estimated regression equation

shows positive estimates for foreign price and exchange rate in all specifications except difference data and ordinary least square approach. Positive estimates of exchange rate and foreign price are consistent with purchasing power parity. Purchasing Power Parity suggests that exchange rate and foreign price changes are positively associated with domestic prices. Table 4.3 further shows that log level and ordinary least square approach yield significant estimates of both exchange rate and foreign price. Furthermore, the t-values are substantially reduced when they are adjusted using the Newey-West test in all models. The table further reveals that the use of difference data yields reduced estimated parameters for all variables except for exchange rate in the two-stage least square model. High $\overline{R}^2$ and low DW statistic with nonstationary data suggests a potential spurious regression (Granger and Newbold, 1974). This occurs due to the fact that although independent and dependent variables are random walk and independent of each other, they are trended together and this causes the apparent high correlation among them. Autocorrelation test statistics suggest that we cannot reject the null of no serial correlation in all models, except difference data and 2SLS. However, we cannot reject the null of no heteroscedasticity in difference data estimate of price equation. Since serial correlation is fundamental problem of time series data and gives underestimated standard errors, they are adjusted using Newey-West test statistic. Furthermore, all specifications except log level data and ordinary least square approach yield increased Durbin Watson statistics, which may indicate absence of serial correlation. We prefer to use an exchange rate estimate of stationary data and 2SLS for constructing of exchange market pressure and intervention index. This specification of price equation yields non-spurious regression estimates and are therefore preferred over other specifications of price equation given in the table 4.3 for constructing exchange market pressure and intervention index for Pakistan in the next section.

4.5.3 Estimation of Exchange Market Pressure and Intervention Index

Following Weymark (1995), we use interest rate and exchange rate estimates obtained from first differenced data and two-stage least square approach for constructing exchange market pressure and intervention index for Pakistan. We have adopted this approach to overcome the endogenity problem that arises due to simultaneous determination of dependent and one or more of the independent variables. It necessitates using instruments instead of endogenous variables in the estimation of regression equation. The instrumental variables must be correlated with endogenous variables but uncorrelated with the model's error term. We construct exchange market pressure and intervention index to check the direction of pressure and evaluate the monetary authority's response. The intervention index estimates are then used to characterise the exchange rate regime of the country from 1976 to 2005. Exchange market pressure index is given as:

$$EMP_t = \Delta s_t + \eta \Delta f_t \tag{4.8}$$

The sign of exchange market pressure determines the direction of pressure. A negative sign indicates strengthening pressure on the domestic currency. A positive estimate of exchange market pressure suggests the depreciation of domestic currency ($\Delta s_t > 0$) in the absence of Central Bank intervention. On the other hand, in a fixed exchange rate regime, the Central Bank relieves all the exchange market pressure. In such a case, positive exchange market pressure would suggest an unchanged exchange rate ($\Delta s_t = 0$) and a drop in the Central Bank's holdings of foreign exchange reserves ($\Delta f_t < 0$).

We need the estimate of bilateral elasticity η to construct a model consistent exchange market pressure and intervention index. It is obtained by adding the estimated parameter of interest sensitivity of money demand (b_2) from money demand equation 4.1 in section 3.3 and (a_2) exchange rate estimate from price equation 4.2 in section 4.3. The parameter a_2 reflects the sensitivity of domestic prices to exchange rate changes. Similarly, b_2 is interest rate sensitivity of money demand. The estimates of both these variables obtained from regression equation using difference data and two-stage least square approach following Weymark (1995) are:

$a_2 = 0.828$ and $b_2 = 0.080$

Based on these estimates of interest rate and exchange rate, the model consistent elasticity η is:

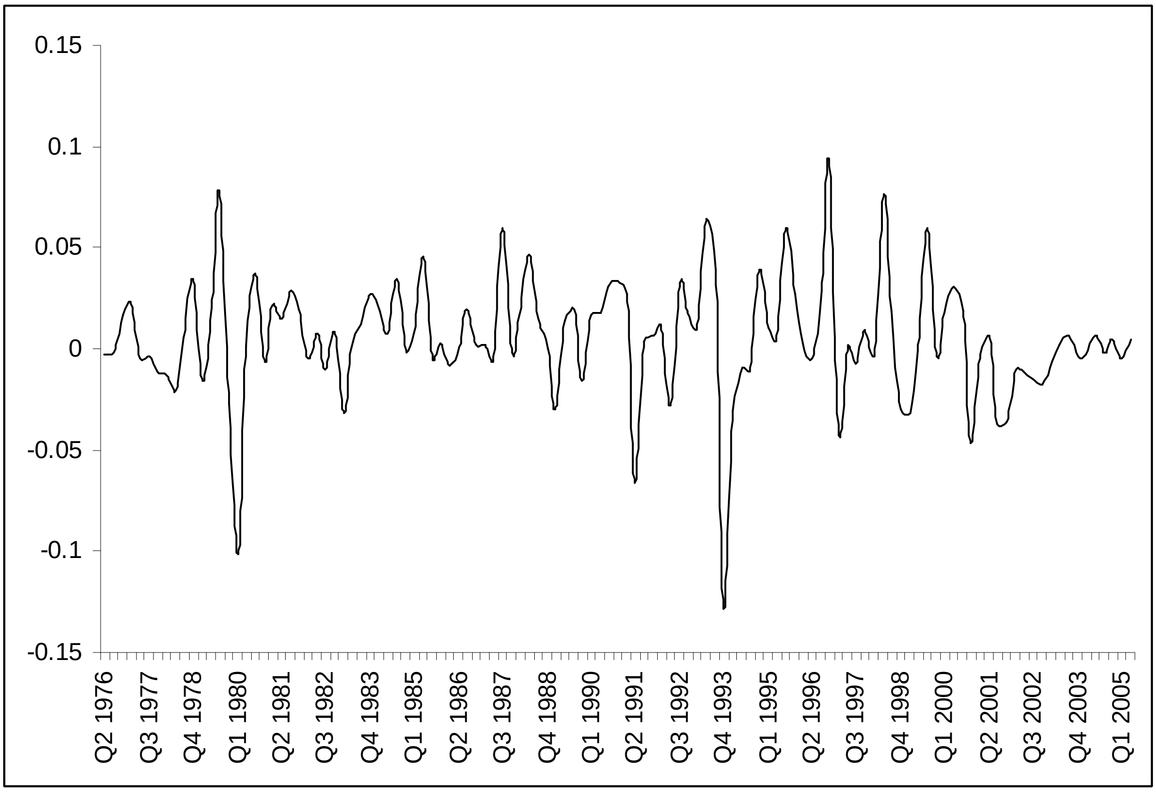
$$\eta = \frac{-1}{a_2 + b_2} = \frac{-1}{0.828 + 0.080} = -1.101$$

η denotes exchange rate elasticity with respect to foreign exchange reserve changes and is used to convert foreign exchange reserve changes into equivalent exchange rate units. We assume that interest rate estimate is of negative sign and lower than that of the exchange rate estimate. This gives us a negative η, which implies that exchange rate and foreign exchange reserve changes move in the opposite direction. An increase in foreign exchange reserves is associated with the appreciation of domestic currency against the US dollar in the foreign exchange market.

Figure 4.3 shows quarterly estimates of exchange market pressure. It is evident from the figure that depreciating pressure has remained dominant over the entire sample period. This is further supported by exchange market pressure mean value of 0.005. This can be interpreted as if the Central Bank had abstained from intervening in the foreign exchange market, the domestic currency would have depreciated by 0.5 percent. However, a positive Exchange Market Pressure mean value does not imply that in each quarter there was downward pressure on domestic currency's value. There are fifty-one quarters for which we have appreciating pressure. For the remaining sixty-six quarters, we have depreciating pressure on the domestic currency.

It is evident from Figure 4.3 that in the initial sample period, there was downward pressure on domestic currency. In this period, there was political uncertainty and a drop in economic growth due to the worst flood that had ever hit the country. However, the 1980s show a reduced Exchange Market Pressure on domestic currency and a period of relative tranquillity. This occurred due to the country's allegiance with Western Powers in their opposition to the Soviet invasion of Afghanistan. Pakistan received increased economic assistance from Western countries that resulted in almost seven percent economic growth. This in turn reduced downward pressure on domestic currency. The rise in exchange market pressure from 1993 to 2001Q3 reflects the effects of sanctions that were imposed on the

Figure 4.3 Exchange Market Pressure (EMP_t) Index



Note: This figure contains the Weymark approach to estimate Exchange Market Pressure between 1976 and 2005.

country due to its imports of missile technology and pursuit of its nuclear programme. This deprived the country of the foreign economic assistance that it received in the 1980s. The post-September 2001 period shows a substantial reduction in depreciating pressure on domestic currency. The drop in exchange market pressure occurred due to (a) increased worker's remittances due to the international community's crackdown on undocumented currency transactions, (b) rescheduling of Pakistan's external debt, (c) repayment of expensive debt and substitution of hard loans into soft ones, (d) robust non-structural inflows, (e) lifting of international sanctions that were imposed due to country's nuclear programme and import of missile technology, and (f) improved relations with international financial institutions and bilateral creditors due to country's support of the international community in its war against terrorism.

Figure 4.4 Intervention Index (ω_t)

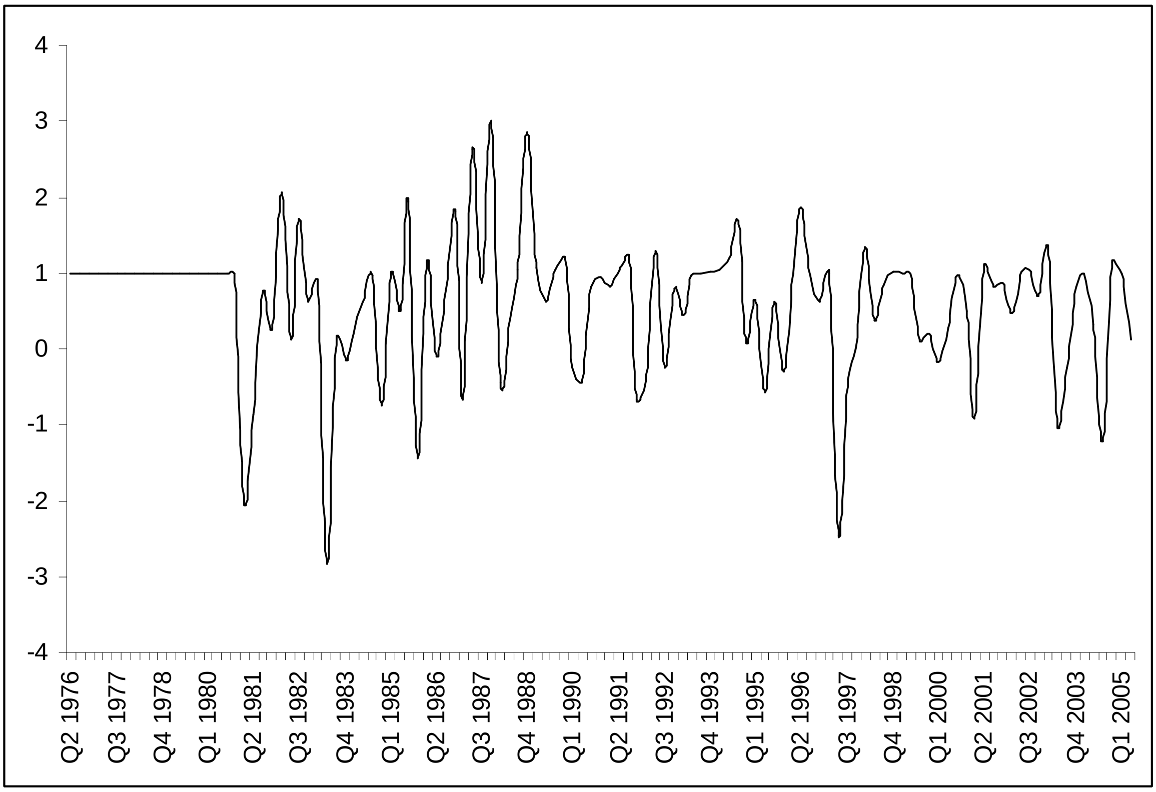


Figure 4.4 shows intervention index values. We define an intervention index as the fraction of pressure that the Central Bank relieves through purchase and sale of foreign exchange reserves and is given as:

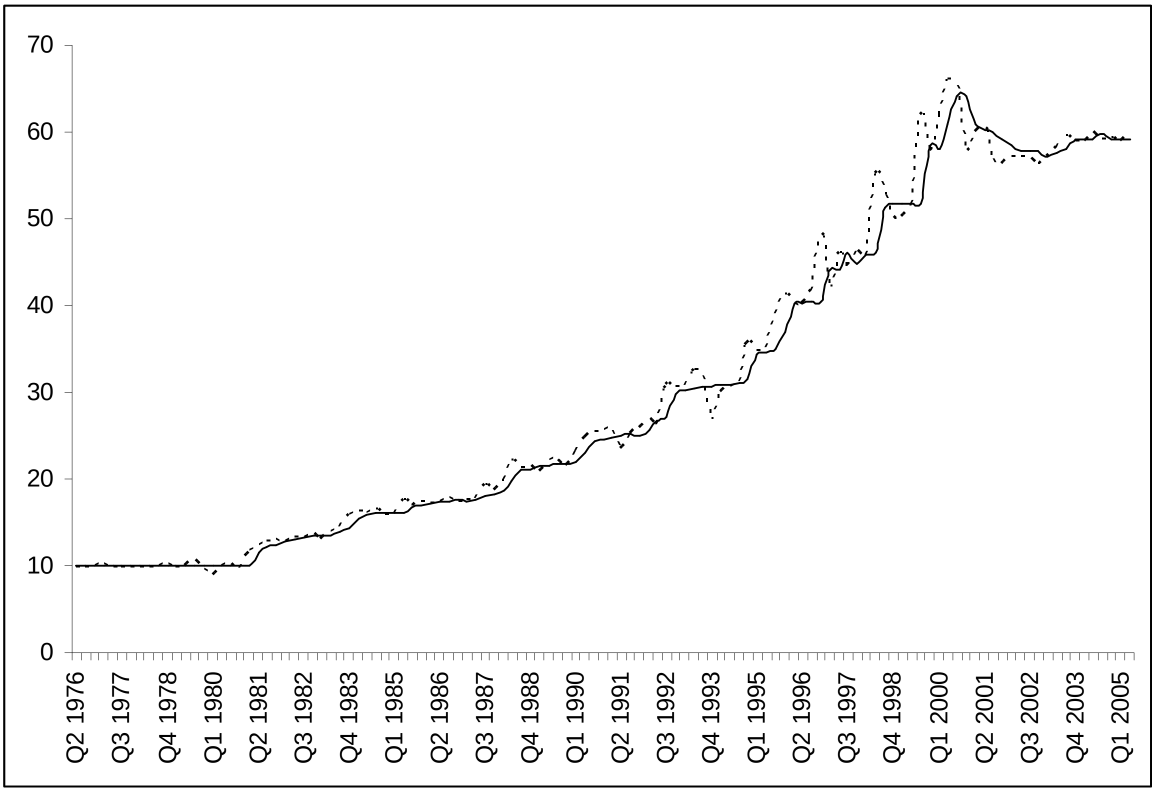
$$\omega_t = \frac{\Delta f_t}{\frac{1}{\eta}\Delta s_t + \Delta f_t}$$

Its values range between $-\infty$ and ∞. $\omega_t = 0$ implies the absence of Central Bank intervention and exchange rate changes relieving the entire exchange market pressure. This is consistent with flexible exchange rate arrangements. $0 < \omega_t < 1$ implies that exchange market pressure is relieved by exchange rate and foreign exchange reserve changes. Such a monetary policy characterises the exchange rate regime as managed float. $\omega_t < 0$ reveals the monetary authority's leaning with the wind in that the central bank purchased foreign exchange reserves when there was already a downward pressure on domestic currency. $\omega_t > 1$ can be interpreted as foreign exchange reserve changes being more than that warranted by the pressure. This leads the exchange rate to move in the direction opposite to that which would have prevailed in the absence of Central Bank intervention.

Figure 4.4 reveals that there are twenty-four quarters, for which $\omega_t = 1$. This can be interpreted as foreign exchange reserves changes having relieved the entire pressure in these quarters. Since the exchange rate did not change, we can term the exchange rate regime fixed one for these quarters. Similarly for forty-one quarters we have $\omega_t < 1$. This reveals that in these quarters both exchange rate and foreign exchange reserves changes absorbed Exchange Market Pressure, which is consistent with a managed float. For twenty eight quarters $\omega_t > 1$, suggesting that relative changes in foreign exchange reserves were more than those warranted by the pressure. This caused the exchange rate to move in the direction opposite to that warranted by the pressure. For the remaining twenty -four quarters, we have ω_t<0. This implies the Central Bank's leaning with the wind policy in that the Central Bank purchased foreign exchange reserves when there was already downward pressure on domestic currency and sold reserves with a strengthening domestic currency.

It is further evident from the exchange market pressure and intervention indices that Central Bank's response varies with the direction of pressure. The intervention index exceeds its unity value when there is upward pressure on domestic currency. This may indicate the Central Bank's preferences for maintaining the competitive advantage of domestic exporters in the international market. On the other hand, the intervention index value ranges between zero and one when there is downward pressure on domestic currency. In this case, the exchange rate also changes, but less than is warranted by the pressure. This can be interpreted as that the Central Bank may be pursuing multiple objectives of enhancing the competitive

Figure 4.5 Predcited ($S_t^{predicted}$) and observed exchange rate (S_{t-1}^{actual})



Note: The dotted line denotes the predicted exchange rate, which is more volatile. Solid lines, on the other hand, denote the observed exchange rate that would have prevailed in the absence of Central Bank intervention. This is less volatile.

advantage of domestic exporters in international markets and at the same time restricting the effects of exchange rate changes on domestic prices and country's foreign debt burden. The intervention index mean value of 0.61 is substantially different from that obtained by Weymark (1995) for Canada $\omega_t = 0.946$ and Apergis and Eleftheriou (2002) for Greece ω_t = 0.971.[36] This shows that foreign exchange reserves and exchange rate changes absorbed sixty-one and thirty-nine percent of the pressure respectively. Since both exchange rate and foreign exchange reserve changes absorbed the pressure we can safely characterise Pakistan's exchange rate regime as managed float for the given sample period.

[36] Kohlschen (2000) made Weymark (1995) approach consistent with Chilean monetary experience and obtained intervention index mean value of 0.196. Similarly Spolander (1997) analysed Finland central bank intervention policy using Weymark (1995) approach and obtained intervention index mean value of 0.99

Exchange Market Pressure reflects the extent of the domestic money market disequilibrium that exchange rate changes restore in the absence of Central Bank intervention. We can therefore calculate actual exchange rate that would prevail in the absence of Central Bank intervention using the one period lagged observed exchange rate:

$$S_t^{predicted} = (1 + EMP_t)S_{t-1}^{observed} \qquad (4.12)$$

where $S_t^{predicted}$ is the unlogged predicted exchange rate which can be interpreted as the level of exchange rate that would prevail in the absence of Central Bank intervention. $S_{t-1}^{observed}$ refers to unlogged one period lagged exchange rate. Comparison of the two gives an idea of the extent of foreign exchange intervention. Figure 4.5 shows that the predicted rate is more volatile than the observed exchange rate which is further supplemented by their standard deviation of 18.499 and 18.380. This suggests that the Central Bank's foreign exchange intervention is successful in achieving its objective of reducing exchange rate volatility.

4.6 Conclusion

In this chapter, we constructed an exchange market pressure and intervention index for Pakistan using the Weymark (1995) model. The objective was to check the direction of pressure and evaluate monetary authority's response. The exchange market pressure's mean value of 0.005 provides evidence that depreciating pressure remained dominant over the entire sample period. Furthermore, the actual exchange rate is less volatile than the predicted exchange rate suggesting that foreign exchange market intervention is successful in achieving its objective of reducing exchange rate volatility.

Intervention index mean value suggests active Central Bank intervention. However, the Central Bank's response is not uniform and varies with the direction of pressure. The intervention index exceeds its unity value when the domestic currency is under pressure to appreciate and vice versa. The mean value of the intervention index is 0.61, indicating that foreign exchange reserve and exchange rate changes absorbed sixty-one and thirty-nine percent of the pressure respectively. Based on the intervention index's mean value, we can safely characterise Pakistan's exchange rate as managed float over the entire sample period. Thus our characterisation of the exchange rate is in conformity with the IMF's rather than Reinhart and Rogoff's (2002). This is because we characterise Pakistan's exchange rate regime based on the actual policy implemented.

In this chapter, we used difference data and two-stage least square approach for estimating real money demand and price equation. Although it helps to overcome the spurious regression problem that arises due to the use of non-stationary data, it results in the loss of vital information about the long-term relationship if the variables of interest are cointegrated. We address this problem in the next chapter by using Johansen's (1988) multivariate cointegration approach.

Appendix

Appendix A.1 Data

We have used logged quarterly data for carrying out our empirical analysis. It is taken from the International Monetary Fund, *International Financial Statistic* for all variables except M1 and quarterly real GDP data. The details of the data are: Call money rate (line 60B…ZF) refers to the rate of interest charged by the lending institutions when extending loans to brokers for the purpose of financing loans for clients of the brokerage firm. In the same way, exchange rate (Line DE.ZF) refers to a unit of domestic currency per unit of foreign currency mainly US dollar. Consumer price indices, both for Pakistan p_t and US p_t^* (Line 64.ZF) reflect changes in the price of acquiring a fixed basket of the goods and services by the average consumer. Data on M1 is taken from Thomson Data stream and denotes currency plus demand deposits. Foreign exchange reserves (Line 1L.DZF) are the sum of the foreign exchange reserve position in the fund, and the US dollar value of the special drawing rights holding by monetary authorities. Monetary authorities comprise Central Bank and, to the extent that they perform monetary authorities' functions, currency boards, exchange stabilisation funds, and treasuries.

Appendix A.2 Instrumental Validity Test

We use instrumental variable technique to overcome endogenity problem. Instead of endogenous variables, we use instrumental variables in the estimation of real money demand function and price equation. The instrumental variables should be correlated with the endogenous variable but should be uncorrelated with the models' error term. Sargan developed a test to check the validity of instruments used. It is a four step test: (a) estimate the original model using the two-stage least square approach, (b) generate residuals from the estimated model, (c) estimate regression equation for residuals using exogenous variables and instrumental variables and (d) obtain the number of observations and R^2.

The test statistic is given as:

$$S = nR^2 \tag{A.1}$$

S and n denote Sargen tests statistic and number of observations. Under the null hypothesis that all instruments are exogenous to model's error term S is distributed as χ^2_{m-r} where $m-r$ is the number of instruments minus the number of endogenous variables.

We suspect that the interest rate is endogenously determined. Estimates of real money demand function using two stage least squares are given in table A.1. The bottom part of Table A.1 shows estimates of residual regression equation. From the residual regression equation, we obtain

Table A.1 Real Money Demand and Residual Regression Equation

Variable	Coefficient	t-values	$\bar{R}^2$
Δi_t	-0.080	-1.13	-0.46
Δp_t	0.129	1.79	
Residual Regression on instrumental variables			
Δi_t^*	-0.003	-0.115	$\bar{R}^2$
Δp_t^*	0.923	3.624 [a]	-0.058
Δy_t	-0.048	-0.0704	

Note: i_t, p_t and y_t denotes interest rate, consumer price index and real domestic income respectively. Δ denotes first difference operator. Quarterly data from 1976Q1 to 2005Q2 is used.

the number of observations and R^2 required for calculating Sargan test. The test statistic is given as:

S = 117 * (-0.057) = -6.669

Since the calculated Sargan test statistic of -6.669 is less than the critical $\chi_{m-r}{}^2$ of 5.99 at two degrees of freedom. Therefore, we can not reject the null that the instruments

Table A.2 Price equation and Residuals Regression Equation

Variable	Coefficient	t – ratio	$\bar{R}^2$
Constant	0.001	0.24	-2.26
Δp_t^*	0.287	0.79	
Δs_t	0.828	1.81	
Residuals Regression on instrumental variables			
Δi_t^*	-0.021	-0.919	-0.01
Δp_t^*	0.109	0.479	
Δs_{t-1}	-0.062	-0.679	
Δy_t	-0.047	-0.779	

Note: i_t^*, p_t^*, s_{t-1} and y_t denotes US Treasury Bill rate, US CPI, lagged nominal exchange rate, and domestic real income. Δ denotes first difference operator. Quarterly data from 1976Q1 to 2005Q2 is used.

used in the estimation of real money demand function are valid. Table A.2 contains two- stage least square estimates of price equation and residuals regression equations. Residual regression equation gives us the number of observations and $\bar{R}^2$ required for estimating Sargen test. Therefore, the Sargen test statistic is calculates as:

S = 117*-0.01 = -1.17

Since the calculated Sargan test statistic of -1.17 is less than the critical χ^2_{m-r} of 7.82 at two degrees of freedom we cannot reject the null hypothesis that the instruments used in the price equation are valid.

Appendix A3 Phillips-Perron Unit Root Test

Phillips and Perron Unit Root Test in Levels		
Variables	Constant	Constant and trend
i_t	-4.419 [a]	-4.739 [a]
m_t	-1.797	-2.970
p_t	-0.989	-2.373
p_t^*	-4.738 [a]	-2.558
s_t	0.005	-2.558
y_t	0.768	-3.319
5% critical values	-2.886	-3.449
Phillips and Perron Unit Root Test in First Difference		
Variables	Constant	Constant and trend
Δi_t	-17.338 [a]	-17.271 [a]
Δm_t	-12.183 [a]	-12.286 [a]
Δp_t	-9.672 [a]	-9.675 [a]
Δp_t^*	-3.769 [a]	-5.209 [a]
Δs_t	-9. 403 [a]	-9.368 [a]
Δy_t	-14.318 [a]	-14.337 [a]
5% critical values	-2.886	-3.449

Note: a indicates the significance of the variables at 5% critical values. * denotes the foreign counterparts of the domestic variables. Lag lengths in parentheses (.) are determined by the Akakike Information Criterion with maximum number of 4 lags. Variables used are defined as: $i_t =$ Treasury Bill Rate, $m_t =$ M1 in Pakistan, $p_t =$ CPI in Pakistan, $p_t^* =$ US CPI, $s_t =$spot exchange rate, and $y_t =$gross domestic product adjusted with GDP deflator. 5% one sided critical values are taken from McKinnon (1996). Quarterly data for the period 1976:Q1 to 2005:Q2 is used. Δ denotes first difference operator.

Appendix A.4

Real Money Demand and Price Equation (intercept is dropped form the estimation).

Real Money Demand						
Indep: Variable	Coeff:	T-Ratio [NW]	DW Stat	$LM_{(4)}$	$ARCH_{(4)}$	$\overline{R}^2$
Δi_t	-0.080	-1.461	2.274	4.406 (0.354)	3.942 (0.005)	-0.66
Δy_t	0.129	1.945				
Price Equation						
Indep: Variable	Coeff:	T-Ratio	DW Stat	$LM_{(4)}$	$ARCH_{(4)}$	$\overline{R}^2$
Δp_t^*	0.319	0.339	1.765	4.406 (0.007)	0.123 (0.97)	-2.761
Δs_t	0.916	2.707 ^{a}				

Note: NW refers to Newey-West test statistic. The variables used are interest rate (i_t), foreign price (p_t^*), nominal exchange rate (s_t) and domestic real income (y_t). Δ denotes first difference operator. Quarterly data for the period 1976Q2 to 2005Q2 is used. a denotes significant t-values. $LM_{(4)}$ and $F_{Het(4)}$ denotes Breusch Godfrey Lagrange multiplier and Autoregressive Conditional Heteroscedasticity test statistics to test the null of no autocorrelation and heteroscedasticity in the estimated regression equation

Table A.4 shows real money demand and price equation in difference data. It shows that all the variables have the signs consistent with the theory. However, except nominal exchange rate, the estimated parameters for all the remaining variables are insignificant. The estimates of Exchange Market Pressure and Intervention index based on the real money demand and price equation given in Table A.4 shows dominant downward pressure and active Central Bank intervention. Exchange Market Pressure and intervention index mean values of 0.005 and 0.579 further support this interpretation. Thus the results that we have obtained by dropping constant term are quite similar to those that are obtained from estimated real money demand and price equations that include constant term.

Appendix A5

Real Money Demand and Price Equation (Uses interest rate in level).

Real Money Demand						
Indep: Variable	Coeff:	T-Ratio [NW]	DW Stat	$LM_{(4)}$	$ARCH_{(4)}$	$\overline{R}^2$
Δi_t	0.00083	6.025 [a]	2.180	4.398 (0.354)	2.324 (0.061)	-0.05
Δy_t	0.043	0.943				
Price Equation						
Indep: Variable	Coeff:	T-Ratio	DW Stat	$LM_{(4)}$	$ARCH_{(4)}$	$\overline{R}^2$
Δp_t^*	0.519	2.920 [a]	1.771	9.687 (0.046)	67.085 (0.00)	-1.401
Δs_t	0.639	3.246 [a]				

Note: NW refers to Newey-West test statistic. The variables used are interest rate (i_t), foreign price (p_t^*), nominal exchange rate (s_t) and domestic real income (y_t). Δ denotes first difference operator. Quarterly data for the period 1976Q2 to 2005Q2 is used. a denotes significant t-values. $LM_{(4)}$ and $F_{Het(4)}$ denotes Breusch Godfrey Lagrange multiplier and Autoregressive Conditional Heteroscedasticity test statistics to test the null of no autocorrelation and heteroscedasticity in the estimated regression equation

Table A.5 shows the estimates of real money demand and price equation when both Pakistan and US interest rate are used in levels. The table shows that although the estimated domestic interest rate parameter is significant yet it is wrongly signed. In addition, the estimated parameter of domestic real income although of positive sign is not significantly different from zero. However, the estimated parameters of both foreign price and exchange rate are positive and significant when the price equation is estimated using the US interest rate in levels as an instrument for exchange rate. The constructed exchange market pressure and intervention index based on the use of interest rate in levels show that on average domestic currency was under pressure to depreciate and active Central Bank intervention. Exchange Market Pressure and intervention index mean values of 0.004 and 0.594 further support this interpretation. These finding shows that our estimates of Exchange Market Pressure and intervention index obtained using difference data and the real money demand and price equation containing intercept are robust to different specifications.

Chapter Five

Exchange Market Pressure and Intervention Index: case of Pakistan.

Evidence from Cointegration Approach

Abstract

To work with a model based approach to Exchange Market Pressure, estimation on level data may be spurious. This chapter utilises a cointegration framework to estimate the parameters of a Weymark's (1995) model. We also construct an intervention index. Additionally, we utilise the same framework to estimate Girton and Roper's (1977) monetary model of Exchange Market Pressure. The objective is to check the direction of pressure, evaluate monetary authorities' response to prevailing pressure and test the independence of Central Bank in pursuing independent monetary policy over the given sample period. The results indicate monetary independence, dominant downward pressure on the Pakistan's currency and active Central Bank intervention. An intervention index suggests that foreign exchange reserve relieved seventy-three percent of the pressure. Exchange rate changes absorbed the remaining pressure.

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5.1 Introduction

Exchange market pressure is defined as money market disequilibrium that arises due to nonzero excess demand of domestic currency in foreign exchange market (Taslim, 2003). Since it is directly unobservable, exchange market pressure is measured by changes in the macroeconomic variable that are used for restoring money market equilibrium. In fixed exchange rate system, it is reflected in foreign exchange reserve changes. On the other hand, exchange rate changes measure the extent of foreign exchange market disequilibrium in a free float. In a managed float or intermediate exchange rate system, simultaneous changes in exchange rate and foreign exchange reserve measure foreign exchange market disequilibrium.

Girton and Roper (1977) first derived an Exchange Market Pressure index using a monetary approach to the balance of payments. It refers to the volume of intervention necessary to restore foreign exchange market equilibrium. Such an intervention takes the form of money market operations and exchange rate changes under two extreme exchange rate regimes of fixed and flexible exchange rates. Under a managed float, both money market operations and exchange rate changes simultaneously characterise the volume of intervention necessary for restoring foreign exchange market equilibrium. In Girton and Roper's (1977) model, both these components are equally weighted.

Weymark (1995) made a notable contribution to the theory of exchange market pressure. She used a stochastic macroeconomic model for deriving the weights assigned to the components of exchange market pressure index. It converts foreign exchange reserves changes into equivalent exchange rate units. Since its development, many researchers have applied the Weymark (1995) approach to different countries for checking the direction of pressure and have evaluated monetary authorities' response to it. These studies include Poso and Spolander (1997) to Finland, Kohlscheen (2002) to Chile, Taslim (2003) to Australia, Akiba and Ida (2004) to Singapore and Jeisman (2005) to Australia. Kohlscheen (2002) slightly modified

Weymark's (1995) approach to incorporate the Chilean policy of reserve requirements on foreign capital inflows.[37] On the other hand, Poso and Spolander (1997) used pure intervention data for evaluating the Finnish Central Bank's response to exchange market pressure.[38] Empirical evidence shows that the Central Banks of these countries actively intervened in the foreign exchange market to avoid undesirable exchange rate fluctuations. Apergis and Eleftheriou (2002) on the other hand, assumed interest rate insensitivity of money demand and imperfect substitutability of domestic and foreign assets. Their empirical evidence supports the predominance of downward pressure and active central bank intervention.

In this study, we use Girton and Roper's (1977) and Weymark's (1995) methodology. Girton and Roper's (1977) approach is used to test the monetary authorities' independence in formulating an effective monetary policy. On the other hand, Weymark's (1995) approach is used to check the direction of pressure and evaluate the monetary authorities' response by constructing an intervention index values. We adopt Weymark's (1995) approach because contrary to Frenkel and Aizenman's (1982) approach, it enables us to evaluate the monetary authority's response to undesirable exchange rate fluctuations by constructing an intervention index.[39] It refers to the fraction of pressure that a Central Bank relieves through the purchase and sale of foreign exchange reserves. The objective is to provide estimates of an exchange market pressure and intervention index which can be used as tools for analysing monetary policy in Pakistan.

We use Johansen's (1988) multivariate cointegration approach for empirical analysis. We use Johansen's (1988) approach because there is potentially a spurious regression with

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[37] Due to increase in capital inflows, the Chilean monetary authorities imposed a twenty percent non-interest bearing reserve requirement on selective capital inflows which was increased to thirty percent in May, 1992. This was reduced to ten percent in June, 1998 and was eliminated three months later.

[38] Pure intervention includes those purchasing and selling foreign exchange reserves by the Bank of Finland which are aimed at affecting the markka exchange rate

[39] Frenkel and Aizenman (1982) defined optimal exchange rate regime in terms of stochastic shocks affecting the economy. The real shocks induce fixity of exchange rates. On the other hand, monetary shocks are consistent with the desire for flexibility of exchange rate. Furthermore, the desire for flexibility of exchange rate diminishes if the share of non-traded relative to traded goods is higher.

non-stationary data when used with classical regression. An important exception arises when a linear combination of nonstationary variables is stationary. In such a case, we say that there exists a long run cointegrating relationship among the variables and there is not a spurious regression. Johansen (1988) developed a multivariate cointegration approach that is widely used in the literature for analysing long run relationship among the nonstationary variables. Indeed we go substantially beyond the previous chapter by not only using Johansen (1988) to estimate a money demand and price equation in a single system. But to do so within system full information maximum likelihood should improve our estimated results. The results indicate monetary independence and downward pressure on domestic currency over the entire sample period. Furthermore, the gathered evidence suggests that the Central Bank actively intervened in the foreign exchange market for avoiding undesirable exchange rate changes.

The rest of the chapter follows as: in section 5.2 we derive the Exchange Market Pressure and intervention index using Weymark's (1995) method. In section 5.3, we analyse the data which includes data discussion and graphical analysis. In section 5.4 we outline Johansen's multivariate cointegration approach and in section 5.5, we discuss the results. The results include testing of nonstationarity of the data on the variables of interest in section 5.5.1, discussion of vector error correction model estimates of real money demand and price equation in section 5.5.2. In section 5.5.3 we construct exchange market pressure and intervention index for Pakistan using Johansen's multivariate estimates of real money demand and price equation. Section 5.5.4 is addressed to the summary of results obtained from log levels and log difference data with Johansen multivariate cointegration approach and two stage least square method. Section 5.6 concludes.

5.2 The Model

We firstly set out the Weymark (1995) model used to construct exchange market pressure and an intervention index for Pakistan. It is given in logarithmic form as:

$$m_t^{d} = p_t + b_1 y_t - b_2 i_t + v_t \qquad b_1 > 0 \text{ and } b_2 > 0 \qquad (5.1)$$

$$p_t = a_0 + a_1 p_t^{*} + a_2 s_t \qquad a_1, a_2 > 0 \qquad (5.2)$$

$$i_t = i_t^{*} + E_t s_{t+1} - s_t \qquad (5.3)$$

$$m_t^{s} = m_{t-1}^{s} + \Delta d_t + \Delta f_t \qquad (5.4)$$

$$\Delta f_t = -\bar{\rho}_t \Delta s_t \qquad (5.5)$$

Asterisks denote foreign counterpart of domestic variables. Equation (5.1) explains that an increase in real income (y_t) increases the demand for nominal money balances (m_t^d) because there is a larger volume of transactions to be financed. An increase in interest rate (i_t) raises the opportunity cost of holding money and thus reduces the demand for money (Kreinin and Officer, 1978). Equation (5.2) defines the evolution of domestic price level. The exchange rate (s_t) is defined as the number of units of domestic currency per unit of foreign currency such that a rise in the exchange rate is associated with a depreciation of domestic currency. Equation (5.2) states that domestic price level is positively influenced by foreign price (p_t^*) and exchange rate (s_t) changes. Absolute purchasing power parity is assumed to hold, if a_0 is constrained to zero and a_1 and a_2 are assumed to be equal to unity (Spolander, 1999). Equation (5.3) is Uncovered Interest Rate Parity. Given that the domestic financial institutions are well developed, it explains that any divergence between domestic and foreign interest rate (i_t^*) is reflected in expected exchange rate changes. The notation $E_t s_{t+1}$ represents the value that rational agents expect in period *t*+1 given the information in period *t.* Equation (5.4) defines money supply (m_t^s) in terms of its sources. It states that inherited money stock (m^s_{t-1}), domestic credit (Δd_t) and foreign exchange reserve (Δf_t) determine money supply in period *t*. Equation (5.5) is monetary authority's response to exchange rate fluctuations. It indicates the way the central bank changes foreign exchange reserves in response to exchange rate fluctuations (Chen and Taketa, 2007).

Substitution of equation (5.2) and (5.3) in (5.1), taking the difference of the resulting equation, combining it with the Central Bank's response function and re-arranging the resulting equation yields:

$$\Delta s_t = \frac{-\{(a_1 \Delta p_t^{*} + b_1 \Delta y_t - b_2 \Delta i_t^{*} + v_t - \Delta d_t - b_2 \Delta E_t S_{t+1}) + \Delta f_t\}}{a_2 + b_2} \qquad (5.6)$$

Equation (5.6) shows that changes in foreign price, domestic income, foreign interest rate, and domestic credit, expected change in the spot exchange rate and foreign exchange reserves determine exchange rate changes. The elasticity of exchange rate with respect to foreign reserves η is given by equation (5.7):

$$\eta = -\frac{\partial \Delta s_t}{\partial \Delta f_t} = \frac{-1}{a_2 + b_2} \qquad (5.7)$$

η converts foreign exchange reserve changes into equivalent exchange rate units.

Exchange market pressure index based upon the macroeconomic model given in equation (5.1) to (5.5) is given as:

$$EMP_t = \Delta s_t + \eta \Delta f_t \qquad (5.8)$$

Exchange market pressure index indicates the distribution of pressure between exchange rate and foreign exchange reserve changes. It further reveals that in the absence of central bank intervention, the entire pressure is absorbed by exchange rate changes. Based on exchange market pressure index, Weymark (1995) defines foreign exchange intervention index as:

$$\omega_t = \frac{\eta(\Delta f_t)}{EMP_t} = \frac{\eta \Delta f_t}{\Delta s_t + \eta \Delta f_t} \qquad (5.9)$$

Dividing the numerator and denominator of the right hand side of the equation (5.9) by $1/\eta$ gives:

$$\omega_t = \frac{\Delta f_t}{\frac{1}{\eta}\Delta s_t + \Delta f_t} \tag{5.10}$$

The intervention index reveals the fraction of the pressure that the Central Bank relieves through the purchase and sale of foreign exchange reserves. Its values range between $-\infty < \omega_t < \infty$. ω_t equal to zero represents that the Central Bank abstained from intervention. When ω_t equals to one there was fixed rate. ω_t between zero and one implies changes in both exchange rate and foreign exchange reserves. $\omega_t < 0$ shows the Central Bank's leaning with the wind policy. This can be interpreted that the Central Bank purchased foreign exchange reserves when there was a downward pressure on domestic currency. $\omega_t > 1$ shows that the Central Bank response was more than that warranted by the pressure $(\Delta f_t > EMP_t)$. This leads the exchange rate to move in the direction opposite to that warranted by the pressure.

5.3 Data

Quarterly data on all variables except nominal money ($M1$) for Pakistan and US. Pakistan's Gross Domestic Product (GDP) are obtained from International Monetary Fund *International Financial Statistic*. The authorities at Statistical Department, State Bank of Pakistan (SBP) provided us quarterly data on nominal GDP. Similarly, we obtained $M1$ data from Thomson data stream. $M1$ data for US is taken from Federal Reserve Bank webpage. Due to unavailability of quarterly GDP deflator data, we adjusted the nominal GDP and nominal money balances ($M1$) for Pakistan and US using their CPIs. Since the data on real GDP and money ($M1$) showed seasonality problem, it was adjusted using X – 12 ARIMA seasonal adjustment programme as available in Eviews standard version. In the analysis that follows, all the variables are used in logarithmic form.

Call money rate (i_t) refers to rate of interest that domestic financial system charges to brokerage firms to finance their clients financial needs. Similarly, exchange rate (s_t) refers to domestic currency per unit of foreign currency. p_t and p_t^* refers to domestic and foreign price respectively. Money (m_t) denotes currency in circulation and demand deposits.[40] Foreign exchange reserves (f_t) refer to total reserves minus gold. y_t is real income obtained by adjusting nominal GDP with Pakistan consumer price index.

Figure D1 (given in Appendix D) shows graphs in log levels. It indicates that except interest rate, all variables display nonstationarity. Interest rate on the other hand, varies over a time with a tendency to rise and fall. Exchange rate plot indicates that prior to 1982, it has remained fixed. It further shows that a shift in the level of exchange rate took place in the first quarter of 1982 and fourth quarter of 2001. The former shift occurred due to country's switch from fixed to managed float exchange rate regime on 8th January, 1982. The latter shift occurred due to Pakistan's cooperation with the world in its war against terrorism.

Figure D2 (given in Appendix D) contains the graphs of differenced data on all these variables. It indicates that the differenced data does not display such a clear stochastic trend and fluctuates around constant mean which confirms that the data is stationary. This is further confirmed by the values obtained for Augmented Dicky–Fuller unit root test using differenced data, as given in section 5.5.1.

[40] US $M1$ is defined as currency, travellers' checks, demand deposits, and other checkable deposits.

5.4 Econometric Method

In this section, we present an empirical methodology. If the data is nonstationary, we can not use classical estimation methods due to spurious regression problem (Granger and Newbold, 1974).[41] A simple approach to deal with this problem is first difference the data as is the case with previous chapter. Although differencing satisfies stationarity properities of time series variables for estimation yet it also results the loss of vital information about long run relationship, if the variables involved are cointegrated. This problem can be overcomed by using either Engle and Granger (1987) or Johansen (1988) approach.

In this paper, we test the presence of cointegrating relationship using Johansen's (1988) and Johansen and Juselius' (1990) multivariate cointegartion approach. We prefer this approach to Engle and Granger's (1987) method due to (a) Engle and Granger's (1987) do not distinguish between the presence of one or more cointegrating vectors (Hafer and Jansen, 1991), (b) Engle and Granger's (1987) being a two-step procedure. At first stage, we estimate our model using ordinary least square approach and in the second stage we test the stationarity of the residuals. Stationarity of the residuals implies the presence of cointegrating relationship. However, the error committed at the first stage influence the second stage results. On the other hand, Johansen (1988) and Johansen and Juselius (1990) not only permits us to examine the question of cointegrating vectors in the multivariate system, it also allows us to test the number of cointegrating vectors as well. In addition, due to endogenity of all variables, the results remain invariant with respect to the direction of normalization. The Johansen (1988) and Johansen and Juselius (1990) procedure is based upon the following relationship:

$$X_t = \Pi_1 X_{t-1} + \cdots\cdots\cdots + \Pi_{k-1} X_{t-k} + \varepsilon_t \quad (t = 1, \cdots\cdots, T) \tag{5.11}$$

[41] If R^2 exceeds Durbin Watson statistic, it suggest that the regression is spurious (Granger and Newbold, 1974)

Where Π_i is a vector of parameters, X_t is a vector of variables and ε_t is a vector of error terms with zero mean and constant variance given as Λ. Generally, the above model is estimated in difference form to avoid spurious regression problem. Although it satisfies stationarity property yet it also results the loss of vital information about long run relationship, if variables involved are cointegrated.

Taking first difference of equation (5.11), Johansen and Juselius (1990) suggest writing it in the form given as:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \cdots\cdots\cdots + \Gamma_{k-1} \Delta X_{t-k+1} - \Pi X_{t-k} + \varepsilon_t \tag{5.12}$$

Where

$$\Gamma_i = -(\mathrm{I} - \Pi_1 - \cdots\cdots - \Pi_k) \qquad (i = 1 \cdots\cdots\cdots k-1),$$

and

$$\Pi = -(\mathrm{I} - \Pi_1 - \cdots\cdots - \Pi_k)$$

Equation (5.12) is first order vector auto regression model except for the final matrix ΠX_{t-k} which contains information about the long run relationship. The equality of the rank of Π denoted as r and the number of variables p indicate the stationarity of all the variables. Therefore, any combination of stationarity variables yields stationary variables i.e., cointegrated. Zero rank $(r = 0)$ of matrix Π suggests that all the elements of the matrix are nonstationary and first difference may be recommended. When $r < p$, it implies that there are p x r matrices α and β such that $\Pi = \alpha\beta'$. Here β denotes the matrix of cointegrating vectors, and α represents the matrix of weight with which each cointegrating vector enters each of the ΔX_t equation. Johansen and Juselius (1990) demonstrate that β, the cointegrating vector, can be estimated as the eigenvector associated with r largest and significant eigenvalues found by solving

$$\left|\lambda S_{kk} - S_{k0} S_{00}{}^{-1} S_{0k}\right| = 0 \qquad (5.13)$$

where S_{00} denotes the residual moment matrix from the regression of ΔX_t on its lagged values, S_{kk} is the residual moment matrix from an ordinary least square regression of X_{t-k} on ΔX_{t-k+1}, and S_{0k} is the product of moment matrix. Given these eigenvalues, we can test the null hypothesis that there are r cointegrating vectors by calculating two test statistics known as trace test and maximum eigenvalue test give as:

$$\lambda_{trace}(r_0) = -T \sum_{i=r+1}^{N} \log(1-\lambda_i) \qquad (5.14)$$

and

$$\lambda_{\max}(r_0) = -T \log(1-\lambda_{r+1}) \qquad (5.15)$$

Here trace and max refers to trace and maximum eigenvalue test respectively. The trace test is used to evaluate the null hypothesis that there are r or fewer cointegrating vectors against a general alternative hypothesis. On the other hand, maximum eigenvalue test, tests the null hypothesis that $r = 0$ against the alternative hypothesis that $r \leq 1$.

5.5 Results

5.5.1 Unit Root Tests

The presence of cointegrating relationship requires that the time series data on the variables of interest should be integrated. This implies that the data should be nonstationary in levels and stationary at first difference. Dicky Fuller test identifies the integrating order of the time series data and is given as:

$$\Delta x_t = \gamma_0 + \theta x_{t-1} + \sum_{i=0}^{p} \gamma_i \Delta x_{t-i} + \varepsilon_t \qquad (5.16)$$

where Δ is the difference operator, x_t is the logarithm of the variable being tested, γ_i, θ are the parameters to be estimated and ε_t is an error term. The null of nonstationarity of x_t series is rejected if calculated t – values are less than the critical values. On the other hand, if

Table 5.1: Unit Root Test in log levels and first difference[42]

ADF Unit Root Test in log levels			ADF Unit Root Test in First Difference		
Variables	Constant	Constant and trend	Variables	Constant	Constant and trend
i_t	-1.442 (1)	-1.673(1)	Δi_t	-10.837^a (1)	-10.810^a (1)
m_t	-1.750(1)	-2.950(1)	Δm_t	-12.268^a (1)	-12.377^a (1)
m_t^*	-1.431(1)	-2.479(1)	Δm_t^*	-3.950^a (1)	-3.932^a (1)
p_t	-0.287(1)	-2.534(1)	Δp_t	-2.908^a (1)	-3.033(1)
p_t^*	-2.853(1)	-3.891^a (1)	Δp_t^*	-3.791^a (1)	-4.897^a (1)
s_t	-0.453(1)	-2.496(1)	Δs_t	-9.386^a (1)	-9.531^a (1)
y_t	-1.399(1)	-2.571(1)	Δy_t	-10.287^a (1)	-10.289^a (1)
y_t^*	0.255(1)	-2.546(1)	Δy_t^*	-7.066^a (1)	-1.069(1)
emp_t	-10.241^a (1)	-10.221^a (1)			
5% critical values	-2.887	-3.449	5% critical values	-2.887	-3.449

Note: a indicates the significance of the variables at 5% critical values. * denotes the foreign counterparts of the domestic variables. Lag lengths in parentheses (.) are determined by the Akakike Information Criterion with maximum number of 4 lags. Variables used are defined as: i_t = Treasury Bill Rate, m_t = M2 in Pakistan, p_t = CPI in Pakistan, p_t^* = US CPI, s_t =spot exchange rate, and y_t =gross domestic product adjusted with GDP deflator. 5% one sided critical values are taken from McKinnon (1996). Quarterly data for the period 1976:Q1 to 2005:Q2 is used. Δ denotes first difference operator

[42] We also tested the nonstationarity of all variables in levels using Phillips and Perron test. The results indicate that the calculated t-values are less than critical values; therefore, we can not reject the null of nonstationarity for all variables in levels. However, Phillips-Perron unit root test applied to difference data yields t-values that are greater than critical ones. Therefore, we can reject null of nonstationarity for all variables at first difference.

calculated t–values are greater than the critical ones, we do not reject the null of nonstationarity of time series. Table 5.1 reports calculated t–values of variables of interest in log levels and log first difference with drift and drift and trend model. The results show that we are unable to reject the nonstationarity null for all variables in log levels except foreign price p_t^* with drift and deterministic trend model and exchange market pressure with both drift and deterministic trend model. This means that foreign price is drift nonstationary but trend stationary in levels. However, Phillips- Perron unit root test (given in appendix) provide evidence that foreign price p_t^* is drift stationary and trend nonstationary in levels. In addition, US income is of positive sign with drift model. This can be interpreted that the data generating process is explosive. This implies that the US income does not converge to its equilibrium value over the given sample period. Table 5.1 further indicates that all variables except domestic price with trend model are stationary at first difference. However, first difference domestic price is stationary with drift. This shows that first difference domestic price with drift is appropriate specification for estimation. This is further confirmed from the figure D2 (given in appendix). It indicates that first difference domestic price does not show any systematic trend and fluctuates around its zero mean. Furthermore, we also estimate Phillips and Perron unit root test (given in appendix) which shows all variables are stationary at first difference. All this shows that we can reject the null of nonstationarity for all variables at least in one specification.

5.5.2 Vector Error Correction Model Results

We test the presence of long run relationship using Johansen (1988) cointegration approach. The linear combination of two or more of $I(1)$ variables yields nonstationarity variable as well. An important exception arises when linear combination of nonstationarity variables yields stationary outcome than these variables are said to be cointegrated. Stationary linear combination of these nonstationary variables suggests the presence of long run cointegrating relationship.

In this section, we have adopted an approach that improves upon Weymark (1995). Instead of separately estimating real money demand (5.1) and price equation (5.2) using Johansen (1988) cointegration approach, we examine six dimensional vector process that allows us to test whether there is evidence that distinct money demand and price equation relations prevail in the data. The variables used in the analysis are defined in the data section.

As a priori, we can think of two cointegrating vectors governing the long run behaviour of these variables. First cointegrating vector is expressed in terms of real money demand function and is given as:

$$m_t - p_t = b_1 y_t - b_2 i_t + v_t \qquad (5.1)$$

where b_1 and b_2 denotes the income and interest rate elasticity. It is expected that b_1 is close to unity, corresponding to a unitary elasticity, and that b_2 > 0. Second, if the real exchange rate is stationary, we can expect that:

$$p_t = a_0 + a_1 p_t^* + a_2 s_t \qquad (5.2)$$

corresponds to second cointegrating relationship with $a_1 = a_2 = 1$. In addition to estimating real money demand and price equation using single vector error correction model, we also estimate Girton and Roper (1977) model to test the domestic monetary authority's independence in pursuing an independent monetary policy. The Girton and Roper model is given as:

$$\Delta s_t + \Delta f_t = \alpha - \beta_1 m_t + \beta_2 m_t^* + \beta_3 y_t - \beta_5 y_t^* \qquad (5.17)$$

It is assumed that an increase in domestic money supply and a rise in foreign income put pressure on domestic currency to depreciate. On the other hand, an increase in domestic income and foreign money supply reduces pressure on domestic currency.

Table 5.2 Diagnostic statistics

Diagnostic test	Test Statistic
Real Money Demand and Price Equation	
LM(1)	37.563[0.397]
LM(2)	27.495[0.845]
LM(3)	20.387[0.737]
LM(4)	49.498[0.067]
LM(5)	34.161[0.556]
LM(6)	42.185[0.221]
$\chi^2_{(Het)}$	1546.414[0.263]
$\chi^2_{Nor}(4)$	1.561[0.458]
Girton and Roper Model	
LM(1)	37.625[0.051]
LM(2)	31.265[0.181]
$\chi^2_{(Het)}$	11.819[0.92]
$\chi^2_{Nor}(2)$	4.396(0.111)

Note: LM denotes Lagrange Multiplier test for residual serial correlation up to third order. χ^2 normal is a chi-square test for normality. *F het* is an *F* test for heteroscedasticity. Numbers in square brackets are the probability values of the test statistics.

For estimating six dimensional vector process (i.e. $X_t = m_t - p_t,\ p_t,\ y_t,\ i_t,\ p^*_t,$ s_t) using Johansen multivariate cointegration approach, we first need to determine the optimal lag length. Instead of using some information criterion for determining optimal lag length, we estimated the unrestricted Vector Autoregression model up to eight lags and checked the residuals properities which were satisfied at the chosen lag length of six. For estimating Girton and Roper (1977) model, we used two lags at which the residuals of unrestricted vector Autoregression model satisfied required properities. Table 5.2 shows the results of statistical tests used to check residuals properities of estimated unrestricted VAR. It is evident from the table that the null of no serial correlation and homoscedasticity can not be rejected. Similarly, we can not accept the null of non-normal distribution of residuals.

Prior to estimation of long run relationship, we impose restrictions on intercept and trend in the short run and long run with a view of selecting appropriate model. The first possible specification includes intercept but no trend in cointegration equation, no intercept or trend in VAR. Thus data do not contain linear trends and therefore, the differenced data has zero mean. Moreover, cointegrating equation and VAR in model three includes intercept but no trend. In this case, data does not contain trend but the specification is allowed to drift around an intercept. Intercept in VAR cancels intercept in the cointegrating equation. This leaves only one intercept in the short run. Finally, model four contains intercept in both VAR and cointegrating equation, linear trend in cointegrating equation, no trend in VAR. Trend in cointegrating equation takes account of exogenous growth.

We select the appropriate model by moving from the most restrictive to least restrictive model by comparing trace or maximal eigen value test statistic to their critical values. We select the model when the null that there are *r* cointegrating vectors is not rejected for the first time (Asteriou and Hall, 2007).

Table 5.3 reports the results of cointegration test using the specification that includes real money balances, real domestic income, interest rate, domestic and foreign price indices Pakistan's nominal exchange rate, US money supply and US real income. Two test statistics are used to determine the number of cointegrating vectors. The decision about the number of cointegrating vector is based upon the calculated and critical statistics. The null hypothesis is not rejected if the calculated values are less then the critical ones. If calculated maximum or trace statistics are less than their 95% critical ones, we do not reject the null of presence of cointegrating relationship.

It is evident from Table 5.3 that Maximum eigenvalue and trace test statistic provide evidence of two and three cointegrating vectors for the specification that uses real money demand and price equation in single vector error correction model. We prefer maximum eigen value test statistic in selecting the number of cointegrating vector because of its strong alternative hypothesis compare to trace test statistic (Enders, 2010). On the other hand, both trace and maximum eigen value suggest one cointegrating vector for specification that uses exchange market pressure, domestic and foreign real money balances and domestic and foreign real income.

Next we impose exact – identifying (also called non – testable) restrictions for identifying cointegrating vectors. These restrictions are imposed to identify the cointegrating space and are equal to the number of cointegrating vectors (Ostero and Milas, 2001). On the other hand, over-identifying restrictions (also called testable restrictions) are the additional restrictions and are imposed on the cointegrating vectors. We test the validity of these restrictions using standard likelihood ratio test statistic (Milas, 1999). The presence of two cointegrating vectors in six dimension vector system suggests imposing two non –testable restrictions on each of the cointegrating vector. In order to do so, the two cointegrating vectors associated with $X_t = [m_t - pt, p_t, i_t, y_t, p_t^*, s_t]$ are given as:

$\Pi_1 = [\phi_{11}, \phi_{12}, \phi_{13}, \phi_{14}, \phi_{15}, \phi_{16}, \phi_{17}]$ and

$\Pi_2 = [\phi_{21}, \phi_{22}, \phi_{23}, \phi_{24}, \phi_{25}, \phi_{26}, \phi_{27}]$

Here Π_1 and Π_2 denote first and second cointegrating vector which denote the real money demand ($m_t - p_t$) and price equation (p_t) respectively. Each cointegrating vector contains seven elements, they represent the coefficient of each of the endogenous variable $[m_t - p_t, p_t, i_t, y_t, p_t^*, s_t]$ and intercept term, μ respectively. The non–testable restrictions imposed for identifying cointegrating vectors are given as:

$\phi_{11} = 1$, $\phi_{12} = 0$ (real money demand equation) and

$\phi_{21} = 0$, $\phi_{22} = 1$ (price equation)

Table 5.3: Cointegration test based on Johansen maximum likelihood method

Real Money Demand and Price Equation				**Girton and Roper Model**			
Null Hypothesis	Alternative Hypothesis	$\lambda_{\max}$ rank value	5% critical values	Null Hypothesis	Alternative Hypothesis	$\lambda_{\max}$ rank value	5% critical values
$\lambda_{\max}$ rank test				$\lambda_{\max}$ rank test			
$H_0: r = 0$	$H_a: r > 0$	46.593	40.957	$H_0: r = 0$	$H_a: r > 0$	50.398	33.877
$H_0: r \leq 1$	$H_a: r > 1$	42.155	34.806	$H_0: r \leq 1$	$H_a: r > 1$	22.766 [a]	27.584
$H_0: r \leq 2$	$H_a: r > 2$	23.144 [a]	28.588	$H_0: r \leq 2$	$H_a: r > 2$	16.586	21.132
$H_0: r \leq 3$	$H_a: r > 3$	15.674	22.299	$H_0: r \leq 3$	$H_a: r > 3$	7.596	14.265
$H_0: r \leq 4$	$H_a: r > 4$	9.178	15.892	$H_0: r \leq 4$	$H_a: r > 4$	0.372	3.841
$H_0: r \leq 5$	$H_a: r > 5$	6.428	9.165				
λ_{trace} rank test		λ_{trace} rank value		λ_{trace} rank test			
$H_0: r = 0$	$H_a: r = 1$	143.142	103.847	$H_0: r = 0$	$H_a: r = 1$	97.718	69.819
$H_0: r = 1$	$H_a: r = 2$	96.549	76.973	$H_0: r = 1$	$H_a: r = 2$	47.320 [a]	47.856
$H_0: r = 2$	$H_a: r = 3$	54.393	54.079	$H_0: r = 2$	$H_a: r = 3$	24.554	29.797
$H_0: r = 3$	$H_a: r = 4$	31.279 [a]	35.193	$H_0: r = 3$	$H_a: r = 4$	7.968	15.495
$H_0: r = 4$	$H_a: r = 5$	15.606	20.261	$H_0: r = 4$	$H_a: r = 5$	0.372	3.842
$H_0: r = 5$	$H_a: r = 6$	6.428	9.165				

Note: a denotes the first time when the null hypothesis is not rejected for the 95% significance level. Model 2 contains intercept but no trend in the cointegarting equation, no intercept or trend in VAR. Model 3 includes intercept in the cointegrating equation and VAR, no trend in cointegrating equation and VAR. Model 4 includes intercept in cointegrating equation and VAR, linear trend in cointegrating equation and no trend in VAR. Variables used in the VAR are: $m_t - p_t$, i_t, y_t, p_t, and s_t which denotes real money balances, inter bank call money rate, domestic real income. Domestic prices, foreign prices and Pakistan's nominal exchange rate. VAR is estimated using three lags from 1976Q1 to 2005Q2. n and r indicates the total number of the cointegrating vectors and the rank of the cointegrating matrix. * denotes foreign counterparts of domestic variables.

The non-testable restrictions imposed on the first cointegrating vector ϕ_{11} reveals that we express it in terms of real money demand $m_t - p_t$ (ϕ_{11} = 1) and drop the long run estimates of price equation p_t(ϕ_{12} = 0). The remaining variables are included unrestrictly. Similarly the non-testable restrictions imposed on the second cointegrating vectors ϕ_{21} allows us to express it in terms of price equation p_t (ϕ_{22} = 1) and drop long run estimates of real money demand equation $m_t - p_t$ (ϕ_{11} = 0). This also allows us to include the rest of the variables unrestricted in the second cointegrating vector.

The over – identifying restrictions (also called testable restrictions) the validity of which is to be tested, are given as:

H_0^a : ϕ_{15} = ϕ_{16} = 0 (on the real money demand equation)

ϕ_{15} and ϕ_{16} denote foreign price and exchange rate estimates and are dropped from the first cointegrating vector with a view to normalize it in terms of real money demand equation. Similarly, the testable restrictions imposed on the second cointegrating vector are:

H_0^b : ϕ_{23} = ϕ_{24} = 0 (price equation)

ϕ_{23} and ϕ_{24} represent interest rate and income estimates and are dropped from the second cointegrating vector with a view of expressing it in terms of price equation. The estimated Likelihood Ratio statistic for testing the validity of over – identifying restrictions on the two cointegrating vectors at two degrees of freedom are 10.296[*P* value = 0.801] and 3.676 [*P* value = 0.999] respectively.[43] Insignificant estimates of likelihood ratio test statistic distributed as χ^2 suggest that that the testable restriction imposed on the two cointegrating

[43] Degree of freedom is equal to the total number of restrictions minus the number of just – identifying restrictions.

vectors can not be rejected. Since the testable restrictions imposed are accepted therefore, we can express two cointegrating vectors in terms of real money demand and price equation as given in Weymark (1995) model and are given as:

$$m_t - p_t = -0.724 - 0.010 i_t + 1.191 y_t \qquad (5.20)$$
$$(-4.788)^a \quad (-0.462) \quad (2.561)^a$$

$$p_t = 2.474 - 1.701 p_t^* + 1.634 s_t \qquad (5.21)$$
$$(2.035)^a \quad (5.632)^a \quad (5.305)^a$$

Equation (5.20) and (5.21) shows the long run estimates of real money demand and price equation. Real money demand equation shows insignificant and significant interest rate and real domestic income estimates with having negative and positive signs which is in accord with the literature. Similarly, price equation shows significant estimates of both foreign price and exchange rate.[44] However, contrary to theoretical prediction, foreign price estimate is of negative sign which is inconsistent with the literature.[45]

5.5.3 Estimation of Exchange Market Pressure and Intervention Index

In this section, we construct quarterly exchange market pressure and intervention indices for Pakistan using real money demand (5.1) and price equation (5.2). Table 5.4 shows the estimate of real money demand and price equation using log differenced and log level data with two stage least square and Johansen multivariate cointegration methodology. It also contains Johansen estimates of Girton and Roper (1977) model (equation 5.17). Johansen estimates are obtained by normalising real money demand estimates by -1. We do this to express the remaining cointegrating vectors in terms of real money demand function (Hafer and Jansen, 1991). Negative and positive estimates of interest rate and domestic real income in

[44] We obtain the t-values by dividing the restricted estimates of parameter of interest with their corresponding standard errors from unrestricted contegrating vector.
[45] Separate VAR estimates of real money demand and price equation are given in appendix.

Table 5.4 are in accord with literature.[46] It is further evident from Table 5.4 that we obtain insignificant and significant estimates of interest rate and domestic income using two stage least square and Johansen approach respectively. However, the insignificant estimate of interest rate in two stage least square approach could be due to the use of differenced data. In addition, the use of instruments instead of interest rate may account for its insignificant estimate in two stage least square approach. This occurs when instruments although strongly correlated with the endogenous variable have weak correlation with the dependent variable. This gives increased values of standard errors which results in insignificant t–values. Insignificant interest rate coefficient in 2SLS approach implies that the short term interest rate does not have any significant impact on nominal money holdings (Khan, 1980).[47]

Negative interest rate coefficient is based on the assumption that as interest rate increases; people prefer to hold their cash balances in terms of assets that earn interest rate than holding them in cash balances. This gives negative relationship between interest rate and real money balances. Compare to Hetzel and Mehra (1980) who obtained -0.76 and -2.2 for *M1* and *M2* monetary aggregates for the US, our interest rate estimate of -0.010 for Pakistan is quite low. However, it is slightly greater than that obtained by Hafer and Jansen (1991) for M2 monetary aggregate for the US. Low interest rate coefficient has implications for monetary policy. This implies that monetary authorities will have to bring greater changes in the interest rate for inducing desired changes in demand for $M1$ (Bahmani-Oskooee and Shabsigh, 1996).

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[46] The interest rate has also been used in the levels due to different results obtained in log form for the same change. For example, if interest rate rises from 0.04 to 0.05, the log of the interest rate rises from -3.21889 to 2.99573, which is a change of 0.223144. If, on the other hand, the interest rate rises from 0.08 to 0.9, the log of the interest rate rises from -2.40795 to -2.52573, which is only change of 0.0117783. It is generally not expected that one percent increase in the interest rate to have more than two times effect on the log of the desired real money balances when the change from the base of 0.04 than when it is from a base of 0.08 (Fair, 1987). Despite that, we used log interest rate to maintain consistency between the first and second chapter. The real money demand equation based on the interest rate in levels is given as: $m_t - p_t = -0.157 - 0.007\, i_t + 1.068\, y_t$. The estimated parameter of interest rate although negative is not significantly different from zero.

[47] Mangla (1979) and Nisar and Aslam (1983) used call money rate and obtained insignificant and significant interest rate coefficients for Pakistan.

Table 5.4 Real Money demand, Price and Girton & Roper (1977) model estimates

Technique	Variables				
Real Money Demand	Constant	i_t	y_t	Δi_t	Δy_t
2SLS[Diff]				-0.080 (-1.46)	0.129 (1.95)[a]
Johansen	-0.724 (-4.788)[a]	-0.010 (-0.462)	1.191 (2.561)[a]		
Price Equation		p_t^*	s_t	Δp_t^*	Δs_t
2SLS[Diff]	0.001 (0.22)			0.287 (0.58)	0.828 (1.81)
Johansen	2.474 (2.035)[a]	-1.701 (-5.632)[a]	1.634 (5.305)[a]		
Girton and Roper (1977) model		m_t	m_t^*	y_t	y_t^*
Johansen		-0.419 (1.165)	-0.456 (20.66)[a]	0.026 (0.055)	-1.322 (2.380)[a]

Note: t – values are given in parenthesis. *a* denotes significant t-values. 2SLS denotes two stage least square. Johansen is in levels and 2SLS is first difference. Constant is included following Weyamrk (1995). Δ denotes first difference operator. * denotes foreign counterparts of domestic variables.

The income coefficient is positive in both specifications as expected. It can be interpreted that as income increases, people demand more money for financing their increased number of transactions. The income coefficient of 1.191 is slightly greater than some of the recent studies by Bahmani–Oskooee and Shabsigh (1996), Hwang (2002) and Peytrigent and Stahel (1998) who obtained income elasticity estimate that range from 0.69 to 1.039 for Japan, Korea and Switzerland.[48]

The middle part of Table 5.4 shows estimates of price equation obtained from log level and difference data along with two stage least square and Johansen (1988) and Johansen and Juselius (1990) multivariate cointegration methods. The long run estimates are obtained by normalizing cointegrating vectors for Pakistan's consumer price index to -1. This is done to

[48] Nagayasu (2003) studied the stability of the Japanese money demand function using quarterly data for the period 1958 to 2000 and concluded that the standard money demand function is instable.
Bhamani – Oskooee and shin (2002) studied the stability of Korean money demand function using quarterly data from 1973 to 1997 using cointegration approach and CUSUM and CUMSUMSQ test to the residuals. They concluded instable money demand function for the period thus analyzed.

express the remaining cointegrating vectors as price equation. Table 5.4 indicates that the price equation estimated parameters for 2SLS are insignificant, whilst they are significant for Johansen. The insignificant estimates of price equation from two stage least square method could be due to the use of difference data and instrumental variables for endogenous variables.

Positive estimate of exchange rate is in accord with the literature. This suggests that increase in exchange rate is reflected in positive domestic price change. However, the foreign price estimate does not confirm the literature that suggests positive sign. In addition, the homogeneity condition–that changes in exchange rate and foreign price cause domestic price level to change by the same proportion–and symmetry condition–the coefficient of exchange rate and foreign price are equal–are not satisfied. These findings support a weak-version of price equation.[49] Furthermore, cointegration approach yield negative estimate of foreign price which is unexpected.

The lower part of Table 5.4 shows the estimates of the Girton and Roper (1977) monetary model of exchange market pressure. It indicates that all the estimated parameters have signs that are in accord with the literature. However, the estimates of domestic income and domestic real money balances are insignificant. This indicates that changes in domestic real income and domestic real money balances do not have any influence on Exchange Market Pressure. This can be interpreted in terms of independence of domestic monetary authorities in pursuing an independent monetary policy. [50]

Following the Weymark (1995) approach, Exchange Market Pressure (EMP_t) is given as: $EMP_t = \Delta s_t + \eta \Delta f_t$. Given exchange rate as number of units of domestic currency per unit

[49] Weak – version of purchasing power parity places no restrictions on the cointegrating vectors and simply requires that the exchange rate and relative prices be correlated (see MacDonald, 1993, and 2007).

[50] The literature that has tested the null of monetary independence for different countries has used domestic component of monetary base namely domestic credit instead of changes in domestic money balances. This could be the reason that we get insignificant estimate of real money in the estimates of Girton and Roper (1977) model for Pakistan (See Girton and Roper, 1977).

of foreign currency, we can interpret positive and negative estimates of exchange market pressure with downward and upward pressure on domestic currency. It is evident from Exchange Market Pressure equation that we need estimates of η for constructing exchange market pressure index. It is obtained using the formulae given as: $\eta = \frac{-1}{a_2 + b_2}$ which shows that we need the estimates of interest rate (b_2) and exchange rate (a_2) for obtaining the estimate of η. These in turn are obtained by estimating real money demand (5.1) and price equation (5.2) using Johansen (1987) multivariate cointegration approach and are given as:

a_2 = 1.634 and b_2 = 0.010

Based on interest rate and exchange rate estimates, we construct model consistent elasticity $\eta_{Johansen}$ as:

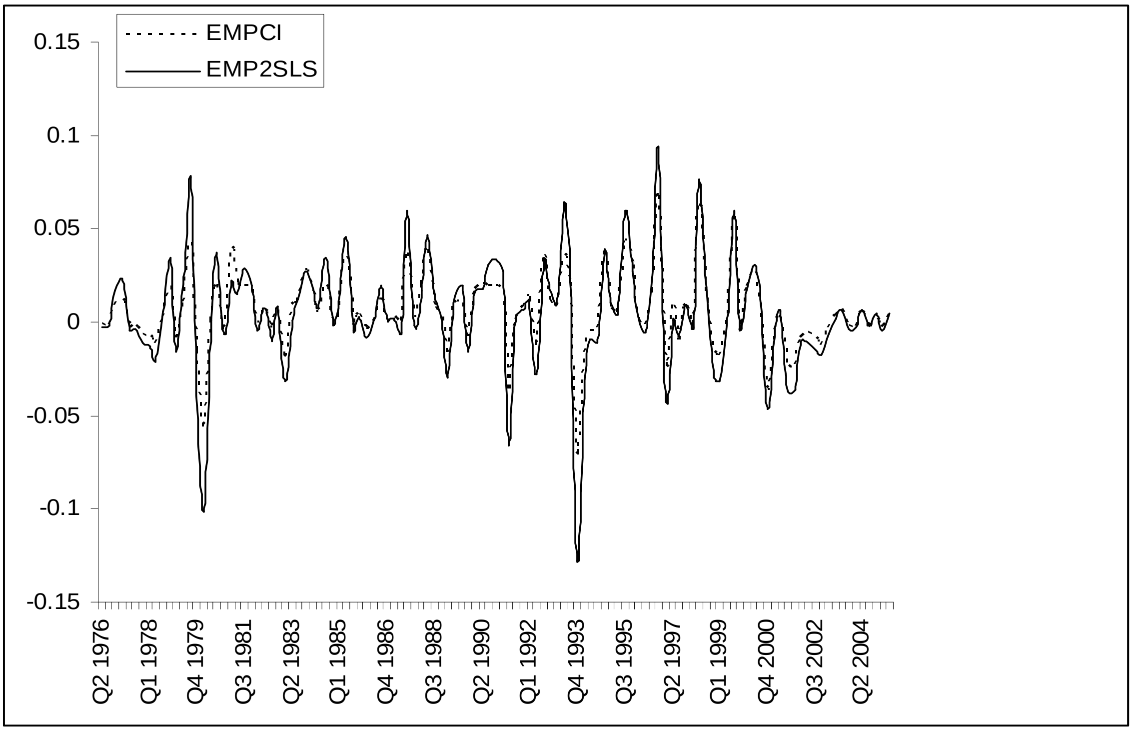
$$\eta_{Johansen} = \frac{-1}{1.634 + 0.010} = -0.608$$

η converts foreign exchange reserves changes into equivalent exchange rate units. Its negative sign implies that the Central Bank purchases foreign exchange reserves when domestic currency strengthens against the US dollar in the open market.

Figure 5.3 shows quarterly estimates of exchange market pressure using log level and log difference data with Johansen (1988) multivariate cointegration and two stage least square approach. Both approaches show that it is downward pressure on domestic currency that has remained dominant over the entire sample period. Exchange market pressure mean value of 0.005 obtained from both approaches further support this finding.[51] Furthermore, two stage

[51] Two stage least square and Cointegration yield exchange market pressure mean values of 0.0047666 and 0.0057904 which are almost the same.

Figure 5.3 Exchange Market Pressure

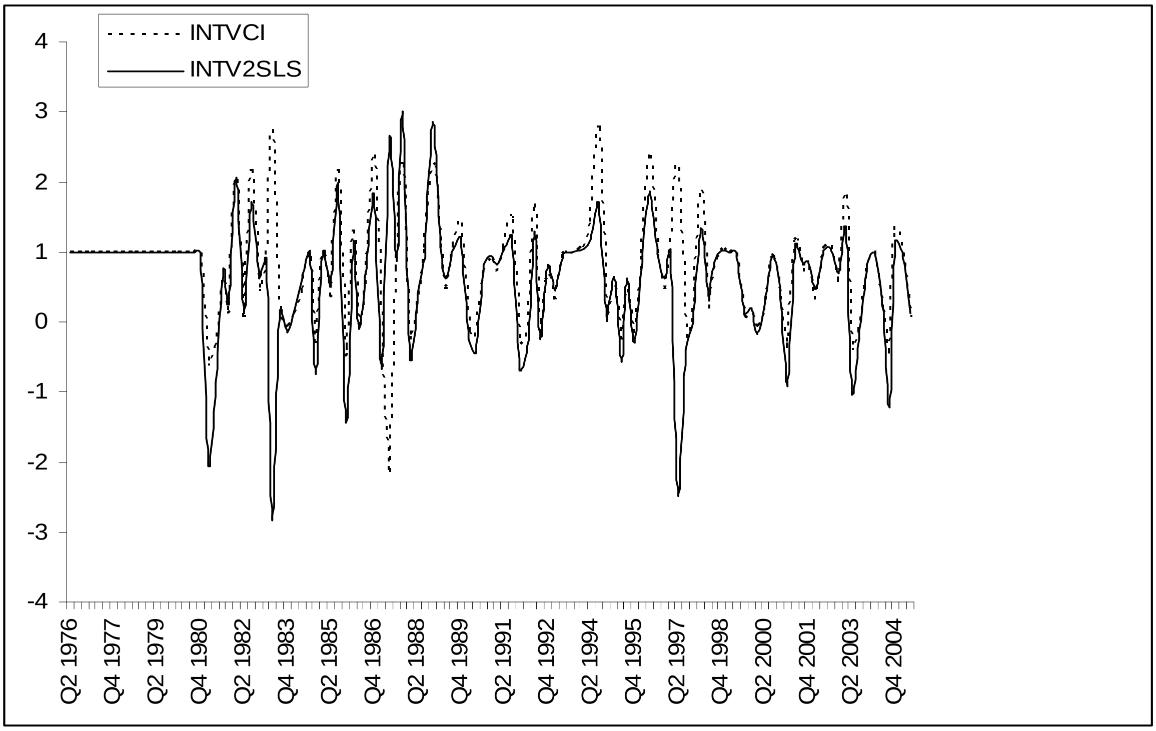


Note: EMPCI and EMP2SLS refer to Exchange Market Pressure obtained from cointegration and two stage least square approach.

least square estimates of exchange market pressure appear to be more volatile than Johansen cointegration approach. This could be due to the use of different estimation techniques that yield different estimates of exchange rate elasticity of foreign exchange reserves.[52] Figure 5.3 further shows that prior to September 2001; downward pressure has remained dominant. However, post September 2001 shows upward pressure on domestic currency. This is evident from negative sign for ten of fifteen quarters. This has occurred due to (a) increased workers remittances due to international community's crackdown against undocumented currency transactions, (b) rescheduling of Pakistan's external debt, (c) repayment of expensive debt and substitution of hard loans into soft ones, (d) robust non – structural inflows, (e) lifting of international sanctions that were imposed in the wake of nuclear explosions, and (f) improved

[52] Two stage least square and Johansen (1988) multivariate cointegration estimates of exchange rate elasticity with respect to foreign exchange reserves are -1.337 and -0.618 respectively.

Figure 5.4 Intervention Index (ω_t)



Note INTVCI and INTV2SLS refer to intervention index values obtained from cointegration and two stage least square approach respectively.

relations with international financial institutions and bilateral creditors due to support of international community in its war against terrorism (Post 2001 State Bank Quarterly Reports).

Figure 5.4 show two stage least square and Johansen (1988) multivariate cointegration estimates of intervention index. Intervention index is described as the fraction of pressure that Central Bank relieves through the purchase and sale of foreign exchange reserves and is given as:

$$\omega_t = \frac{\Delta f_t}{\frac{1}{\eta}\Delta s_t + \Delta f_t} \tag{5.10}$$

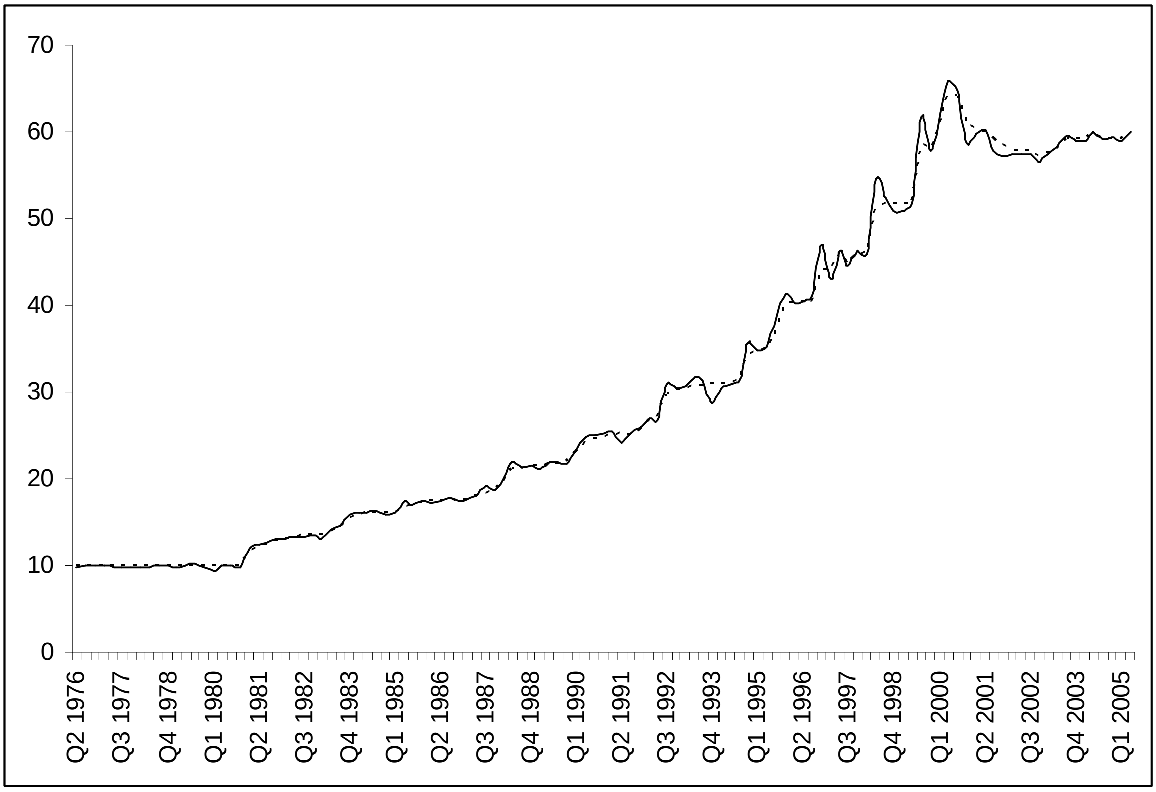
Both two stage least square and Johansen multivariate cointegration estimates suggest active Central Bank intervention in foreign exchange market for avoiding undesirable exchange rate fluctuations. 2SLS and cointegration approach estimates of intervention index mean value of 0.61 and 0.73 respectively, further support this interpretation. This suggest that under two stage least square approach, exchange rate and foreign exchange reserves relieved thirty nine and sixty one percent of the pressure respectively. Similarly, under Johansen cointegration approach, exchange rate and foreign exchange reserves absorbed twenty seven and seventy three percent of the pressure.

Exchange market pressure reflects foreign exchange market disequilibrium that arises due to nonzero excess demand of domestic currency in the foreign exchange market. Based on this definition of Exchange Market Pressure, we can calculate the exchange rate level that would prevail in the absence of Central Bank intervention using one period lagged exchange rate:

$$S_t^{predicted} = (1 + EMP_t)S_{t-1}^{observed} \tag{5.22}$$

where $S_t^{predicted}$ refers to unlogged exchange rate that would prevail in the absence of Central Bank intervention. S_{t-1} denotes one period lagged observed unlogged exchange rate. The difference between the two exchange rates reflects the extent of Central Bank intervention. It is evident from figure 5.5 that observed exchange rate is less volatile than the predicted exchange rate. Standard deviations of 18.521 and 18.484 for predicted and observed exchange rate further support this interpretation. Furthermore, correlation coefficient of 0.99 shows strong association between observed and predicted exchange rate. Since the observed exchange rate is less volatile than the predicted exchange rate, it provides evidence that the Central Bank intervention is successful in reducing exchange rate volatility.

Figure 5.5 Predicted and actual exchange rate



Note: dotted line denote predicted exchange rate which is more volatile. Solid lines, on the other hand, denotes observed exchange rate. This is less volatile.

5.5.4 Summary of Results from Two Methods

In this section, we present summary of results of two stage least square and Johansen multivariate cointegration approach. It is apparent from Table 5.5 that η has negative sign indicating that foreign exchange reserves and exchange rate changes move in the opposite direction. This shows that the Central Bank relieves pressure by purchase and sale of foreign exchange reserves. Positive mean values of Exchange Market Pressure shows the extent of exchange rate changes required for restoring foreign exchange market equilibrium in the absence of Central Bank intervention. This suggests that in the absence of Central Bank intervention in the foreign exchange market, exchange rate would have depreciated by five percent under both approaches. Mean value of intervention index suggest active Central Bank

Table 5.5 Summary of Results from 2SLS and Johansen Approach

	2SLS	Johansen
η	-1.101	-0.608
$\overline{EMP_t}$	0.005	0.005
$\overline{\omega}_t$	0.61	0.73
$\omega_t < 0$	24 Quarters	24 Quarters
$\omega_t = 1$	24 Quarters	24 Quarters
$\omega_t < 1$	41 Quarters	41 Quarters
$\omega_t > 1$	28 Quarters	28 Quarters
$\overline{EMP_t}$	-0.019	-0.010
$\overline{\omega}_t$	1.031	1.035
$\overline{EMP_t}$	0.022	0.017
$\overline{\omega}_t$	0.303	0.523

Note: 2SLS refers to two stage least square method. η denotes exchange rate elasticity with respect to foreign exchange reserves. Similarly *EMP* refers to exchange market pressure. $\overline{\omega}_t$ and ω_t intervention index mean value for the entire sample period, and intervention index different values. + and - indicates appreciating and depreciating pressure

intervention. It signals the extent of the pressure that is relieved by exchange rate and foreign exchange reserve changes respectively.

Table 5.5 further reveals $\omega_t < 0$ for twenty four quarters. This shows the Central Bank's leaning with the wind - that the Central Bank purchased foreign exchange reserves when there was already a pressure on domestic currency to depreciate. $\omega_t = 1$ for twenty four quarters. This shows that in these quarters, proportionate changes in foreign exchange reserves were equal to the prevailing pressure. This did not allow the exchange rate to depreciate which is consistent with the fixed exchange rate regime. $0 < \omega_t < 1$ for forty one quarters. This implies that in these quarters, simultaneous changes in exchange rate and foreign exchange reserves restored foreign exchange equilibrium. This kind of monetary authority's response to Exchange Market Pressure is consistent with a managed float. $\omega_t > 1$ for twenty eight quarters shows that in these quarters, proportionate changes in foreign exchange reserves were more than that warranted by the pressure ($\Delta f_t > EMP_t$). This moved the exchange rate in the direction opposite to that which would have prevailed in the absence of the Central Bank intervention.

Table 5.5 further reveals that Central Bank's response varies with the prevailing pressure. It exceeds to its unity value when there is upward pressure. This led the domestic currency to depreciate rather then appreciate against the US dollar as implied by the prevailing pressure. On the other hand, the proportionate changes in foreign exchange reserves were less than that warranted by the weakening pressure. This caused the exchange rate to change as well though less than that warranted by the pressure. The evidence obtained from the cointegration approach about exchange market pressure and intervention index is quite similar to that obtained using two stage least square in the previous chapter. The active Central Bank intervention revealed by both two stage least square and Johansen (1988) multivariate cointegration approach may reflect monetary authorities fear that exchange rate changes may influence domestic prices and further deteriorate countries' foreign debt burden.

5.6 Conclusion

In this chapter, we adopted the Girton and Roper (1977) and the Weymark (1995) approach. The former approach aimed at testing the independence of domestic authorities in pursuing independent monetary policy. On the other hand, we used Weymark (1995) approach with a view of checking the direction of pressure and evaluate monetary authorities' response function. The innovation in this chapter was to use Johansen approach to account for data nonstationarity. Girton and Roper (1977) estimates shows the independence of monetary authorities in conducting monetary policy. The results obtained from Weymark (1995) approach indicate downward pressure on domestic currency over the entire sample period. The results further indicate active Central Bank intervention. This is further evident from intervention index mean value of 0.73 which shows that exchange rate and foreign exchange reserve changes absorbed twenty seven and seventy three percent of the pressure respectively.

Furthermore, Johansen estimates of intervention index reveal that it varies with the prevailing pressure. The proportionate changes in foreign exchange reserves were more than that warranted by upward pressure on domestic currency. This caused the exchange rate to depreciate rather than appreciate as implied by the prevailing pressure. On the other hand, changes in the foreign exchange reserves were less than that warranted by the weakening pressure on the domestic currency. In such a case exchange rate also changed although less than that warranted by the pressure. Johansen's estimates of exchange market pressure are almost the same as obtained from log differenced data and two stage least square approach. This further supports our findings in first chapter.

The estimated parameter of interest rate is insignificant in chapter four and five. This could be that inter bank call money rate is called the short term interest rate. It is the interest rate that commercial banks charge to brokerage firms for financing their clients' financial needs and therefore, may not represent the true opportunity cost of holding real money balances in the long run. We also used Treasury Bill Rate as the opportunity cost of holding real money balances. It gave us significant estimate for the interest rate. However, the basic issue with Treasury Bill Rate is that it has remained fixed for more then half of the sample period. Therefore, we were left with the choice of either to use Treasury Bill Rate that does not show variation – a basic requirement for the time series data and obtain significant interest rat estimate or to use inter bank call money rate and get insignificant estimate. We adopted the latter approach and estimated real money demand function using inter bank call money rate.

In the last two chapters, we used fixed parameter approach in constructing Exchange Market Pressure and intervention index for Pakistan from Weymark (1995) model. However, fixed parameter approach does not allow the estimated parameters to take account of the effects of structural changes on parameter constancy. In addition, it has been considered as one of the important factor for the failure of exchange rate models. Furthermore, Pakistan economy has seen structural changes over the given sample period. This necessitates using an approach that overcomes the disadvantages of fixed parameter approach and evaluate the effects of structural changes on parameter constancy. We overcome this issue by using Kalman Filter time varying parameter approach in the next chapter.

Appendix A

Table 5.1: Unit Root Test in levels and first difference

PP Unit Root Test in log levels			PP Unit Root Test in First Difference		
Variables	Constant	Constant and trend	Variables	Constant	Constant and trend
i_t	-4.419 [a]	-4.739 [a]	Δi_t	-17.338 [a]	-17.271 [a]
m_t	-1.797	-2.970	Δm_t	-12.183 [a]	-12.286 [a]
m_t^*	-1.088	-1.779	Δm_t^*	-5.055 [a]	-5.029 [a]
p_t	-0.989	-2.373	Δp_t	-9.675 [a]	-9.672 [a]
p_t^*	-4.738 [a]	-2.558	Δp_t^*	-5.209 [a]	-3.769 [a]
s_t	0.005	-2.558	Δs_t	-9.368 [a]	-9. 403 [a]
y_t	0.768	-3.319	Δy_t	-14.337 [a]	-14.318 [a]
y_t^*	0.223	-2.254	Δy_t^*	-7.149 [a]	-7.148 [a]
emp_t	-9.919	-9.958			
5% critical values	-2.886	-3.449	5% critical values	-2.886	-3.449

Note: a indicates the significance of the variables at 5% critical values. * denotes the foreign counterparts of the domestic variables. Lag lengths in parentheses (.) are determined by the Akakike Information Criterion with maximum number of 4 lags. Variables used are defined as: i_t = Treasury Bill Rate, m_t = M2 in Pakistan, p_t = CPI in Pakistan, s_t =spot exchange rate, and y_t =gross domestic product adjusted with GDP deflator. 5% one sided critical values are taken from McKinnon (1996). Quarterly data for the period 1976:Q1 to 2005:Q2 is used. Δ denotes first difference operator

Appendix B

$$m_t - p_t = -0.031 - 0.235 i_t + 1.061 y_t$$
$$(-0.144)\ \ (-4.273)^a\ \ (22.104)^a$$

$$p_t = 3.569 - 2.675 p_t^* + 2.059 s_t .$$
$$(3.468)^a\ \ (-3.114)^a\ \ (5.509)^a$$

Appendix C

Figure C1 data in levels

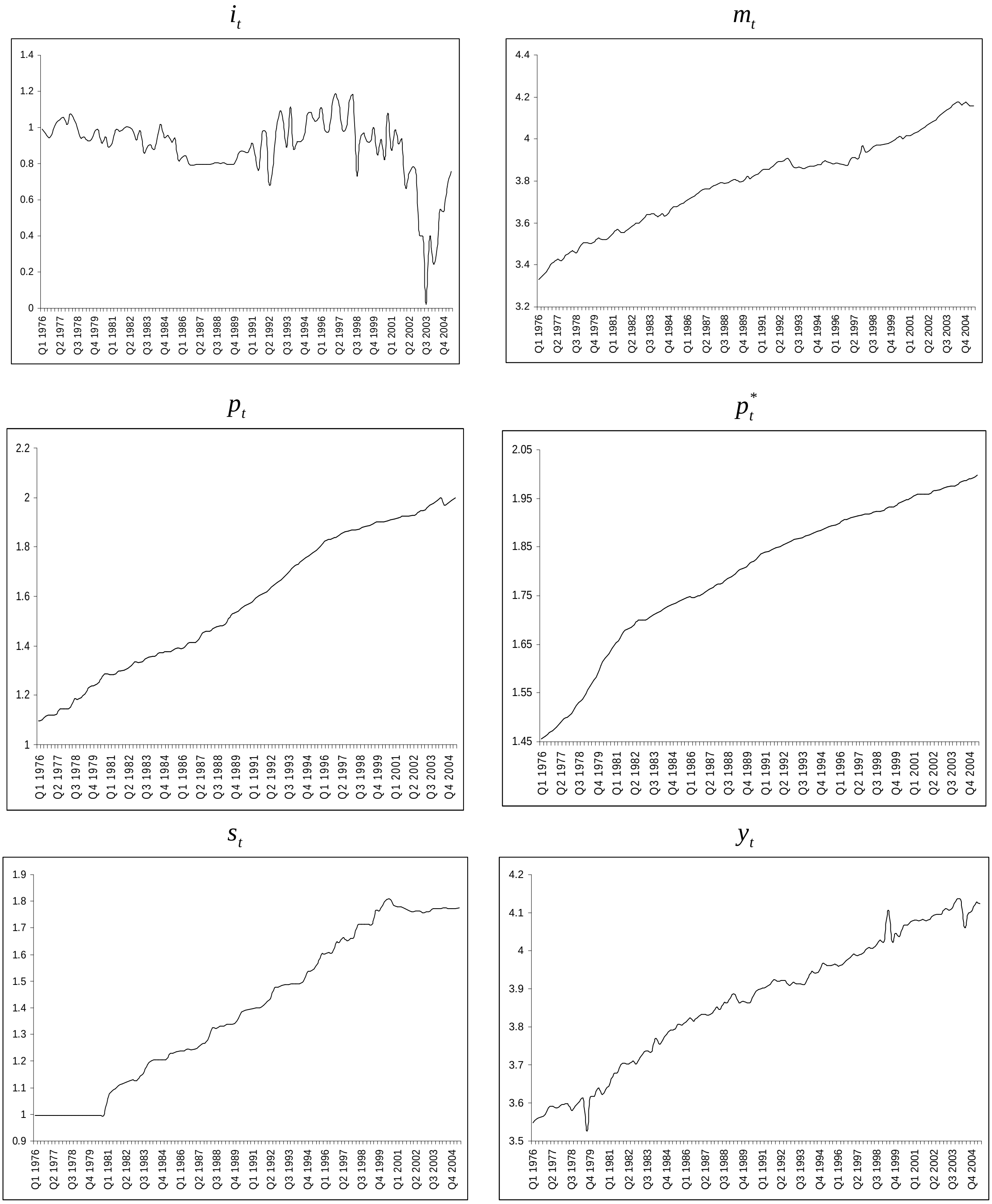
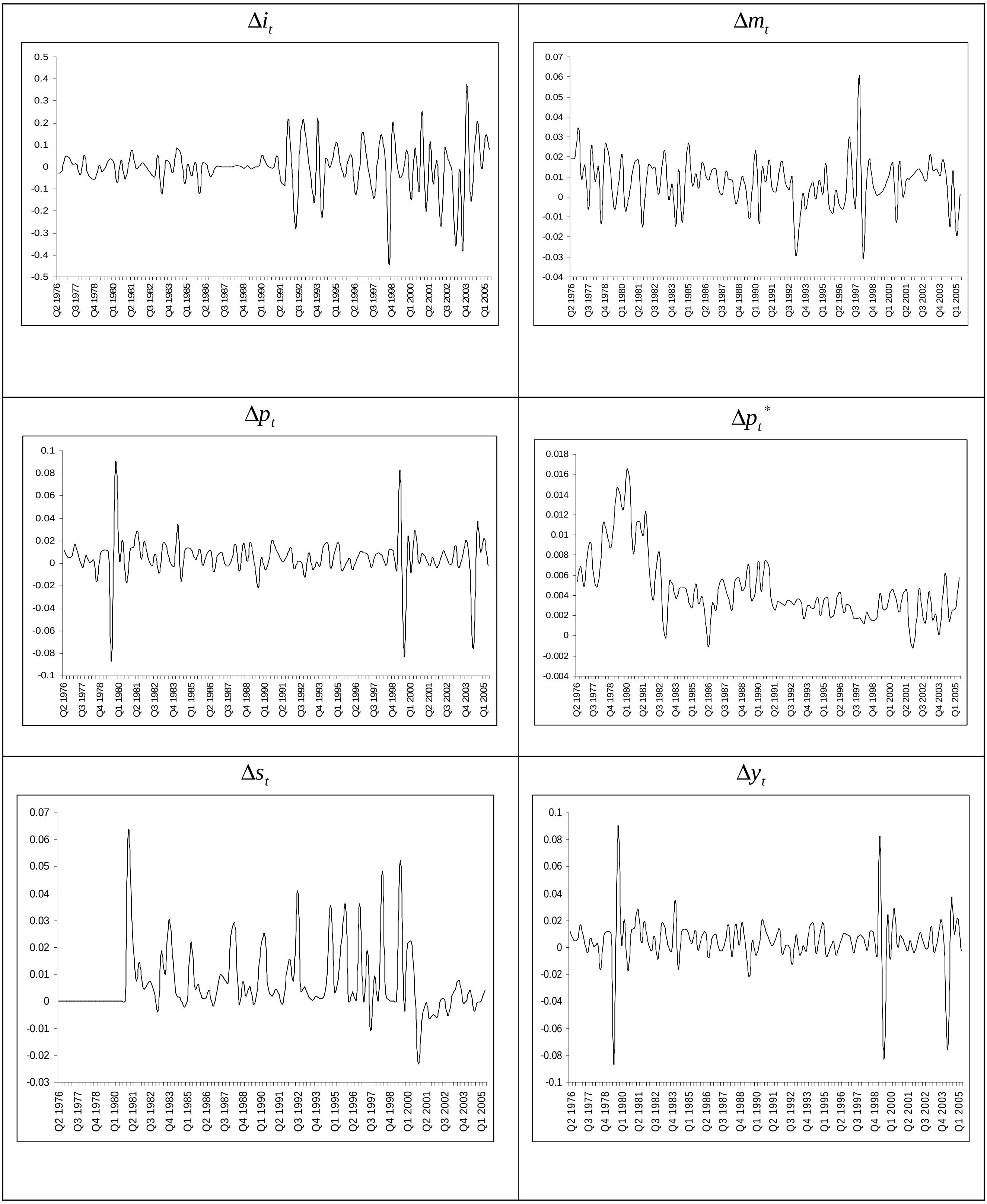


Figure C2 data in first difference



Chapter Six

Exchange Market Pressure and Intervention Index for Pakistan. Evidence from a Time-Varying Parameter Approach

Abstract

In this chapter we use the approach of Weymark (1995) for constructing exchange market pressure and intervention index for Pakistan and to account for potential linearity. A rolling regression indicates unstable real money demand and price equation estimates. Consequently, we use a Kalman filter approach to evaluate the effects of structural changes that have taken place over the entire given sample period on parameter constancy. The results indicate unstable real money demand and price equation parameters. Kalman filter-based exchange market pressure and intervention index show downward pressure and active Central Bank intervention. Exchange Market Pressure and intervention index mean values for the first half are higher than in the second half of the sample period, which indicates the post-reform period as more tranquil. The intervention index mean value for the entire period suggests that foreign exchange reserves and exchange rate changes absorbed seventy-one and twenty-nine percent of the pressure respectively.

6.1 Introduction

A stable relationship among the variables of interest is a prerequisite for the formulation of effective policy. This implies that an effective response to exchange rate fluctuations in the context of a fixed parameter exchange rate model rests on stable real money demand and price equation.[53] This implies that monetary policy will have any predictable effect on exchange rate stability only if real money demand and price equation are stable. This makes it necessary to investigate the stability of our model's equilibrium relationship.

Weymark (1995) used a fixed parameter approach for constructing an exchange market pressure and intervention index for Canada. However, a fixed parameter approach in the face of structural instability is considered as one of the most important factors for the poor performance of exchange rate models. Lucas (1976), Meese and Rogoff (1983) and Wolf (1987) consider changes in policy regime, unstable money demand functions, changes in global trade patterns and productivity differential as the important factors for the out-of - sample poor performance of exchange rate models. Frenkel (1981) particularly attributes the 1970s collapse of purchasing power parity for France, Germany, UK and US to the volatile nature of the decade that resulted from real shocks, supply shocks, commodity booms and shortages, shifts in the demand for money, differential productivity growth and the uncertain future course of political and economic events which induced sharp and frequent changes in expectations. Therefore, it seems important that when estimating real money demand and price equation we take account of the potential time-varying nature of estimated parameters.

Pakistan economy has seen major structural changes over recent decades. These changes include: (a) Pakistan switched from a fixed to a managed floating exchange rate regime with effect from January 8th, 1982, (b) introduction of an interest-free banking system in 1981and subsequent replacement of interest–bearing deposits with a system based on profit

[53] Arnold (1994) attributes money demand instability to three sources: (a) institutional changes, (b) international payments and (c) Monetary Policy.

and loss–sharing principle from July 1st, 1985 (Khan, 1994; Ahmad and Khan, 1990), (c) denationalisation of public sector banks[54], (d) enhancement of Central Bank authority over the financial system of the country[55] and, (d) the imposition of sanctions on the country in the wake of nuclear explosions.[56]

We therefore adopt a time-varying parameter approach for evaluating the effects of structural changes on parameter constancy. Contrary to F – test or dummy variable, a non-linear approach has the advantage of not requiring any prior knowledge of a point in time when a shift in the parameters of equation is suspected (Laumas, 1977). Based on time-varying estimates of real money demand and price equation, we construct an exchange market pressure and intervention index for Pakistan from 1976Q1 to 2005Q2. The objective is to check the direction of pressure and use intervention index values as a tool for analysing the monetary policy thus implemented. This will allow us to determine the extent which Central Bank allows market forces to determine the exchange rate.

To our knowledge, this is the first study that attempts to construct Exchange Market Pressure and intervention indices based on time-varying estimates of real money demand and price equation. It attempts to check the effects of structural changes on parameter constancy and will enable the monetary authorities to formulate an effective policy response to exchange rate fluctuations. The results indicate that the estimated parameters are time-varying and show

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[54] A total of 24 commercial banks (7 domestic and 17 foreign) were operating as of 30th June, 1990. The domestic banks were under the strict control of the government and owned 90% of the total assets and deposits of the banking system.
Prior to financial liberalisation, all the domestic banks operated under the strict supervision of the government and were merged to from five large public sector banks by the mid-1970s (Ataullah, et al. 2004).
Domestic banks were nationalised in 1974 and were merged in to six major national commercial banks (Hardy and di Patti, 2001).

[55] The state bank of Pakistan guided and regulated the banking system of the country. Other institutions that shared the authority of central bank in supervising the financial system were: (a) Pakistan Banking Council (PBC) dealt with the matters related to public sector banks and development financial institutions (DFIs), (b) The Corporate Law Authority (CLA) that regulated non-bank financial institutions.

[56] The state bank of Pakistan took extraordinary measures to mitigate the uncertainty about Pakistan's economy. These include: (a) freezing the foreign currency accounts, (b) introducing multiple exchange rate regime (c) preventing speculative activity in inter-bank forex market, (d) discouraging capital outflows, (e) containing import demand and (f) discouraging overdue export bills.

large fluctuations, thus implying parameter instability over the given sample period. The time-varying estimates of Exchange Market Pressure and intervention index show downward pressure on domestic currency and active central bank intervention. The intervention index mean value indicates that foreign exchange reserves rather than the exchange rate changes absorbed most of the pressure facing exchange market.

The rest of the chapter proceeds as follows: in Section 6.2 we review the empirical work that has addressed the issue of real money demand and price equation stability. In section 6.3, we briefly discuss the structural changes that have taken place in the economy over the given sample period and how they influence the real money demand and price equation stability. In section 6.3.1, we discuss financial sector reforms and the enhancement of Pakistan's Central Bank authority in regulating the financial sector of the country. In Section 6.4 we derive Weymark's (1995) macroeconomic model. Section 6.5 details the methodology that includes rolling regression results of real money demand and price equation and discussion on Kalman filtering approach. Section 6.6 discusses the data while in Section 6.7 we present Kalman filter estimates of real money demand and price equation. In Section 6.7.1, we construct exchange market pressure and intervention index for Pakistan using Kalman filter estimates of real money demand and price equation and Section 6.7.2 provides summary of results obtained from three approaches. Section 6.8 concludes.

6.2. Literature Review

The formulation of an effective monetary policy to deal with exchange rate fluctuations requires stable real money demand and price equation. This implies that monetary policy will have a more predictable impact upon exchange rate fluctuations, if there is a stable relationship among the variables of interest. In addition, the linear estimation methods in the previous chapters have occasionally indicated insignificant parameters signifying potential parameter instability. This makes it necessary to investigate the stability of real money demand and price equation.

A large number of studies have examined the stability of money demand function. Khan (1974) tested the stability of the US money demand function from 1901 to 1965. The residuals -based test developed by Brown and Durbin (1968) shows stable US money demand function for the given period. Laumas and Mehra (1976) applied Cooley and Prescott's (1973) time-varying parameter approach for testing the stability of the US money demand function. The results indicate stable money demand function for the 1952Q2 to 1973Q4 period. Laumas (1977 and 1983) also found a stable US money demand function from 1953Q1 to 1975Q2 using the same econometric approach. Similarly, Bahmani-Oskooee and Bohl (2000) evaluated the effect of German monetary unification on German $M3$ money demand function. The evidence they gathered from CUSUM and CUSUMSQ tests in the context of cointegration and error correction modelling suggests unstable $M3$ money demand function for the post-unification period. Hwang (2002) considered two alternative monetary aggregates, $M1$ and $M2$, two alternative interest rate, short-term rate and long-term rate, and one scale variable, real GDP, for Korea. He found a long-term cointegrating relationship between $M2$ and its determinants. A stability test applied to residuals did not reject the stability hypothesis. Bahmani-Oskooee and Shin (2002), while applying the same approach found a long-term cointegrating relationship between $M2$ and its determinants for Korea. However, the residuals-based stability tests like CUSUM and CUSUMSQ did not support the stability hypothesis. The difference between the results of Hwang (2002) and Bahmani-Oskooee and Shin (2002) could be due to the latter study including exchange rate as a determinant of real money demand.[57]

As far as Pakistan is concerned, a large number of studies have focused on different aspects of money demand function such as (a) which monetary aggregate ($M1$ or $M2$) should be used as a proper definition of money, (b) whether income, permanent income or wealth should be used as a scale variable, (c) if interest rate represents opportunity cost of holding money then which interest rate or interest rates should be used. However, a few studies have focused on the issue of money demand stability. Mangla (1979) applied Chow's test statistic to ordinary least square estimates of money demand function and found evidence in support of stability. Khan (1980) evaluated the effects of country's split in two wings in 1971 on the stability of money demand function using a covariance analysis.[58] The results suggested a structural shift due to country's disintegration. However, a Chow test statistic in Khan's (1980) provided evidence that supported stable money demand function from 1971 to 1978. Nisar and Aslam (1983) also used covariance analysis for testing the stability of money demand function. The results indicate a stable term-structure specification of $M2$ money demand but not for the conventional one. The studies discussed above are spurious regression due to the use of non-stationary data and ordinary least square approach. They also use Chow and covariance test statistics that do not tell if the instability in the estimated macroeconomic model is due to change in intercept or slope or both. Furthermore, the Chow test assumes prior knowledge of structural breaks (Gujarati, 2003).

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[57] Bahmani-Oskooee and Chomsisengphet (2002) tested the stability of short run dynamics of M2 monetary aggregate in the context of cointegration and error correction approach using CUSUM and CUSUMSQ test statistic. The result supported the null of stability for Australia, Austria, Canada, France, Italy, Japan, the Netherlands, Norway, Sweden and USA. However, in case of the UK and Switzerland, empirical estimates show some sign of instability.

[58] Prior to December 1971, Pakistan consisted of two wings namely East and West Pakistan. However, East Pakistan separated from West Pakistan in 1971 and emerged as a new country called Bangladesh.

Contrary to above studies, Ahmad and Khan (1990) tested the stability of $M1$ and $M2$ money demand function for the period 1959-1960 to 1986 –1987 using Cooley and Prescott's (1976) time-varying parameter technique. The results obtained show stable $M1$ and $M2$ money demand function for the period 1959/1960 to 1980/1981 and unstable $M1$ and $M2$ money demand function thereafter. Hossain (1994) investigated the stability of narrow and broad monetary aggregates for Pakistan using Johansen's (1988) multivariate cointegration approach and equated long-term relationship with the stability of money demand function. However, Bhamani-Oskooee and Shin (2002) criticised the interpretation of the presence of a cointegrating vector with the stability of money demand function. They argued that the presence of a cointegrating vector and stability of money demand function are two different things and it is important to apply statistical tests to check if the long-term as well as the short-term estimated elasticities are stable over time. Qayyum (2001) applied Chow's test to cointegration and error correction estimates of aggregate, business and personal demand for $M2$ and obtained results that did not reject the null of stability of all these money demand specifications. Qayyum (2005) estimated aggregate $M2$ money demand function using Johansen's cointegration and error correction modelling. The CUSUM and CUSUMSQ tests applied to the short-term dynamics supported the stability hypothesis. To summarise, the fixed parameter approach supports stable money demand function for Pakistan. The above discussion indicates that all studies except Ahmad and Khan (1990) and Hossain (1994), have applied either Chow or covariance tests to the residuals of fixed parameter estimates and found evidence that support stable real money demand function. On the other hand, Ahmad and Khan (1990) evaluated the stability of real money demand from 1959/1960 to 1986/1987 using Cooley and Prescott's (1976) time-varying approach. Hossain (1994), on the other hand, inappropriately equates the evidence of cointegrating vector with the stability of real money demand function.

There is extensive literature on purchasing power parity from the perspective of developed countries. However, it has not received adequate attention from the developing countries perspective. Baillie and Selover (1987), Corbae and Ouliaris (1988) and Taylor (1988) examined the recent float period for Canada, France, Germany, Italy, Japan, UK, US and West Germany using Engle and Granger's (1987) residual-based cointegration approach. Although they found evidence of unit root in exchange rate and relative prices, the null of non-stationarity of the residuals was not rejected. This implies that exchange rate and relative prices drift apart and do not converge at their equilibrium level. Taylor and McMahon (1987) on the other hand, applied the same approach to bilateral rates between the US dollar, UK pound, the French franc and the German mark and found evidence that supported the validity of an absolute version of PPP for all countries except the UK from February, 1921 to May, 1925. Kim (1990) also obtained the same results for France, Italy, Japan, UK and US using a wholesale price index. However, for consumer price index, the results do not support the validity of long-term purchasing power parity. The difference in the results could be due to larger weights assigned to non-traded goods in CPI than WPI. Contrary to these studies, Dutt (1998) applied the Harris-Inder null of cointegration approach to real exchange rate and found evidence supportive of PPP for European Monetary System member countries.[59]

Frenkel (1981) instead of adopting a cointegration approach tested the validity of purchasing power parity for the US, the UK France and Germany using the two-stage least square approach. He found evidence that supported PPP for the period 1920 to 1925. However, 1973 to 1979 estimates do not support the validity of PPP. Frenkel (1981) attributed the collapse of purchasing power parity during 1970s to the volatile nature of the decade that resulted from real shocks, supply shocks, commodity booms and shortages, shifts in the demand for money and differential productivity growth. He re-estimated PPP equation for

[59] Harris-Inder tests the null of stationarity against the alternative of a unit root. It makes a distinction between series with unit and near unit roots.

exchange rates that do not include US dollar or US prices and found evidence that was more supportive of PPP. The difference in the results could be due to transport cost, change in US commercial policies and non-tariff barriers on trade, US price controls and their gradual removal during the first half of the 1970s and institutional arrangements like SNAKE and European Monetary System.[60] Therefore, it seems important that when estimating price equation, we take account of potential time-varying parameters.

The above studies provide mixed evidence on long-term validity of purchasing power parity. This may be due to failure of the fixed parameter approach to take account of the effects of structural changes on parameters. A time-varying parameter model allows us to evaluate the effects of structural changes on parameter constancy. Corbae and Ouliaris (1991) and Flynn and Boucher (1993) evaluated the effects of structural breaks on real exchange rate using Augmented Dicky Fuller (1984) and Perron (1989) modified unit root tests. The results show that the hypothesis of unit root in real exchange rate cannot be rejected. On the other hand, Liu and Burkett (1995) relied on a Kalman filtering approach for testing the stability of short-term adjustment to long-term purchasing power parity and found evidence that did not support the null of stability for Argentina, Chile, Colombia, and Mexico. Contrary to these studies, Canarella et al. (1990) re-examined the cointegration property of exchange rate and relative prices in a time varying parameter framework.[61] Based on monthly data for Canada, Germany, Japan and United Kingdom vis-à-vis United States, they show that a cointegration approach in a time-varying framework yields results that support the validity of long-term purchasing power parity.

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[60] EMS was signed in 1979 between several European countries that linked their currencies in an attempt to stabilise their exchange rate. Later on this was replaced by European Monetary Union in 1999, which established the common currency called the Euro.

[61] Moodley et al. (2000) evaluated the Canada-US trade agreement (CUSTA) from the perspective of market integration using Johansen cointegration and Kalman filtering approach. The results indicated the convergence of the price indices and the evidence of long run purchasing power parity relationship for the two countries.

6.3 Structural Change in Pakistan

An efficient financial system is a prerequisite for economic development. It channels private savings to firms to enable them to finance their investment projects. Furthermore, it enhances the efficient use of country's resources and is thus pivotal for countries' economic development. Pakistan embarked on denationalisation of the domestic banking system in the decade of 1990s. Its objective was to realise its potential in the development of the country. Furthermore, it aimed at enhancing the efficiency of the banking system and thus making it more competitive by liberalising the interest rates and credit ceilings, enhancing the State Bank of Pakistan's supervisory capacity and promoting economic growth.

Prior to financial sector reforms, several important events took place in the economy, including the following. (a) The introduction of a partial interest-free banking system in the country. Banks were allowed to open separate interest-free counters. The basic objective was to gradually Islamise the banking system of the country. The public was offered profit and loss sharing and term deposits accounts to invest their money. (b) Pakistan switched from a fixed exchange rate to a managed float on 8th January, 1982.

6.3.1 Financial Sector Reforms

Prior to 1990s, Pakistan's financial system was predominantly state-owned. There were twenty-four banks doing business in the country.[62] Ninety percent of the total assets and total deposits were owned by the government-owned banks. Domestic banks were characterised by high government borrowing, bank-by-bank credit ceiling, interest rate controls and directed credit to state chosen sectors. Non-bank financial institutions (NBFIs) also worked in parallel to banking sector. Development financial institutions, housing finance companies, and mutual funds constituted fifteen out of 36; even then, they controlled 90

[62] Out of twenty-four banks, seven were foreign-owned. Remaining seventeen banks were under the strict control of government.

percent of the total business. Furthermore, the Central Directorate of National Saving also worked in the country. It operated different National Saving Schemes (NSS) and had mobilised Rs 131.9 billion till 30th June, 1990. It worked through a network of 363 national Saving Centres and also some nationalised Commercial Banks and Pakistan Post Office acted as its agents.

Similarly, three different organisations were responsible for supervising the financial sector of the country. State Bank Act 1956 authorised the State Bank of Pakistan to supervise the banking sector of the country. At the same time, Banks (Nationalized) Act authorised Pakistan Banking Council to oversee the NBFIs and commercial bank activities. And the Corporate Law Authority established in 1984 was given powers to oversee capital markets. This resulted substantial overlapping of regulatory power among these organisations.

The State Bank of Pakistan (SBP) used bank-wise credit ceiling for the conduct of monetary policy.[63] Even the domestic credit was rationalised; government-preferred sectors were given priority in the disbursement of domestic credit. All the commercial banks, under cash reserve requirement condition were required to maintain five percent of demand and time liabilities in cash with State Bank of Pakistan. Furthermore, under Statutory Liquidity Requirement (SLR) each bank kept 35 percent of its time and demand liabilities in cash or government securities. The State Bank of Pakistan (SBP) also exercised strict control over the functioning of foreign exchange market. Although Pakistan switched from fixed to float exchange rate on 8th January, 1982, the Foreign Exchange Committee of the SBP frequently made adjustment in rupee/dollar parity. The SBP also exercised strict controls on interest rates offered on different deposits. The basic objective was to provide cheap credit to government priority sectors as the increase in interest rates was considered socially and politically

[63] Credit ceilings depended on the bank’s share in total deposits during previous year, size of the capital fund, foreign currency deposits and previous year’s utilisation of credit ceiling.

undesirable. Therefore, the real interest rate on different deposits remained negative for most of the time.

With these characteristics, it was realised that the prevailing domestic financial system was not serving the interests of the country. It was with this background that a comprehensive financial sector reform programme was introduced at the end of 1989. Its objective was to reduce market segmentation, enhance competition, strengthen the supervision and switch to market based monetary and credit policies. Although the reforms were introduced in the early 1990s, they only gathered momentum in 1997, when a comprehensive reform package aimed at strengthening institutions, restructuring banks and development financial institutions and improving supervisory framework was introduced.

A number of steps were taken in the 1990s to privatise the nationalised commercial banks (NCBs). Banks (Nationalization) Act, 1947 was amended. It enabled the government to transfer the ownership rights in case of sale of 51 percent of the share to the private sector. This amendment facilitated the privatisation and transfer of management of the Muslim Commercial Bank (MCB), Allied Bank Limited (ABL) and United Bank Limited to their buyers. In addition, new banks were permitted to commence business. Accordingly, in August 1991, ten new banks started commercial activities.[64] In the subsequent years, 11 new banks started their banking activities in the country.[65]

The amendment of Banks (Nationalization) Act in 1997 enhanced SBP authority to supervise and effectively regulate the financial sector of the country. Pakistan Banking Council was dissolved and its powers were transferred to State Bank of Pakistan (SBP). SBP consultation was made necessary in the appointment of the members of board of directors of

[64] These banks included: Bank Al-Habib Limited, Soneri Bank Limited, Union Bank Limited, Mehran Bank Limited, Indus Bank Limited, Prime Commercial Bank Limited, Askari Commercial Bank Limited, Bolan Bank Limited, Capital Bank Limited, and Republic Bank Limited.

[65] These included: Metropolitan Bank Limited, Habib Credit & Exchange Bank Limited, Schon Bank Limited, Faysal Bank Limited, Platinum Commercial Bank Limited, Prudential Commercial Bank Limited, Gulf Commercial Bank Limited, Bank Al-Falah Limited, Bank of Ceylon, Oman International Bank and Trust Bank Limited.

nationalized commercial banks and development financial institutions. Furthermore, in 1997 the Securities Exchange Commission of Pakistan was established and replaced the Corporate Law Authority. Initially, it regulated the corporate sector and capital market. Later, its authority was extended to supervise and regulate insurance companies, non-bank financial institutions and private pension funds.

Prior to financial sector reforms, SBP used direct instruments for the conduct of monetary policy. These include administratively-set interest rates, credit ceilings, directed and subsidised credit and direct involvement of government in formulation of and implementation of monetary policy. However, in the post-reform period, SBP relied on indirect instruments for the conduct of monetary policy. In January 1992, an open market operation was introduced and since then has become an important tool of monetary policy. Additionally, it was made necessary for the banks to keep certain fraction of total demand and time liabilities as special cash deposit with SBP. However, this condition was withdrawn on 1st July 1996. The policy of providing subsidised credit to government priority sector was withdrawn and banks were permitted to set their lending rates based on demand and supply conditions in the market.

In May, 1998 Pakistan conducted nuclear tests. This created uncertainty among the investors about the country's ability to meet its external sector obligations. In order to meet its external obligations, SBP imposed controls on the capital movement to meet its external obligations. It imposed restrictions on the withdrawals of hard currency from foreign currency accounts. The SBP even suspended the encashment of foreign currency certificates. In July, 1998 a multiple exchange rate system was introduced. It consisted of an official exchange rate and floating inter-bank exchange rate (FIBR). State Bank of Pakistan fixed the former and the later was determined in the inter-bank market.

The post-September 2001 events proved turning points for Pakistan economy. The sanctions that were imposed in the wake of nuclear explosions were lifted. Pakistan was also provided with enormous funds on account of its cooperation with international community in its war against terrorism. Furthermore, foreign exchange reserves of the country increased tremendously due to transfer of funds by Pakistanis living abroad through official channels. This is also evident from a surge in foreign exchange reserves which peaked to US $ 14 billion. All these developments have resulted in the slight appreciation of domestic currency against US $ in the wake of terrorist attack on US and improved credit rating of the country.

The financial sector reforms that were implemented during the decade of 1990s, lifting of sanctions and increased capital inflows in the wake of US terrorist attack and improved credit rating has changed the structure of the economy. We are of the opinion that structural changes discussed above may have influenced the parameters stability of the variables of the interest. This makes it necessary to adopt a time-varying approach to evaluate the effects of these structural changes on parameter constancy.

6.4 Time-Varying Parameter Model

In this section, we derive exchange market pressure and intervention indices for Pakistan using Weymark's (1995) macroeconomic model with the time-varying parameter. This is given as below:

$$m_t^d = p_t + b_{t1} y_t - b_{t2} i_t + v_t \qquad b_{t1} > 0 \text{ and } b_{t2} > 0 \tag{6.1}$$

$$p_t = a_0 + a_{t1} p_t^* + a_{t2} s_t \qquad a_{t1}, a_{t2} > 0 \tag{6.2}$$

$$i_t = i_t^* + E_t s_{t+1} - s_t \tag{6.3}$$

$$m_t^s = m_{t-1}^s + \Delta d_t + \Delta f_t \tag{6.4}$$

$$\Delta f_t = -\rho_t \Delta s_t \tag{6.5}$$

Asterisks denote foreign counterpart of domestic variables. The t subscripts show that the estimated parameters are time varying. This indicates that we allow the parameters to vary over a time to take account of the effects of new information that becomes available on parameter constancy. This differs from the previous chapters that use a fixed parameter approach and do not allow the estimated parameters to take account of the effects of structural changes on parameter constancy.

Equation 6.1 is the money demand function, which is a positive and negative function of domestic income and interest rate. Similarly, equation 6.2 is purchasing power parity, which indicates that domestic prices are positively influenced by changes in foreign prices and exchange rate. Equation 6.3 is uncovered interest rate parity, which shows that the difference between domestic and foreign interest rate is reflected in expected exchange rate changes. Equation 6.4 shows the evolution of domestic monetary base. It indicates that domestic monetary supply (m_t^s) is determined by inherited money stock (m_{t-1}^s), changes in domestic credit (Δd_t) and foreign exchange reserves (Δf_t). Equation 6.5 is the monetary authority's response function. It shows that the Central Bank intervenes in foreign exchange market to reduce pressure. This explains the negative sign for exchange rate changes.

The macroeconomic model given in equations 6.1 to 6.5 provides the Exchange Market Pressure index given as:

$$EMP_t^{TVP} = \Delta s_t + \eta_t \Delta f_t \tag{6.6}$$

Based on the above definition of the Exchange Market Pressure index, Weymark (1995) defines the intervention index as:

$$\omega_t^{TVP} = \frac{\eta_t(\Delta f_t)}{EMP_t} = \frac{\eta_t \Delta f_t}{\Delta s_t + \eta_t \Delta f_t} \tag{6.7}$$

Dividing the numerator and denominator of the right-hand side of the equation (6.7) by $1/\eta_t$ gives:

$$\omega_t^{TVP} = \frac{\Delta f_t}{\frac{1}{\eta_t}\Delta s_t + \Delta f_t} \tag{6.8}$$

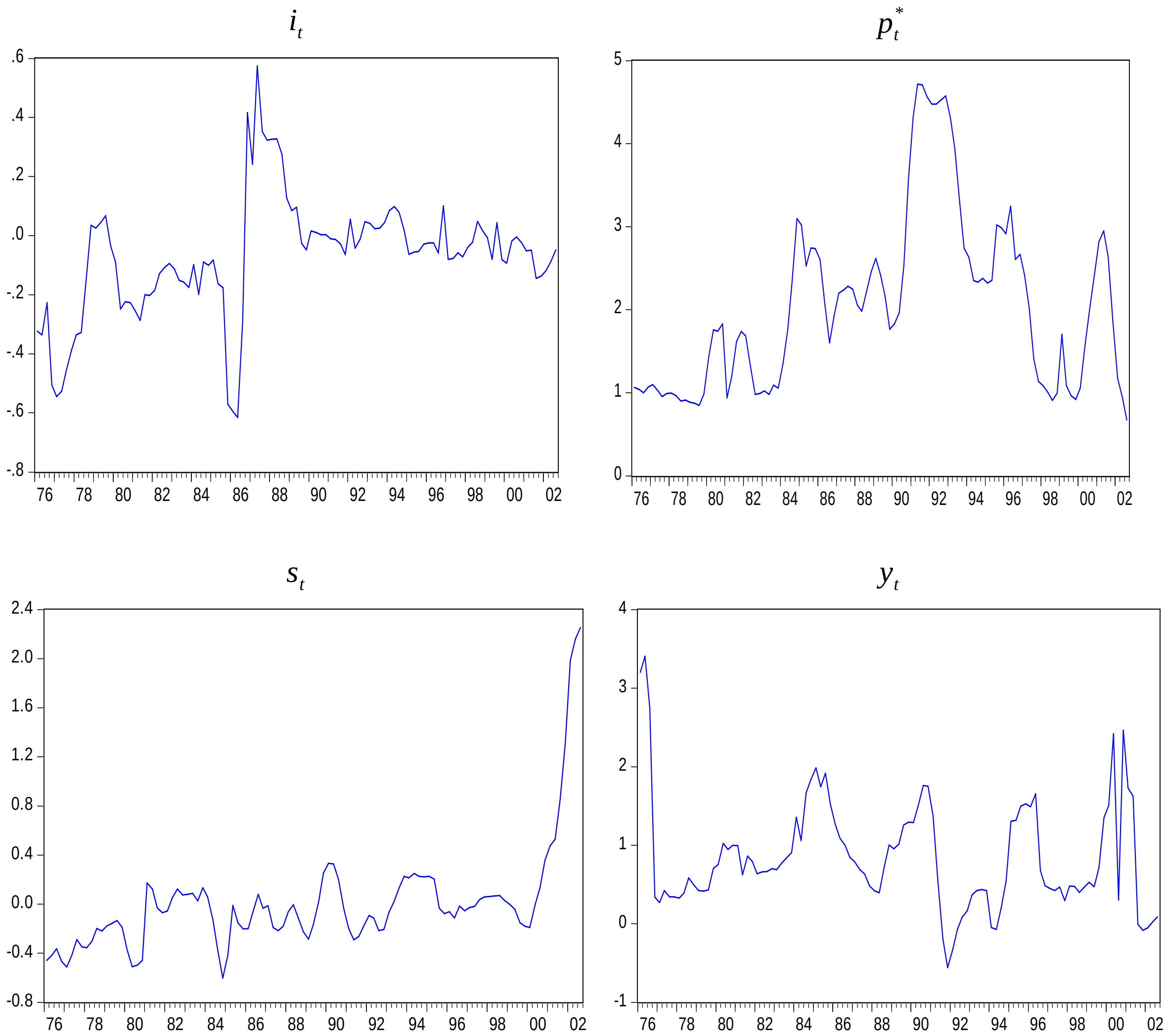
ω_t^{TVP} is the fraction of pressure that Central Bank relieves through purchase and sale of foreign exchange reserves. It takes values between $-\infty < \omega_t^{TVP} < \infty$. $\omega_t^{TVP} = 0$ indicates absence of Central Bank intervention. This shows a flexible exchange rate system. $\omega_t^{TVP} = 1$ indicates that the Central Bank relieved the entire pressure by purchasing and selling foreign exchange reserves. This is consistent with fixed exchange rate regime. $0 < \omega_t^{TVP} < 1$ shows that the Central Bank used both exchange rate and foreign exchange reserves for restoring foreign exchange market equilibrium. $\omega_t^{TVP} < 0$ shows that Central Bank purchasesd foreign exchange reserves when there was already a downward pressure on domestic currency. $\omega_t^{TVP} > 1$ suggests $\Delta f_t > EMP_t^{TVP}$. This is called the Central Bank's leaning against the wind-that the Central Bank's response was more than that warranted by the pressure. This caused the exchange rate to move in the direction opposite to that warranted by the pressure.

6.5 Methodology

In the last two chapters, we used a fixed parameter approach for estimating real money demand and price equation. This assumes parameter constancy over time and does not take into account the effects of structural changes on the parameter constancy over the given sample period. In this chapter we relax this assumption and allow the parameters to vary using Kalman filter time varying parameter approach. This will enable us to evaluate the effects of structural changes on parameter constancy.

Prior to discussing Kalman filter approach, we use a rolling regression method based on three-quarter window to justify the use of the time-varying parameter approach. Initially,

Figure 6.1: Rolling Regression Estimates



Note: Sample period used is from 1976Q1 to 2002Q3. Three-quarter window is used for rolling regression. These graphs represent the time -arying estimated coefficients for equation 6.1 on income (y_t) and interest rate (i_t) and equation 6.2 on foreign price (p_t^*) and exchange rate (s_t)

we use the first twelve observations for estimating coefficients using the OLS approach. Since serial correlation is a fundamental problem of time series data therefore, we adjust the standard errors of estimated coefficients using Newey-West test statistics. The first observation is then dropped and another one added (in this case the thirteenth observation) and re-estimated. We continue this process until the last observation is used in the analysis. Figure 6.5.1 shows rolling regression estimates of coefficients for both real money demand and price equation. It is evident from the figure that estimates of both real money demand and price equations are not constant but time-varying, thus justifying the use of the Kalman filter approach.

6.5.1 Kalman Filter Approach

In this section we outline Kalman Filter algorithm-based time-varying parameter approach. We have adopted this approach because it allows us to evaluate the effects of structural changes that have taken place in the economy over the given sample period on the parameter stability. The Kalman filter is based on the following:

$$y_t = x_t^{'}\beta_t + \varepsilon_t \qquad (6.9)$$

where y_t denotes dependent variables, x_t is a vector of explanatory variables, β_t is k x 1 vector of time–varying coefficients and ε_t is a disturbance term. The error term ε_t is assumed to be normally distributed with mean $E(\varepsilon_t) = 0$ and variance $[\text{var}(\varepsilon_t) = \sigma^2_{R,t}]$ Equation (6.9) is also called observation or measurement equation. Generally, the elements of β_t are not observable and are generated by the first order Markov process (Harvey, 1989):

$$\beta_t = \beta_{t-1} + u_t \qquad (6.10)$$

Equation (6.10) is called transition equation because it describes the transition of state equation from period *t* – 1 to period *t* (Lutkepohl, 2005). The matrix β_t is a coefficient matrix that depends on its past values and the error process u_t. It is assumed that the transition equation error term is normally distributed with mean $E(u_t) = 0$ and variance $[\text{var}(u_t) = \sigma^2_{Q,t}]$. Furthermore, it is assumed that ε_t and u_t are independently distributed: that is $E(\varepsilon_t u_t) = 0$ and ε_t, u_t and β_t are independent of each other. Equations 6.9 and 6.10 are called the state space system that can be estimated recursively using Kalman filter algorithm.

The basic objective of the Kalman filter is to update the knowledge of the system each time a new observation is brought in (Durbin and Koopman, 2001). If it is assumed that the errors ε_t and u_t have normal distribution and that the coefficient matrix β_t has a prior distribution with mean $\beta(0|0)$ and covariance matrix $p(0|0)$ then the conditional distribution $p(\beta_t | Y_t)$ and $p(\beta_{t+1} | Y_t)$ are also normal. If we denote the mean and the covariance of the state vector by $p(\beta_t | Y_t)$ by $\beta_{t/t}$ and $P_{t/t}$ respectively and those of $p(\beta_{t+1} | Y_t)$ by $\beta_{t+1/t}$ and $P_{t+1/t}$ then the Kalman filter recursion which is commonly referred to as Kalman filter are given by equations 6.11 to 6.14 (Abraham and Ledolter, 1983):

$$\beta_{t+1/t} = \beta_t \tag{6.11}$$

$$P_{t+1/t} = P_{t/t} + Q \tag{6.12}$$

$$\beta_{t+1/t+1} = \beta_{t+1/t} + k_{t+1}(y_t - x'_{t+1}\beta_{t+1/t}) \tag{6.13}$$

$$P_{t+1/t+1} = P_{t+1/t} - k_{t+1}x'_{t+1}P_{t+1/t} \tag{6.14}$$

where

$$k_{t+1} = P_{t+1/t}x'_{t+1}[x_{t+1}P_{t+1/t}x'_{t+1} + R]^{-1}$$

Equation (6.11) and (6.12) are one step ahead estimate of the state vector and its covariance matrix. Equation (6.13) and (6.14) are updated means and variances of state vectors once new observation y_{t+1} becomes available. The revised estimate is simply the sum of estimates of state vector up to period *t* and a linear combination of the one step ahead forecast error. The matrix k_{t+1} is the Kalman gain matrix and determines the weight assigned to the most recent forecast errors.

6.6 Data

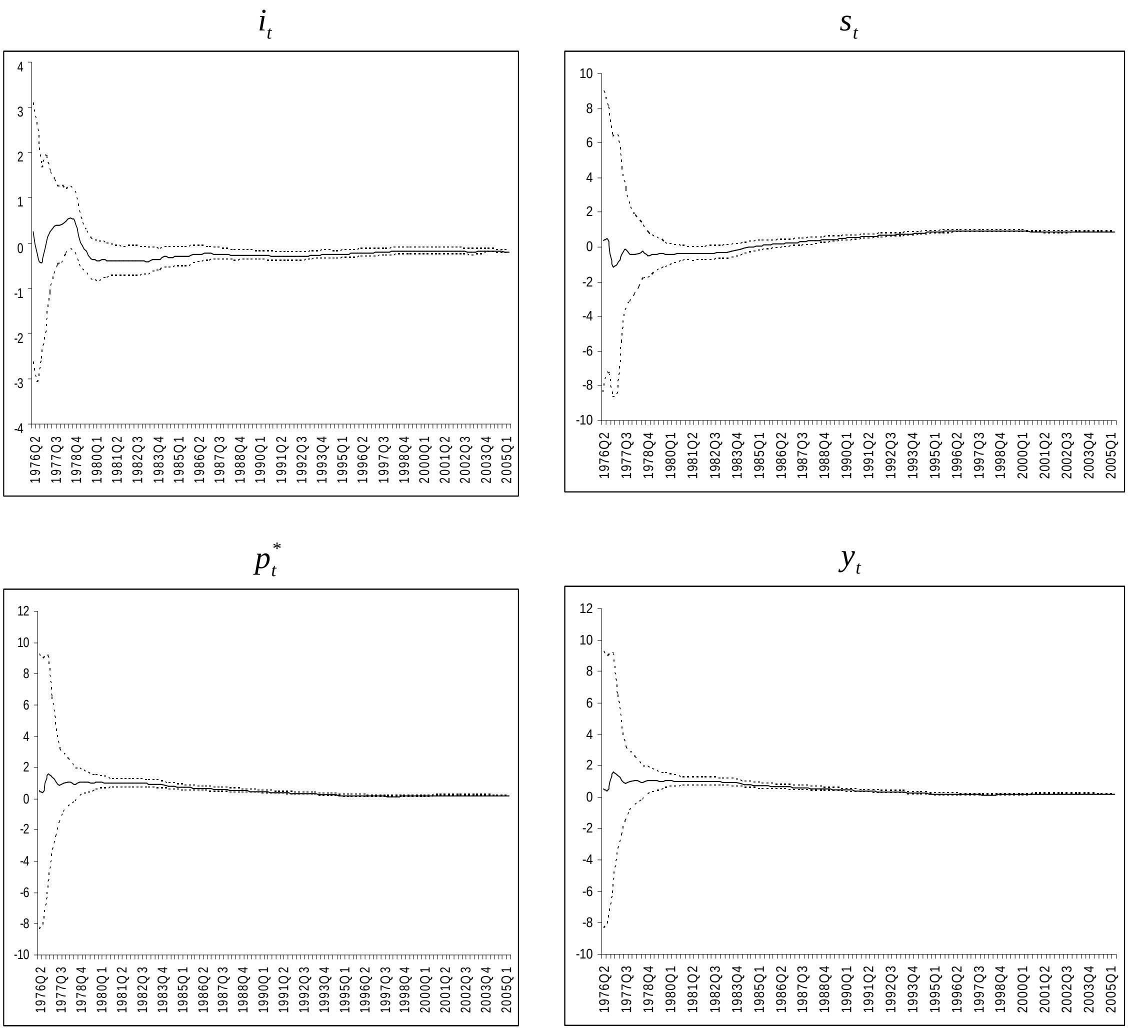
In this section, we discuss the data used in the estimation of real money demand and price equation. Quarterly data for the period 1976Q1 to 2005Q2 were obtained from International Monetary Fund *International Financial Statistic* for all variables except nominal Gross domestic Product (y_t) and monetary aggregate. We obtained quarterly nominal GDP data from the Statistical Department of State Bank of Pakistan. Nominal monetary aggregate (m_t) data is taken from Thomson datastream. Real GDP and real monetary aggregate data is obtained by adjusting their nominal counterparts using Pakistan CPI. Real GDP and money ($M1$) were seasonally adjusted using X–12 ARIMA seasonal adjustment program in Eviews. All variables are in logarithmic form.

6.7 Results

In the last two chapters, we have constructed exchange market pressure and intervention index using fixed parameter approaches. These approaches assume parameters constancy and do not incorporate the effects of structural changes on parameter constancy in the estimation process. In this section, we relax parameter constancy assumption and allow the parameters to vary using Kalman filter time varying parameter approach. This permits us to evaluate the effects of structural changes that have taken place over the given sample period on parameter constancy.

Figure 6.2 shows one-step ahead $\pm 2SE$ estimates of interest rate, foreign price, exchange rate and domestic real income. It is evident from the figure that at the very beginning, $\pm 2SE$ interval is quite large. However, once more information becomes available predicted values converge to their mean values at faster rate and hence $\pm 2SE$ interval becomes smaller and smaller. This suggests faster convergence of predicted values of the variables of interest to their mean values over a time.

Figure 6.2 One Step Ahead Time varying parameter estimates of real money demand and price equation



Note: dotted lines show β $\pm$ 2 standard errors.

Figure 6.2 further shows that initially the estimated parameters show some fluctuation with increased standard errors. This is due to a small number of observations that are used for estimating additional observation of parameter of interest. Once the information that is used for predicting *t*+1 observation increases, the estimated parameter stabilises and their corresponding errors are reduced. In addition, unfavourable developments in domestic economy may also explain initial fluctuations in the estimated parameters. These include government initiated nationalisation policy that peaked in year 1975 and subsequent floods that hit the country in 1976. In addition, elections were held in 1977. The ruling party won a majority of the seats. This invoked protests by the opposition parties which were followed by military coup and declaration of martial law in September, 1978. These factors may account for initial large standard errors. However, once more information becomes available; standard errors of the estimated parameters are substantially reduced.

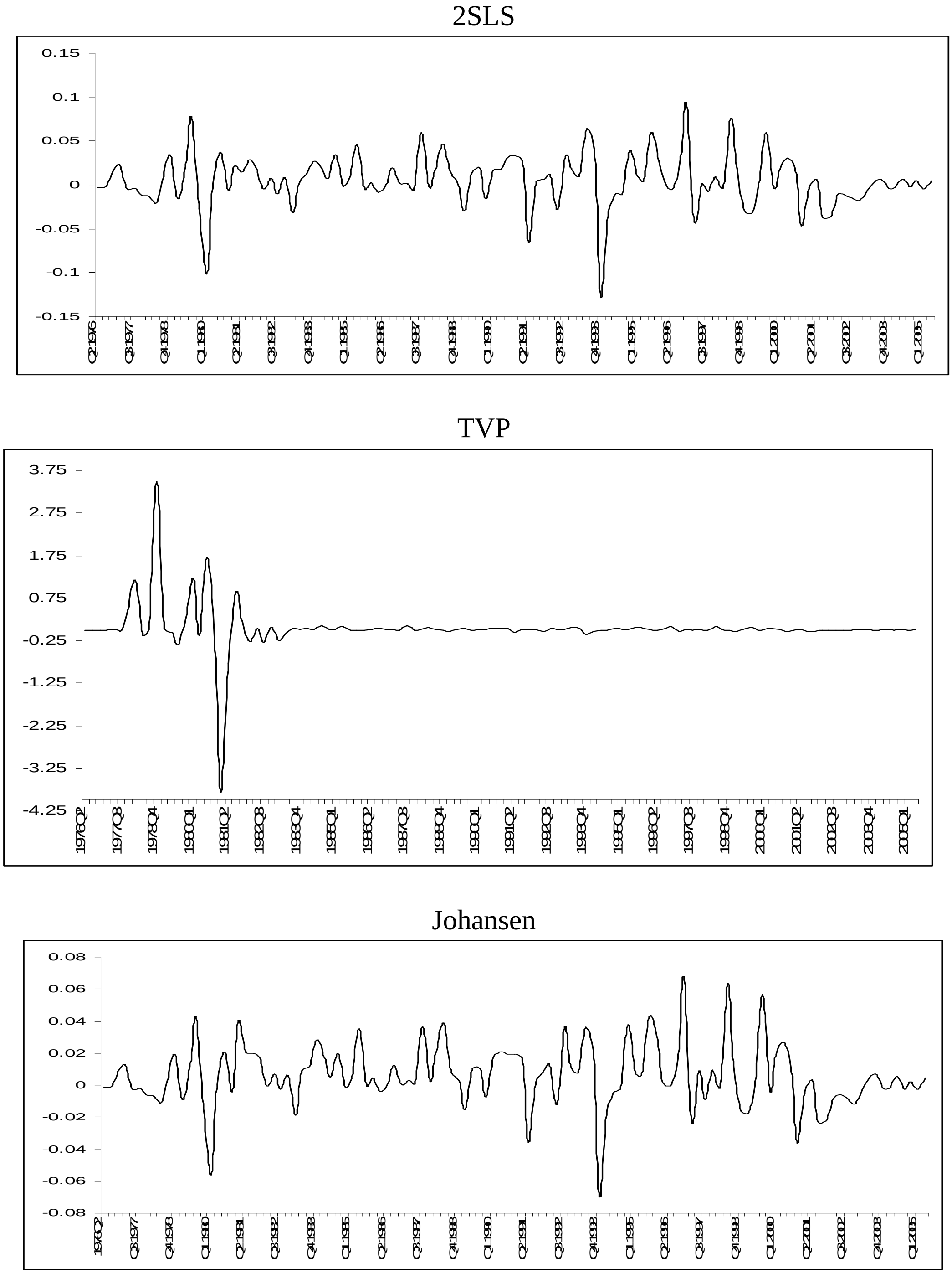
Figure 6.2 further shows that all variables stay within $\beta_t \pm$ two standard error band. The interest rate estimate first declines and even shows positive sign for short period. However, for the later period, it is although negative but is not significantly different from zero. The negative interest rate coefficient confirm the theory that argues that as the opportunity cost of holding money increases, people prefer to hold their nominal balances in terms of assets that earn interest rate then in cash. On the other hand, the estimated parameter of exchange rate shows negative sign for the initial period. However, for the later period, it is positive and significantly different from zero. The estimated coefficient of foreign price, on the other hand, is of positive sign for the entire sample period. Initially, it increases and then fluctuates around its unity value. The positive estimated parameters of both foreign price and exchange rate confirm theoretical predication that exchange rate and foreign price changes influence domestic prices positively. Furthermore, exchange rate changes dominate foreign price changes. This could be due to monetary authorities' management of exchange rate with corresponding implications for domestic price level (Liu and Burkett, 1995 and Mahdavi and Zhou, 1994). The estimated coefficient of domestic income shows pattern similar to foreign price. It first increases and then fluctuates around it unity value. Furthermore, the estimated domestic income parameter plot shows that it is significantly different from zero. Positive estimate of domestic income confirms the theory that suggest that as income increases people demand more money in order to finance their increased number of transactions. All the estimated parameters except interest rate fluctuate around unit value. On the other hand, interest rate fluctuates between zero and minus one. These findings confirm that the structural changes that have taken place over the given sample period have caused parameter instability.

6.7.1 Estimation of Exchange Market Pressure and Intervention Index

We need the estimates of η_t in equation (6.6) for constructing an exchange market pressure and intervention index for Pakistan. This in turn requires the estimate of interest rate b_{t2} and exchange rate a_{t2} which we obtain by estimating real money demand (6.1) and price equation (6.2) using Kalman filter approach. It gives separate estimates of interest rate b_{t2}, exchange rate a_{t2} and η_t for each quarter. Based on Weymark (1995) macroeconomic model, exchange market pressure index is given as: $EMP_t = \Delta s_t + \eta_t \Delta f_t$. The rise and fall of exchange market pressure is associated with depreciation and appreciation of Pakistan currency against US $ in the foreign exchange market.

Figure 6.3 shows quarterly estimates of exchange market pressure based on two stage least square, Johansen (1988) cointegration and Time Varying Parameter (TVP) approach. TVP estimates of Exchange Market Pressure indicate downward pressure on domestic currency over the entire sample period. This suggests that in the absence of Central Bank intervention, domestic currency would have lost its value against US dollar in the foreign exchange market. Exchange Market Pressure mean value of 0.032 further supports this interpretation. Furthermore, all three approaches yield identical results and show downward pressure on domestic currency over the entire sample period. The correlation coefficient of 0.97 suggests strong relationship between two stage least square and cointegration approach estimates of exchange market pressure. On the other hand, fixed and time varying parameter estimates of exchange market pressure yields weak correlationship that range between -0.08 to 0.13. Furthermore, the estimates of exchange market pressure obtained from time varying

Figure 6.3 Exchange Market Pressure



Note: The correlation coefficient between 2SLS and Johansen estimates of Exchange Market Pressure is 0.97. Similarly, the correlation coefficient between Time Varying Parameter and 2SLS and Johansen estimates of Exchaneg Market Pressure is of 0.92 and 0.96 respectively. The average values of Exchange Market Pressures values from 2SLS, Johansen and Kalman filter method are 0.005, 0.005 and 0.06 respectively. Similarly the variance of Exchaneg Market Pressure from three approaches is 0.00091, 0.000404 and 0.001104 respectively.

parameter approach are more volatile then those obtained using fixed parameter approaches. Standard error estimates of 0.548, 0.030 and 0.020 for time varying parameter, two stage least square and Johansen's cointegration approach estimates of exchange market pressure further support this interpretation. The difference in the results could be due to the estimate of η_t. Its time varying parameter value is three times its value obtained from fixed parameter approaches.[66] This result more volatile time varying parameter estimate of exchange market pressure estimate. Furthermore, the fixed parameter approaches assume parameter constancy and do not permit to evaluate the effects of structural changes on parameter constancy. On the other hand, time varying parameter approach allows the parameters to take account of the effects of new information on the estimation process. This may also explain why we have more volatile time varying parameter estimate of exchange market pressure then that obtained from fixed parameter approach. Furthermore, the use of different econometric techniques may explain weak correlation between time varying and fixed parameter estimates of exchange market pressure.

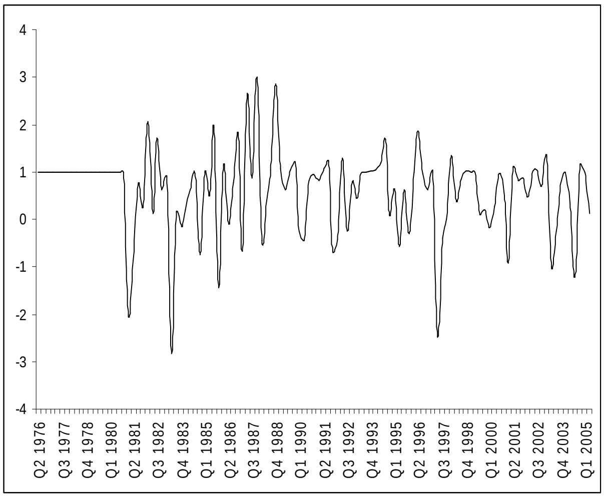
Figure 6.4 shows monetary authority's response to exchange rate fluctuations. It reflects the pressure that Central Bank relieves through the purchase and sale of foreign exchange reserves and is given as: $\omega_t = \dfrac{\Delta f_t}{\dfrac{1}{\eta_t}\Delta s_t + \Delta f_t}$.

It is evident from Figure 6.4 that Kalman filter estimates of intervention index suggest active central bank intervention in foreign exchange market. The intervention index mean value of 0.71 indicates that foreign exchange reserve and exchange rate changes absorbed seventy one and thirty nine percent of the pressure respectively.

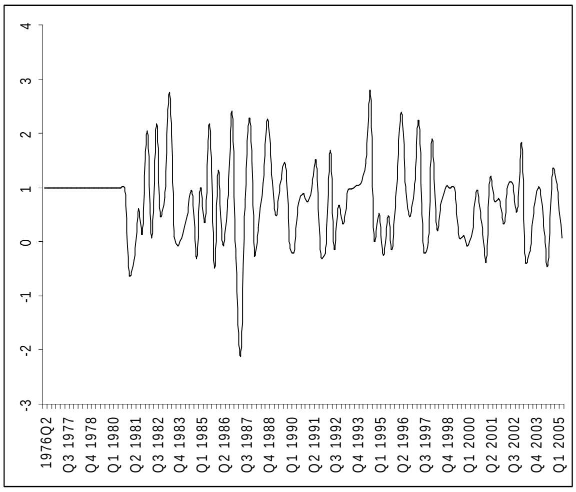
[66] Two stage least square, Johansen cointegration and time varying parameter estimates of η_t are -1.101, -0.068 and -2.964 respectively.

Figure 6.4 Intervention Index (ω_t)

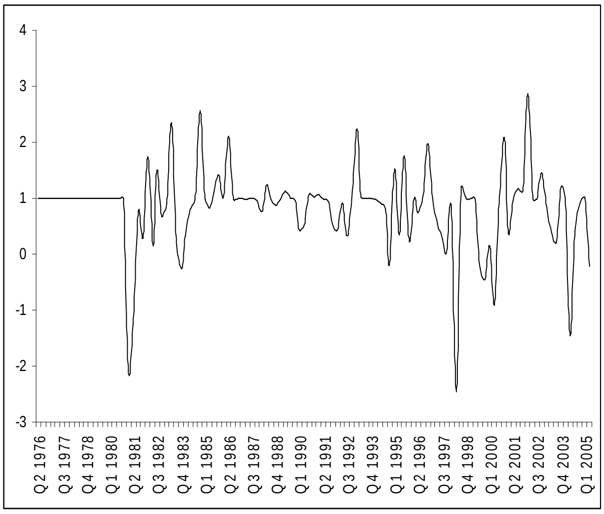
2SLS



Johansen

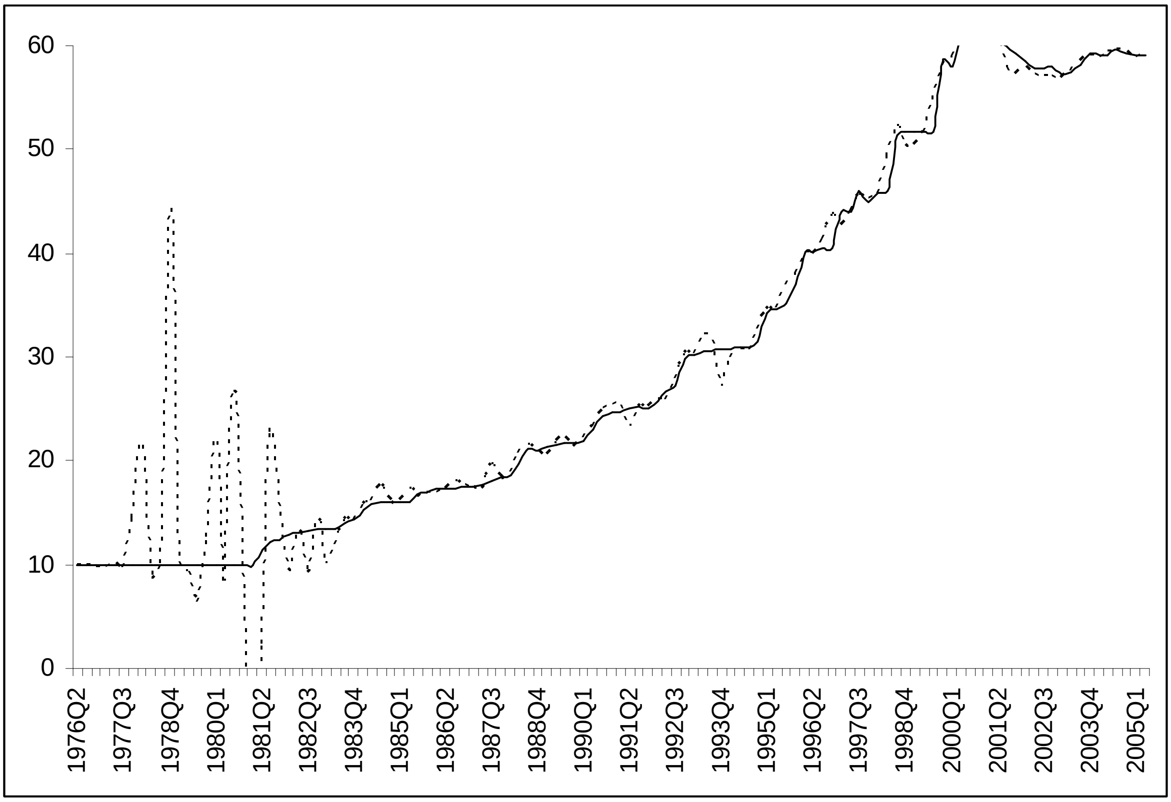


TVP



Note: The average values of intervention index from 2SLS, Johansen and TVP method are 0.608, 0.729 and 0.747 respectively. Similarly, the correlation coefficient between 2SLS and Johansen estimates f intervention index is 0.501. The correlation between 2SLS and TVP and between Johansen and TVP estimates of intervention index is 0.357 and 0.393 respectively. The standard deviation estimates of intervention index from three methods are 0.906, 0.778 and 1.318 respectively.

Figure 6.5 predicted and observed exchange rate



Note: dotted lines denote predicted exchange rate and is more volatile. Solid lines, on the other hand, denotes observed exchange rate. This is less volatile.

Exchange Market Pressure is measured as the extent of exchange rate change that would be required for restoring foreign exchange market equilibrium in the absence of Central Bank intervention. Given the Exchange Market Pressure values, we can calculate the exchange rate level that would prevail in the absence of Central Bank intervention by adding market pressure to one period lagged observed exchange rate:

$$S_t^{predicted} = (1 + EMP_t)S_{t-1}^{obs} \tag{6.15}$$

where $S_t^{predicted}$ refers to unlogged exchange rate that would prevail in the absence of Central Bank intervention. S_{t-1} denotes one period lagged unlogged exchange rate. Figure 6.5 indicates that observed exchange rate is less volatile than the predicted exchange rate. Predicted and observed exchange rate standard deviation of 18.866 and 18.380 further supports this interpretation. It shows that despite instable estimated parameters, Central Bank intervention policy is successful in reducing exchange rate which is unexpected. This finding is unexpected because the formulation of effective monetary policy requires stable parameters. In our case, Central Bank's intervention policy is successful in its objective of reducing exchange rate volatility even in the absence of stable estimated parameters.

6.7.2 Summary of the Results of Three Methods.

In this section, we present the summary of results from three approaches namely two stage least square, Johansen (1988) cointegration approach and time varying parameter approach.

It is apparent from Table 6.1 that all approaches yield almost identical results.[67] All three approaches give negative estimate of η suggesting that exchange rate and foreign exchange reserves move in the opposite direction. Whenever there is a pressure on domestic currency, Central Bank relieves it by purchasing and selling foreign exchange reserves. However, the time varying parameter estimate of η is three times larger than that obtained from fixed parameter approaches. This may account for more volatile time varying parameter estimate of exchange market pressure. All three approaches further reveal that it is depreciating pressure that has remained dominant over the entire sample period.

The intervention index shows that the Central Bank actively intervened in the foreign exchange market and allowed limited role to market forces in determining exchange rate level. The intervention index values range between 0.61 to 0.71. This indicates that foreign exchange reserve changes absorbed sixty one to seventy one percent of the pressure. Exchaneg rate changes relieved the remaining twenty nine to thirty nine percent of the pressure.

Table 6.1 further indicate $\omega_t < 0$ for nineteen to twenty four quarters. This shows that

[67] We take the average value of η_t^{TVP} to compare it with η_t^{2SLS} and $\eta_t^{Johansen}$.

Table 6.1 Summary of results from three approaches

	2SLS	Johansen	Kalman Filter
η	-1.101	-0.068	-2.964
EMP_t	0.005	0.005	0.032
$\overline{\omega}_t$	0.61	0.73	0.75
$\omega_t < 0$	24 Quarters	24 Quarters	19 Quarters
$\omega_t = 1$	24 Quarters	24 Quarters	24 Quarters
ω_t <1	41 Quarters	41 Quarters	41 Quarters
ω_t >1	28 Quarters	28 Quarters	33 Quarters
$EMP_t(-)$	-0.019	-0.010	-0.141
$\overline{\omega}_t$	1.031	1.035	1.098
$EMP_t(+)$	0.022	0.017	0.166
$\overline{\omega}_t$	0.303	0.523	0.414

Note: 2SLS refers to two stage least square method. Similarly, η denotes eta. Similarly *EMP* refers to exchange market pressure. $\overline{\omega}_t$ and ω_t intervention index mean value for the entire sample period, and intervention index different values. + and - indicates appreciating and depreciating pressure.

in these quarters, Central Bank leaned with the wind – that the Central Bank purchased foreign exchange reserves ($\Delta f_t > 0$) when domestic currency was already under pressure to depreciate ($\Delta s_t > 0$) and vice versa. $\omega_t = 1$ for twenty four quarters. This implies that in these quarters proportionate changes in foreign exchange reserves were equal to the pressure ($\Delta f_t = EMP_t$). This did not allow the exchange rate to change which is consistent with fixed exchange rate arrangement. For forty-one quarters, we have ω_t<1 implying that both foreign exchange reserves ($\Delta f_t > 0$) and exchange rate changes ($\Delta s_t > 0$) restored foreign exchange market equilibrium. Exchange rate also changed though less than that warranted by the pressure. This kind of monetary response to exchange market pressure is consistent with managed floating exchange rate system. Similarly, ω_t>1 for twenty-eight to thirty-three quarters. This can be interpreted as, in these quarters, proportionate changes in foreign exchange reserves ($\Delta f_t > EMP_t$) were more than that warranted by the pressure. This resulted the actual exchange rate different from that implied by the prevailing pressure.

Table 6.1 further reveals that the Central Bank's response varies with the prevailing pressure. Intervention index exceeds its unity (ω_t >1) value whenever there was a pressure on domestic currency to appreciate. On the other hand, intervention index does not exceed its unity value (ω_t <1) when domestic currency was under pressure to depreciate. This may reflect changes in the Central Bank's objectives. In case of appreciating pressure, Central Bank may be targeting to maintain domestic exporters competitive advantage in international market. On the other hand, Central Bank response to depreciating pressure may reflect its preference for minimizing the effect of exchange rate changes on domestic prices–that the Central Bank may by trying to maintain domestic price stability.

6.8 Conclusion

In this chapter, we estimated exchange market pressure and intervention index for Pakistan using Weymark (1995) time varying model. Rolling regression estimates of real money demand and price equation do not support parameter stability. This could be due to the structural changes that have taken place in the economy over the given sample period. In order to overcome this weakness of fixed parameter approach, we used a time varying parameter approach in particular a Kalman filter approach. It allows us to evaluate the effects of structural changes on parameter constancy.

Time varying parameter estimates of real money demand and price equation shows parameter instability. Although in the initial period, $\pm 2SE$ is quite high suggesting deviation of predicted values from their actual values. This is due to limited available information for predicting next period estimated parameters. However, once the information required for predicting one period ahead value increases, predicted values adjust to their actual values quite fast. Furthermore, the results indicate that estimated parameters are significantly different from zero.

Estimates of exchange market pressure and intervention index based on time varying parameter approach shows downward pressure on average over the entire sample period. Furthermore, the intervention index mean value suggest active Central Bank intervention. It shows that foreign exchange reserves and exchange rate changes absorbed seventy one and twenty nine percent of the pressure respectively. Intervention index values suggest that Central Bank response varies with the prevailing pressure. It shows that intervention index do not exceed its unity value when the domestic currency is under depreciating pressure. This may reflect Central Bank's intention to limit the effects of exchange rate changes on domestic prices. On the other hand, intervention index exceeds it unity value in the presence of appreciating pressure. It can be interpreted that in such a case, Central Bank may be trying to maintain competitive advantage of domestic exporters in international market. The estimates of exchange market and intervention index values are almost the same as obtained in previous chapters thus providing further evidence in their support.

In the last three chapters, we assumed direct Central Bank intervention that takes the form of purchase and sale of foreign exchange reserves. Interest rate is another channel that Central Bank may use for restoring foreign exchange market equilibrium. In such a case, the exchange market pressure indices that drop interest rate do not fully reflect the extent of foreign exchange market disequilibrium. Eichengreen et al. (1996) constructed such an index that is simple sum of percent changes in exchange rate, relative interest rate differential and relative percent changes in foreign exchange reserves. In the chapter that follows, we use Eichengreen et al. (1996) approach for constructing exchange market pressure for ten countries. Furthermore, we evaluate the determinants of exchange market pressure in a panel of ten countries.

Chapter Seven

Comparing the importance of Openness, macroeconomic indicators and policy variables as determinants of Exchange Market Pressure

Abstract

This chapter empirically examines the determinants of Exchange Market Pressure in a panel of ten countries. Using a statistical approach to constructing Exchange Market Pressure, we examine whether this is affected by a range of macroeconomic indicators, policy variables and measures of openness. Fixed effect parameter approach shows that exchange market pressure is negatively associated with trade openness and reserve import ratio and positively related to the real exchange rate. However, the approaches that addresses endogenity problem show that exchange market pressure is better explained by trade openness, capital openness and real domestic income. Hence weaker currencies are those less open to trade and capital, with lower domestic real income. Thus our finding supports the relevancy of some macroeconomic variables and measures of openness.

E.L. Classification: E31, E51, E52, E58

Keywords: Exchange Market Pressure, Openness Measures, Monetary Policy, Inflation Targeting, Monetization.

7.1 Introduction

Exchange Market Pressure reflects the extent of foreign exchange market disequilibrium that arises due to nonzero excess demand of domestic currency. It is fully reflected in exchange rate changes in the absence of Central Bank intervention. It is argued that exchange rate changes have implications for domestic macroeconomic variables. They influence domestic prices through Purchasing Power Parity, wage setting behaviour of the firms, interest rate changes through Uncovered Interest Rate parity, stability of domestic financial system, unemployment and production levels and thus have direct or indirect consequences for the welfare of virtually all economic participants (Isard, 1995).

Central Bank's frequently intervene in the foreign exchange market and stabilise external value of domestic currency with a view to avoid undesirable consequences of exchange rate changes. In case of direct intervention, Central Bank sales and purchase foreign exchange reserves to restore foreign exchange market equilibrium. There may be the case that Central Bank may intervene indirectly. In such a case, Central Bank uses both interest rate and foreign exchange reserves as instruments of monetary policy for relieving pressure on domestic currency.

Exchange rate regime also determines the nature of intervention. In case of a fixed exchange rate regime, Central Bank uses foreign exchange reserve changes for restoring foreign exchange market equilibrium. On the other hand, exchange rate changes relieve pressure under a free float. However, under a managed float or intermediate exchange rate regime, Central Banks can use exchange rate, interest rate and foreign exchange reserve changes as instruments of monetary policy for relieving market pressure. The basic objective of foreign exchange intervention is to avoid undesirable consequences of exchange rate changes.

Exchange Market Pressure is not directly observable. It is measured through the channels that the Central Bank uses for restoring foreign exchange market equilibrium. In the Girton and Roper (1977) and Weymark (1995) models, exchange rate and foreign exchange reserve changes measure the extent of foreign exchange market disequilibrium. However, these indices differ in assigning weights to the components of exchange market pressure index. Girton and Roper (1977) assign equal weight to both components. On the other hand, Weymark (1995) uses stochastic macroeconomic model for deriving the weight assigned to foreign exchange reserve changes. It converts foreign exchange reserve changes into equivalent exchange rate changes and thus ensures that exchange market pressure index is not dominated by more volatile component. In addition, both these studies assume indirect foreign exchange market intervention. There may be the case that Central Bank may use interest rate changes for relieving pressure. Therefore, the exchange market pressure indices that drop either exchange rate, foreign exchange reserves or interest rate do not fully reflect the extent of foreign exchange market disequilibrium. Eichengreen et al. (1996) constructed such an EMP index that is simple sum of weighted average of exchange rate, relative foreign exchange reserve and interest rate changes. The weights assigned to three components are based upon the inverse of their volatility. This assigns low weight to more volatile component and thus ensures equal importance of all components. Hence this approach has the advantage that it is not conditional upon macroeconomic assumptions used by Girton and Roper (1977) and Weymark (1995).

There are two approaches in the literature to foreign exchange market disequilibrium. One approach uses binary variable as a dependent variable that takes either zero or one value. It is constructed using extreme Exchange Market Pressure values. The second approach uses Exchange Market Pressure index that takes the form of continuous variable for measuring foreign exchange market disequilibrium. This chapter uses the second approach for evaluating the determinants of Exchange Market Pressure in a panel of ten countries. It has the advantage that it allows us to extract more information from the data (Mandilaras and Bird, 2008).

We set out a number of objectives. Firstly, we wish to construct an Exchange Market Pressure index for Australia, Canada, Germany, Italy, Japan, Korea, Malaysia, Pakistan, Singapore and the United Kingdom. In order to do so, we use the Eichengreen et al. (1996) statistical approach and use both interest rate and foreign exchange reserve defences of the exchange rate level as EMP components. It has the advantage that it is not conditional upon stochastic macroeconomic model for deriving Exchange Market Pressure components' weights. This may be very useful in a large panel study since we are not dependent upon the applicability of a particular macroeconomic model to each country.

Second, we evaluate the effects of inflation targeting monetary regime on Exchange Market Pressure. We check what happens to pressure on domestic currency when Central Bank shifts its focus from exchange rate stability to domestic objective of stabilizing inflation. It is argued that the shift in the objectives of monetary policy from exchange rate stability to inflation targeting might increase market pressure on domestic currency.

Third we test the relevance of exchange rate regime for Exchange Market Pressure using Reinhart and Rogoff (2004) exchange rate classification. Particularly, we test the bipolar view that compared to fixed and fully flexible exchange rate systems; intermediate exchange rate arrangements are more volatile. They are an attempt by a country open to capital inflows to have a fixed exchange rate and monetary independence. Sooner or later a conflict arises between domestic objective and stable exchange rate which results the collapse of fixed exchange rate regime. Another possible explanation of nonviability of pegged exchange rate regime is that it raises the belief that exchange rate regime will remain unaltered. This reduces the perception of risk borrowing in foreign exchange market and removes the need for hedging. Then when exchange rate crises struck, it is devastating in terms of its effects on overall economy (Fischer, 2001).

Fourth, we check how the integration of the countries with the rest of the world influences Exchange Market Pressure. We measure country's integration using trade openness and capital openness. The literature provides conflicting views about the impact of capital openness on Exchange Market Pressure. One strand of the literature argues that financial openness increases countries' exposure to foreign speculative attacks. On the other hand, there are some studies that support the evidence that countries' capital openness reduces pressure on its currency. Particularly, Dooley and Isard (1980) and Fischer (2001) argue that investors aware of being unable to withdraw their funds will not be willing to invest in the country. We therefore test, which of these effect is more dominant.

Similar to capital openness, the academic literature provides arguments for and against the effects of trade openness on the build up of foreign Exchange Market Pressure. A weakening of a country's export sector results stops in the inflow of foreign currency and thus makes its currency vulnerable to market pressure. Secondly, trade openness and financial openness go together. Increased trade is conditional upon multinational corporations that need to be able to move their capital across borders (Frankel and Cavallo, 2004). This reduces countries' ability to effectively implement capital controls. The optimistic view about the impact of trade openness on market pressure emphasizes that strong trade links reduce countries' default probabilities. International investors being aware of countries' reduced default probabilities would not withdraw their capital. This will reduce downward market pressure on the currencies of the countries having strong trade links with the rest of the world.

Other questions that we address are: how growth in domestic monetary aggregates, reserve imports ratio, real GDP and real exchange rate influence Exchange Market Pressure. It is argued that the increase in domestic monetary aggregates reduce domestic monetary authorities backing of foreign liabilities. This makes it difficult for the domestic monetary authorities to defend the currency when it is under downward pressure. This explains positive association between Exchange Market Pressure and domestic monetary aggregates. Contrary to this, the literature suggests negative relationship between reserve import ratio and Exchange Market Pressure. It states that increase in reserve import ratio convey the signal to the market participants about the potential of defending the value of domestic currency when it is under pressure. This stabilises the expectations of domestic economic agents and thus reduces downward pressure on domestic currency.

There is a negative association between output growth and Exchange Market Pressure, The second generation currency crisis models argue that an increase in domestic output inversely affect the devaluation expectation and hence reduce downward pressure on domestic in the foreign exchange market. Real exchange rate on the other hand is positively associated with market pressure. Overvalued exchange rate deteriorates the domestic exporters' competitiveness in the international market and thus puts pressure on domestic currency to depreciate. Our approach has the advantage that that it uses continuous instead of binary variable for measuring pressure in foreign exchange market. On the other hand, currency crises literature measures pressure in foreign exchange market in terms of dummy variable that takes either zero or one value.

The rest of the paper is as: In section 7.2, we discuss theoretical studies that argue about the possible determinants of Exchange Market Pressure. In section 7.3, we provide discussion on Eichengreen et al. (1996) exchange market pressure index. Section 7.4 and 7.5 contains data discussion and descriptive statistics. Section 7.6 discusses fixed effect panel estimate approach. In section 7.7, we discuss panel estimates of exchange market pressure regression equation and section 7.8 concludes.

7.2 Determinants of Exchange Market Pressure

The empirical exchange market pressure literature can be divided in two categories. There are some studies that have focused on the estimation of exchange market pressure and its determinants for different countries and regions. On the other hand, there are large numbers of studies that initially estimate exchange market pressure and subsequently construct currency crises index using extreme exchange market pressure values. Contrary to exchange market pressure index, a currency crises index is a binary variable that takes the value of zero or one otherwise when there is a crisis. Since currency crises denotes extreme exchange market pressure values therefore, the determinants of both exchange market pressure and currency crises are almost the same which we review in this section.

First generation currency crisis models emphasize the importance of macroeconomic variables as the determinants of speculative attacks. Krugman (1979) argues that inconsistency between domestic macroeconomic policies and fixed exchange rate regime results in the collapse of fixed exchange rate regime. Krugman (1979) further asserts that increased monetizing of budget deficits leads to the collapse of fixed exchange rate system. Several authors have further extended Krugman’s (1979) model. Connolly (1986) extended it to a crawling peg exchange rate and argued that a rise in domestic credit more than that warranted by the rate of crawl leads exchange rate regime to collapse. He argues that a real exchange rate appreciation deteriorates a current account deficit and puts pressure on the domestic currency to depreciate. Flood and Garber (1984) derived a speculative attack timing using simplified linear model. They argued that fixed exchange rate regime collapses either due to weak fundamentals or arbitrary speculative behaviour and show that a speculative attack occurs when shadow exchange rate equals fixed exchange rate. Speculative attack occurs because it offers an opportunity to speculators to profit at official expense (Obstfeld, 1986). These studies emphasize the importance of fiscal policy in the genesis of currency crises. Calvo

(1987) on the other hand, evaluated the relationship between real exchange rate, current account and speculative attack in cash in advance model. He argued that domestic stabilization policies increase domestic absorption. An increase in current account deficit thus puts pressure on domestic currency to depreciate. The preceding studies assume unsterilised foreign exchange market intervention which reduces domestic monetary base by the scale of sale of foreign exchange reserve and vice versa. Flood et al. (1996) addresses this issue and shows that domestic monetary authorities offset the effect of foreign exchange intervention on domestic monetary base by purchasing and selling domestic government securities.[68] It changes the relative supply of domestic and foreign currency bonds in the hands of private sector with no effect on domestic monetary base.

Krugman (1979) model and its extensions argue that speculative attacks occur due to inconsistency between domestic macroeconomic policies and fixed exchange rate arrangements. Particularly, they argue that increased monetization of government budget deficit results real exchange rate appreciation. This deteriorates current account deficit and results exchange rate depreciation. They further argue that economies with weak fundamentals are prone to speculative attacks. Krugman (1979) model and its extensions are called first generation currency crises models.

A number of alternative explanations are also provided in the literature on pressure on domestic currency in foreign exchange market. They argue the possibility of speculative attacks on domestic currency in the absence of inconsistency between macroeconomic policies and exchange rate parity. The models that explain market pressure on these lines are called second generation currency crises models. They show that the trade off that government faces between domestic macroeconomic objectives and the maintenance of fixed exchange rate arrangements results in multiple equilibria and leads to self fulfilling speculative attacks.

[68] The author shows that Mexican authorities sterilised foreign exchange intervention during December 1994 Mexican currency crises.

Kydland and Prescott (1977) provide the basis for second generation currency crises models. They favour rules over discretion because discretion implies the selection of best policies given the current circumstances. It is argued that the decisions of rational economic agents depend not only on the current policy decisions but also upon their expectation of future policy actions. In such circumstances, the discretionary policies based upon the current and the past economic conditions would not yield optimal outcomes. Contrary to Kydland and Prescott (1977), Flood and Isard (1989) developed escape clause models. They argue that a rule base monetary policy is impractical in a world that (a) lacks knowledge about the macroeconomic structure of the economy and the disturbance, (b) assimilation of information from those events that contains new information is costly and time taking and (c) delaying policy reactions until new information is gathered can be costly to society. Owing to these factors, they emphasized the importance of mixed strategy that contains the elements of both rules and discretion over ruled based monetary policy. Mixed strategy requires monetary authorities to follow clearly defined rules in normal times but to override them in exceptional circumstances.[69] Obstfeld (1986) discusses the possibility of speculative attack in the absence of inconsistency between domestic macroeconomic policies and fixed exchange rate provided that in the post attack period, loose monetary policy is followed. Jeane (1997) distinguishes between fundamentals and self-fulfilling motivated speculative attacks and argue that both complement each other in the build up of speculative attack. When the economic fundamentals are neither good nor bad, it generates self-fulfilling expectations which make it costly for monetary authorities to maintain fixed exchange rate parity and thus collapse occurs. Instead of focusing on post attack policy shift, Flood and Marion (2000) argue that currency crises may result from shifts in speculative opinion about exchange rate risk. They incorporate risk premium into asset market returns. This introduces nonlinearity and provides a mechanism

[69] A policy rule is a mapping from the policy maker's information set to the set of possible actions (Persson and Tabellini, 1990).

through which multiple equilibria can occur even when the policy is invariant to attack. Multiple equilibria are the result of private speculative behaviour instead of post-attack government policy switch.[70]

The third version of currency crises models was developed after East Asian currency crises.[71] It focuses on the role of contagion in the generation of currency crisis. Contagion is defined as devaluation in one country that causes financial troubles in other countries (Choueiri, 1999). Initially researchers focused on asset price co-movement and capital flows across countries and named its significant presence as evidence of contagion. The ERM crises 1992, Mexican financial crises in 1994 that affected the entire region and East Asian currency crises 1997 further increased the importance of contagion in the context of currency crises literature.

The theoretical literature argues that contagion works through two channels: (a) trade contagion or (b) liquidity contagion (Choueiri, 1999). Currency depreciation in one country increases trade deficit of the second country and thus exerts pressure on its currency to depreciate. Secondly, a fall in import prices decreases consumer price index in the second country which in turn reduces demand for domestic money balances. Given that money supply is fixed, the residents of the second country swap their excess domestic money balances for foreign currency. This makes the second country vulnerable to speculative attacks (Eichengreen et al. 1996). On the other hand, liquidity contagion arises when crises in one country drives investors to sell off their assets in another country to raise funds (Valdes, 1996).

[70] Flood and Marion (2000) departs from first generation currency models in four ways. First it introduces stochastic time varying risk premia in the interest parity condition. Second, it models the constraints that prevent monetary authority from undertaking strong defense of the currency by assuming that monetary authority continuously sterilizes the effects of foreign exchange intervention on monetary base. Third, fiscal policy is bond financed rather than being monetized. Fourth, they relax the assumption of purchasing power parity and argue that goods prices are set a period in advance at a level that is expected to clear the market. This assumption enables portfolio holders to ignore goods price variance and concentrate on exchange rate variance.
[71] Gerlach and Smets (1994) evaluated the effects of the Finnish marka depreciation in 1992 on subsequent speculative attacks on Swedish krona.

The studies discussed above define currency crises literature in terms of three generation models. First generation models attribute currency crises in terms of inconsistency between domestic macroeconomic policies and fixed exchange rate regime. They argue that increased monetization of government budget deficit results the collapse of fixed exchange rate regime. Contrary to first generation models, second generation currency crises models emphasize the possibility of currency crises in the absence of inconsistency between domestic macroeconomic policies and fixed exchange rate. They argue that the trade-off that government faces between domestic macroeconomic objectives and stable exchange rate results multiple equilibria and hence the collapses of fixed exchange rate arrangements. The third generation currency crises models focus on the role of contagion in terms of exchange rate regime collapse. They show that contagion works through two channels (a) trade contagion or (b) liquidity contagion. Trade contagion works when currency depreciation in one country causes pressure on second country currency to depreciate. On the other hand, the liquidity channel works when investors withdraw their funds from non-crises countries in order to compensate for liquidity losses from the countries under speculative attack. This kind of contagion is called liquidity contagion.

The studies discussed above mainly focus on currency crises but they can be useful for Exchange Market Pressure, since they highlight important potential determinants. Girton and Roper (1977) first derived the Exchange Market Pressure index and estimated EMP equation for Canada. It includes domestic and foreign monetary aggregates, domestic and foreign income as its determinants. Burdekin and Burkett (1990) applied Girton and Roper (1977) to Canada in dynamic form. They include US and Canadian GNP deflator along with Canadian and US three month Treasury Bill rate as an additional determinants. Connolly and da Silveira (1979) applied Girton and Roper (1977) monetary model of Exchange Market Pressure to Postwar Brazilian experience. Small country assumption enabled them to derive a simple one-country equation of managed float that depend upon four essential ingredients: (a) money demand, (b) money supply, (c) purchasing power parity, and (d) monetary equilibrium. The single equation Exchange Market Pressure model includes domestic credit, foreign price and domestic income as its determinants. Kim (1985), Thornton (1995) and Bahmani-Oskooee and Bernstein (1999) slightly extended Connolly and da Silveira (1979) version of Girton and Roper (1977) and included money multiplier as an additional Exchange Market Pressure determinant.

Wohar and Lee (1992) too extended the Girton and Roper (1977) model and allowed domestic prices to deviate from purchasing power parity. They included foreign real income, foreign money supply and foreign interest rate as additional regressors in Girton and Roper's (1977) Exchange Market Pressure equation for Japan. Pollard (1999) applied Wohar and Lee (1992) specification of Girton and Roper (1977) model to Barbados, Guyana, Jamaica, and Trinidad & Tobago. The estimated regression equation include net central bank credit as a percentage of high-powered money, money multiplier, foreign money supply, deviation from purchasing power parity, domestic and foreign real income, interest rate differential, foreign price and foreign interest rate as EMP determinants. Kamaly and Erbil (2000), on the other hand, adopted a vector auto regression approach and estimated Exchange Market Pressure equation for MENA Region. The estimated regression equation included domestic credit, foreign price, deviations from purchasing power parity, domestic real income and interest rate as EMP determinants.

Girton and Roper (1977), Connolly and da Silveira (1979), Inchul (1985), Thornton (1995), Bahmani-Oskooee and Bernstein (1999), Wohar and Lee (1992), Pollard (1999) and Kamaly and Erbil (2000) used nominal exchange rate and foreign exchange reserve changes as components of Exchange Market Pressure. Karfakis and Moschos (1999) on the other hand, followed the Sachs et al. (1999) approach and defined Exchange Market Pressure as the sum of percentage changes in nominal effective exchange rate and foreign exchange reserve changes. They used an inverse of variance approach for assigning weights to the components of Exchange Market Pressure. The estimated EMP regression equation for Greece used Greek and OECD consumer price indices, the broad definition of money supply, banking claims on the private sector, the current account balance and net capital movement as its determinants.

Contrary to Girton and Roper's (1977) model, Pentecost et al. (2001) derived an Exchange Market Pressure measure from a short-term wealth-augmented monetary model of foreign exchange market. The resulting EMP index includes the change in interest rate differential, in addition to reserve and nominal exchange rate changes. They use a principal component technique for deriving the weights and signs of the components of EMP. The estimated EMP equation for several European countries shows that EMP can be explained by differential money growth, real exchange rate, changes in long-term interest rate differentials and wealth accumulation.[72]

The preceding studies focus on domestic and foreign country macroeconomic variables as Exchange Market Pressure determinants. Hallwood and Marsh (2003) on the other hand, include changes in central parity and deviations from central parity along with macroeconomic variables as the determinants of Exchange Market Pressure. Modeste (2005) evaluated the impact of foreign debt burden on Guyana. Other variables that he used for explaining Guyana Exchange Market Pressure include domestic credit, growth in the relative price of crude oil, macroeconomic uncertainty, growth in real exports and foreign price.

To summarise, the empirical Exchange Market Pressure literature includes domestic credit, foreign money supply, domestic and foreign output, domestic and foreign GNP deflator, domestic and foreign interest rate, foreign price, money multiplier, deviations from purchasing power parity, net Central Bank credit as percentage of high powered money,

[72] The sample countries include Belgium, France, Netherlands, UK, Austria, Italy, Norway, Sweden, Finland, Spain, Denmark, Ireland, and Portugal.

current account balance, net capital movement, accumulation of wealth, change in the central parity, deviation from central parity, foreign debt burden, growth in the relative price of crude oil, macroeconomic uncertainty and growth in real exports as its determinants.

7.3. An Exchange Market Pressure Index

Eichengreen et al. (1996) derived an Exchange Market Pressure (EMP) index using a statistical approach. They argued that the components of exchange market pressure index that restore foreign exchange market equilibrium depend on the structure of the economy and therefore, must be drawn from exchange rate models. However, it is argued that the exchange rate models that link exchange rate with macroeconomic variables have little power to predict exchange rate changes in short and intermediate horizons. Due to these weaknesses of exchange rate models, Eichengreen et al. (1996) used a statistical approach to derive an index of Exchange Market Pressure given as:

$$EMP_{it} \equiv [(\alpha\%\Delta s_{it}) + (\beta\Delta(i_{it} - i_{it}^{*})) - (\gamma(\%\Delta f_{it} - \%\Delta f_{,t}^{*}))] \qquad (7.1)$$

The exchange market pressure index is a weighted sum of exchange rate changes (Δs_{it}), relative interest rate change $\Delta(i_{it} - i_{it}^{*})$ and foreign exchange reserve changes (Δf_{it}). s_{it} denotes exchange rate or the price of US $ in domestic currency, hence a rise in s_{it} is associated with the domestic currency depreciation. The asterisks denote the foreign counterpart of domestic variables. Measuring Exchange Market Pressure using only exchange rate changes will not be appropriate as the monetary authorities may alleviate, for example, upward pressure by raising interest rate and spending foreign exchange reserves. Therefore, interest rate and foreign exchange reserve are the channels that Central Bank may use for alleviating pressure. An increase in exchange rate, a rise in interest rate and a loss of foreign exchange reserves imply an increase in exchange market pressure. The parameters α, β and γ are the weights assigned to components of exchange market pressure index. They are determined by taking the inverse of standard deviation of each component of index. This weighting scheme is adopted to assign low weight to more volatile components and therefore, avoid them dominating the index.

7.4 Data

The data for all variables except monetary aggregates, and financial openness index are taken from the International Monetary Fund's *International Financial Statistic* dataset. Logged annualised data from 1976 to 2005 are used. Foreign exchange reserves refer to total reserves minus gold in US dollars. Similarly, the bilateral nominal exchange rate for Australia, Canada, Germany, Italy, Japan, Korea, Malaysia, Pakistan, Singapore and United Kingdom refers to domestic currency per unit of US dollar. Hence a rise in the exchange rate is associated with deprecation of domestic currency against the US dollar. We use inter-bank money market rates to denote short-term interest rate. We obtained $M2$ data from IMF *IFS* data set for Australia, Korea and United Kingdom. It refers to money plus quasi-money. For the rest of the countries, we obtain $M2$ data from Thomson Data-stream. Thomson Data-stream contained $M2$ data up to 1999 for Italy and Germany. For the remaining years, we obtained $M2$ data for these countries from Bundesbank and Italian Central Bank Monthly and Annual Reports. Bundesbank Annual Reports contained annualized $M2$ data up to 2002. For the remaining three years, we converted German monthly $M2$ data to Annualized data using Eviews 6.0 student version default frequency conversion setting. We have used $M1$ due to absence of $M2$ data for Pakistan. Trade openness refers to current account to GDP ratio. We have used Chin and Ito's (2008) index to measure financial openness. We adjusted nominal money balances and nominal GDP with GDP deflator to get their real values. Reserve import ratio refers to division of reserves by imports. Remittance data for all countries except the UK

Table 7.1 Descriptive Statistics of Panel Data

	EMP_{it}	m_{it}	OP_{it}	OPK_{it}	rem_{it}	$resm_{it}$	q_{it}	y_{it}
Mean	0.04	3.971	0.001	1.359	8.584	-0.649	1.068	2.849
Median	0.119	3.884	-0.009	2.500	8.901	-0.642	0.297	4.143
Maximum	5.845	6.759	0.315	2.500	10.097	0.264	3.382	6.937
Minimum	-6.398	2.278	-0.275	-1.831	5.608	-1.508	-0.294	-14.206
Std. Dev.	1.906	0.894	0.076	1.456	1.182	0.333	1.239	5.784
Corr: Coeff		-0.024	-0.277	-0.076	-0.112	-0.247	-0.064	-0.029

Note: In this table, we have descriptive statistics for Exchange Market Pressure (EMP_t), monetary aggregate (m_t), trade openness (OP_t), capital openness (OPK_t), real exchange rate (q_t), remittances (rem_t), reserve import ratio ($resm_t$) and real Gross Domestic Output (y_t). Std. Dev. denotes standard deviation of the variables included in the analysis. Corr: Coeff denotes correlation coefficient between exchange market pressure and other variables included in the analysis.

(after 1987), Canada and Singapore are taken from the World Bank's *World Development Indicators* data set and refers to Workers' Remittances and Compensation of Employees Paid. Real exchange rate refers to nominal exchange rate times price ratio.

Table 7.1 describes the basic statistic of data used in the study. Positive mean value of Exchange Market Pressure is associated with depreciating pressure over the entire sample period. This can be interpreted that if the Central Bank had abstained from intervening in the foreign exchange market, the currencies of these countries would have depreciated by four percent. However, positive Exchange Market Pressure mean value does not imply that all countries faced downward pressure. Individual country estimates of EMP for Japan, Malaysia and Singapore are of negative sign implying upward pressure on their currencies.[73] Median value of 0.119 separates higher half of sample from lower one. EMP values range from minimum of -6.398 to maximum of 5.845. Standard deviation measures the dispersion of EMP from its mean value and its value is 1.906. Trade openness (OP_t) and capital openness (OPK_t) also show similar descriptive statistics. Trade openness and capital openness show positive mean values. Positive trade openness mean value imply current account surplus as percentage of Gross Domestic Product (*GDP*). The remaining variables except reserve import

[73] Individual country descriptive statistics are given in Appendix A3.

Table 7.2: De Facto Classification of Exchange rate Regime

No Separate Legal Tender	1
Preannounced peg or currency board arrangement	1
Preannounced horizontal band that is narrower than or equal to $\pm$ 2%	1
De facto peg	1
Preannounced crawling peg	2
Pre announced crawling band that is narrower than or equal to $\pm$ 2%	2
De facto crawling peg	2
De facto crawling band that is narrower than or equal to $\pm$ 2%	2
Preannounced crawling band that is wider than $\pm$ 2%	2
De facto crawling band that is narrower than or equal to $\pm$ 5%	3
Noncrawling band that is narrower than or equal to $\pm$ 2%	3
Managed floating	3
Freely floating	4
Freely falling (includes hyperfloat)	5

Notes: Reinhart and Rogoff (2004)

ratio ($resm_{it}$) show positive sign for both mean and median. Similarly, maximum and minimum values for almost all variables show positive and negative signs. Standard deviation which shows dispersion from mean shows positive sign for all variables and its value range between 0.076 for trade openness (OP_{it}) to 5.784 for real Gross Domestic Product (y_{it}). The correlation coefficient between Exchange Market Pressure and the remaining variables is of negative sign. This suggests that an increase in these values is associated with decrease in Exchange Market Pressure (EMP_{it}). However, estimated correlation coefficient value is quite low suggesting a weak relationship between Exchange Market Pressure and independent variables.

Table 7.2 shows exchange rate classification based on de facto exchange rate policy. It is based on dual or multiple markets and multiple exchange rate practices in the post World War II period. It is evident from Table 7.2 that least flexible exchange rate regimes are assigned low value. A new exchange rate category, named freely falling, is introduced. It denotes the countries whose twelve month inflation rate exceeds forty percent. No separate legal tender refers to an exchange rate regime under which a country adopts another country's currency as legal tender or the country becomes part of wider union that adopts the same currency as legal tender. In a pegged exchange rate or currency board arrangement, a country's domestic monetary base is determined by foreign exchange reserves particularly anchor country currency at a fixed rate. Under a preannounced horizontal band exchange rate arrangement, currency is allowed to fluctuate in a fixed band around central parity. Crawling peg exchange rate refers to exchange rate system in which currency is adjusted periodically in response to changes in macroeconomic indicators. A managed float system can be defined as a monetary arrangement in which the Central Bank frequently intervenes in the foreign exchange market to avoid undesirable exchange rate changes. However, intervention is not aimed at maintaining any particular exchange rate level. Free float is the opposite of a fixed exchange rate system. Under this system, market forces determine the value of foreign currency in terms of domestic currency units.

Table 7.3 shows the evolution of exchange rate regime for each country. It indicates that from October 1972, Australia adopted a de facto moving band around the US dollar. However, Australian dollar was allowed to fluctuate by +/- 2% around the band. From November 1982 to December 12, 1983, Australia followed managed float exchange rat regime. This suggests that in this period, the Australian Central Bank frequently intervened in the foreign exchange market to smooth undesirable exchange rate changes. However, the Australian Central Bank did not aim at maintaining any particular exchange rate level. From December 12, 1983 to December, 2007 Australia followed freely float. This implies that in this period, Australian Central Bank let the market forces to determine its currency value.

Table 7.3 Country specific de facto Exchange Rate Regime classification

Country	Date	Classification	Comments
Australia	October 1974 to November 1982	De facto band around US $	Horizontal +/-2% band. Officially pegged to a basket of currencies.
	November, 1982 to December 12, 1983	Managed float	
	December 12, 1983 to December, 2007	Freely floating	
Canada	May 31st, 1970 to May 2002	De facto moving band around US $	+/-2% Band
	June 2002 to December 2007	Managed floating	+/-5% Band
Germany	January 1973 to January 1st, 1999	Peg to US $	
	January 1st, 1999 to December, 2007	Currency union	Euro
Italy	October 1975 to December 1982	Managed float	There were dual rates. Different exchange rate arises for outward transfer of resident owned capital.
	January 1983 to September13th, 1992	De facto crawling band around DM	+/-2% Band
	September 13th, 1992 to March 1993	Freely floating	
	April 1993 to July 1995	De facto crawling band around DM	+/-2%
	August 1995 to November 1996	De facto crawling peg to DM	
	December 1996 to January 1st, 1999	De facto peg DM	
	January 1st, 1999 to December, 2007	Currency Union	Euro
Japan	February 12th, 1973 to November 1977	De facto moving band around US $	+/-2%
	December 1977 to December 2007	Freely floating	
Korea	May 1974 to February 27, 1980	Peg to US $	Parallel premia rose to 28% in February 1980
	February 27th, 1980 to July 1980	De facto crawling peg to US $	Officially pegged to a basket of currencies and the SDR
	March 2nd, 1990 to September 2nd, 1991	Pre announced crawling band around US $	+/-0.4% Band. This fits into crawling peg definition.
	September 2nd, 1991 to July 1st, 1992	Pre announced crawling band around US $	+/-0.6% band. This fits into crawling peg definition
	July 1st, 1992 to October 1st, 1993	Pre announced crawling band around US $	+/-0.8% band. This fits into crawling peg definition
	October 1st, 1993 to November 1st, 1994	Pre announced crawling band around US $	+/-0.1% band. Pre announced crawling band around US $
	November 1st, 1994 to December 1st, 1995	De facto crawling peg to US $	Pre announced band is +/-1.5%
	December 1st, 1995 November 1997	De facto crawling peg to US $	Officially the preannounced band is +/-2.25%
	December 17, 1997 to June 1998	Freely falling	The won was allowed to freely float
	July 1998 to November 2004	Managed floating	
	December 2004 to December 2007	De facto crawling band around US $	+/-5%

Notes: Reinhart and Rogoff (2004)

Table 7.3 Country specific de facto Exchange Rate regime classification (Continued)

Country	Date	Classification	Comments
Malaysia	September 5th, 1975 to July 1997	De facto moving band around US $	Band is +/-2%. Officially Ringgit is pegged to a basket of currencies
	August 1997 to September 30, 1998	Freely floating	
	September 30th, 1998 to June 2005	Peg to US $	
	July 2005 to December 2007	De facto band around US $	+/-2% band. Officially it is a managed float against an undisclosed basket of currencies
Pakistan	September 17, 1971 to January 8th, 1982	Peg to US $/parallel Market	In December 1971 the parallel market premium peaks at 212%
	January 8th, 1982 to January 1984	De facto crawling peg to the US $/Parallel Market	
	February 1984 to August 1989	De facto crawling peg to the US $/Parallel Market	Band width is +/-2%. If the parallel rate is used the band width is +/-5%.
	September 1989 to April 1991	De facto crawling peg/Parallel Market	
	May 1991 to April 1994	De facto crawling band around the US $/ Parallel Market	Band width is +/-2%. If the parallel rate is used the band width is +/-5%. From August 1993 through May 1998 the parallel market premium is in single digit.
	May 1994 to July 22nd, 1998	De facto crawling peg/Parallel Market	A more precise description of the post-November 1996 period is mini pegs lasting a few months interspersed with a regular devaluation.
	July 22, 1998 to May 19, 1999	De facto crawling band/Dual Market/Multiple Exchange Rates	Band width is +/-2% (on the basis of the parallel market rate)
	May 19th, 1999 to December 2007	De facto crawling peg to US $/Parallel Market	
Singapore	June 21st, 1973 to December 2007	De facto moving band around the US $	+/-2% band. Officially adjusted on the basis of a basket of currencies.
UK	June 23rd, 1972 to October 8th, 1990	Managed Floating	Until the dissolution of the sterling Area on October 24, 1979 and the dismantling of capital controls, the UK had a dual rate system
	October 8th, 1990 to December 12, 1992	Pre announced band around ECU/DM	+/-6% band
	September 12th, 1992 to December 2001	Managed floating	
	January 2001 to December 2007	De facto moving band around Euro	+/-2% band

Notes: Reinhart and Rogoff (2004)

Table 7.3 further shows two exchange rate regimes for Canada over the entire sample period. These include de facto moving with a +/- 2% moving band around the US dollar from May 31st, 1970 to May, 2002. For the latter period, Canada maintained managed float. Similarly, Germany followed peg to the US dollar from January 1973 to January 1st, 1999. Since January 1st, 1999, Germany has been following currency union with the Euro as legal tender. Italy, on the other hand, adopted a managed float at the very beginning of sample period. From January 1983 to September 13, 1992 Italy followed de facto crawling with a +/- 2% band around the Deutschemark. From September 13, 1992 to March 1993, the Italian twelve-month inflation rate was greater than forty percent. Therefore, for this period the Italian exchange rate is classified as freely falling. This was followed by a de facto crawling band with a +/- 2% moving band, de facto crawling peg and de facto peg to the Deutschemark from April, 1993 to January 1st, 1999. On January 1st, 1999 Italy entered into the European Monetary System and adopted the Euro as official legal tender. Therefore, for the post-1999 period, the Italian exchange rate regime is characterised as currency union, with the Euro as its legal tender. Japan, on the other hand, followed a de facto band with +/- 2% moving band around the US dollar. For the remaining period, Japan's exchange rate was free float, which suggests the absence of Central Bank intervention.

Table 7.3 further reveals ten phases in Korean exchange rate policy. Initially Korean won was pegged to US dollar. From February 27th, 1980 to July 1980, Korea followed de facto crawling peg to US dollar. From March 2nd, 1990 to November 1st, 1994, Korean exchange rate regime can be classified as crawling peg with varying band around US dollar. This was followed by de facto crawling with changing band around US dollar for November 1st, 1994 to November 1997. From December 17th, 1997 to June 1998, Korean exchange rate regime can be classified as freely falling. It reflects that in this period, Korean twelve month inflation rate exceeded 40 percent level. Managed float characterised the Korean exchange rate regime

Figure 7.1 Exchange Market Pressure (EMP_{it})

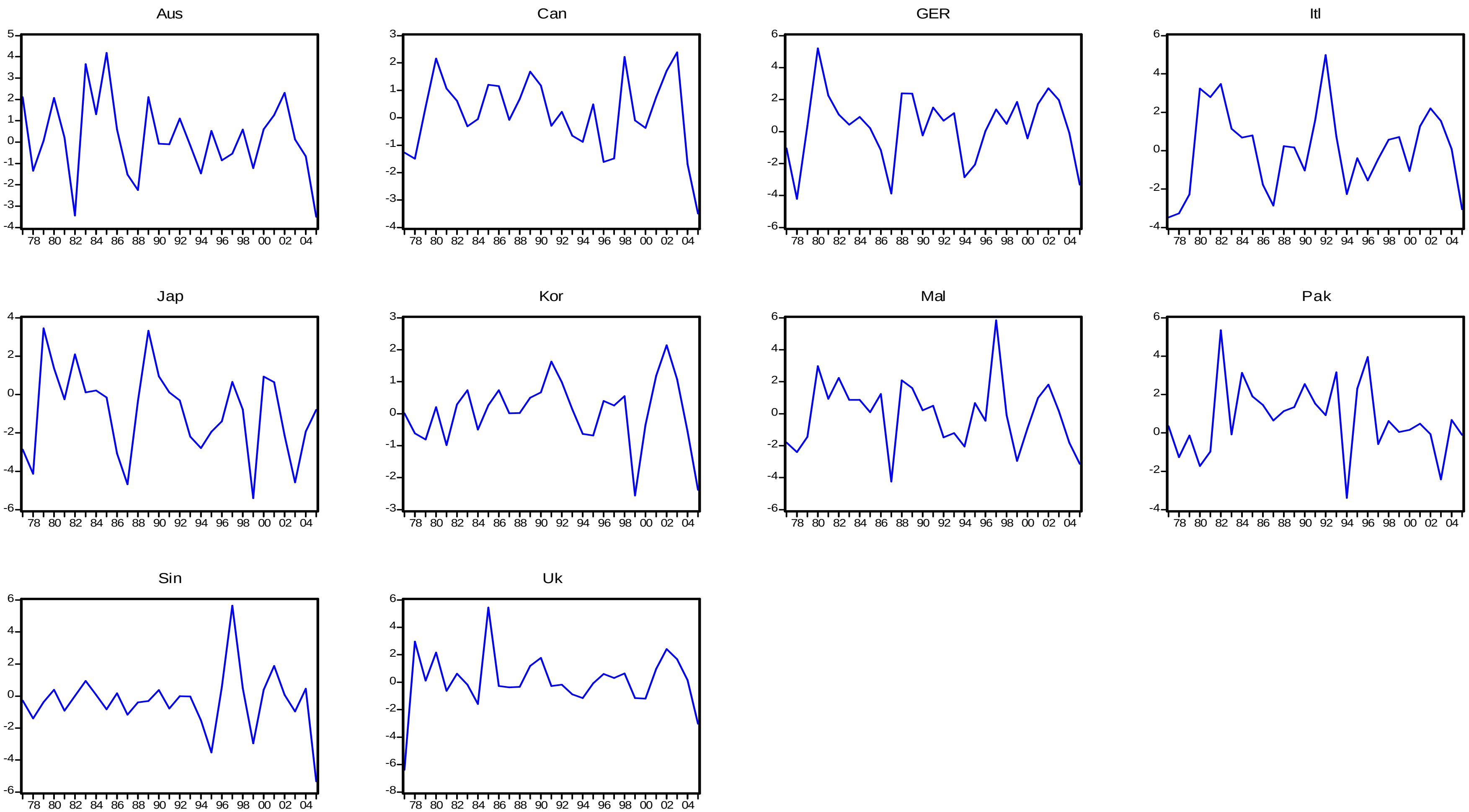


Figure 7.2 Trade Openness (OP_{it})

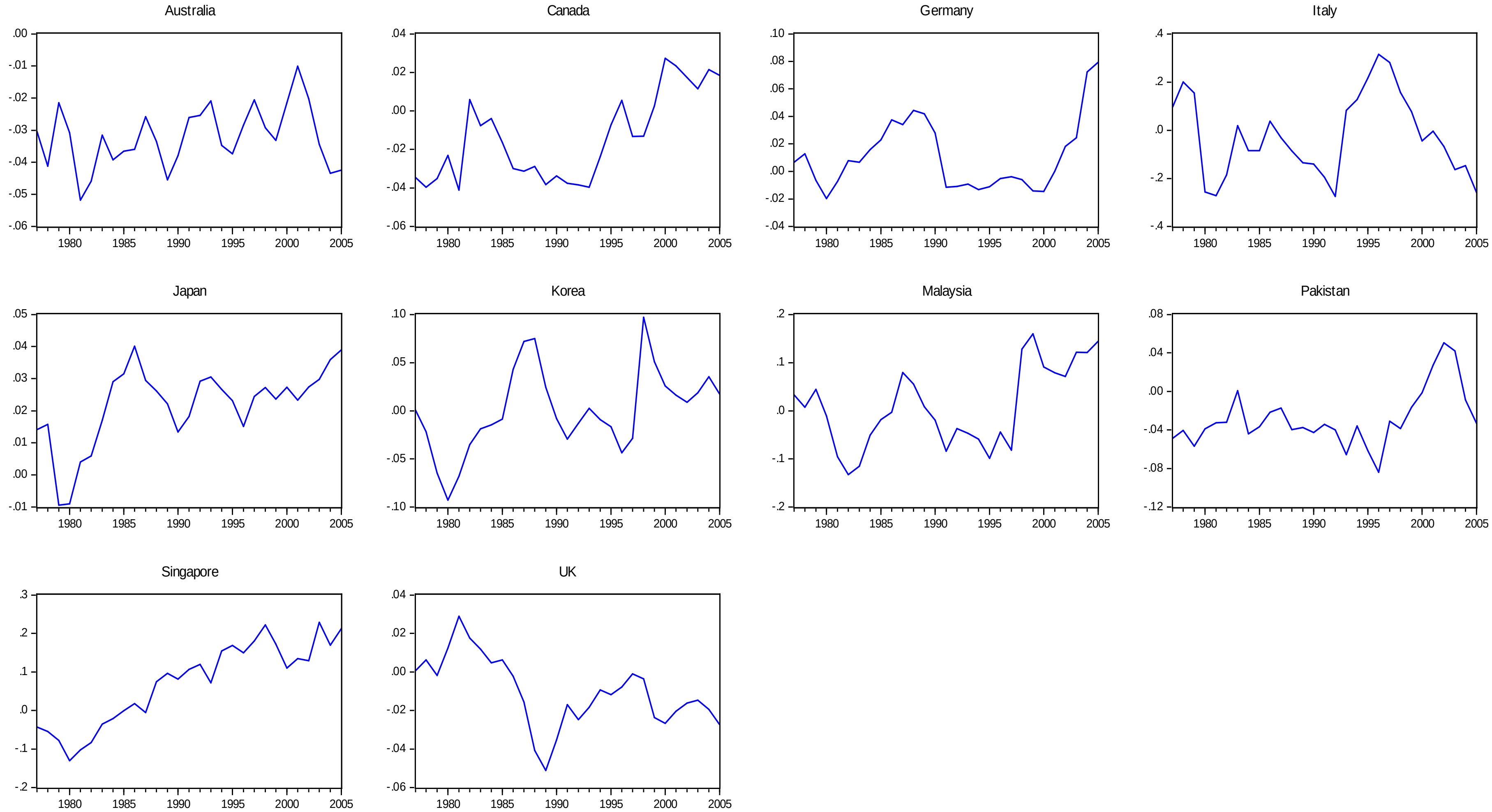


Figure 7.3 Capital Openness (OPK_{it}) Index

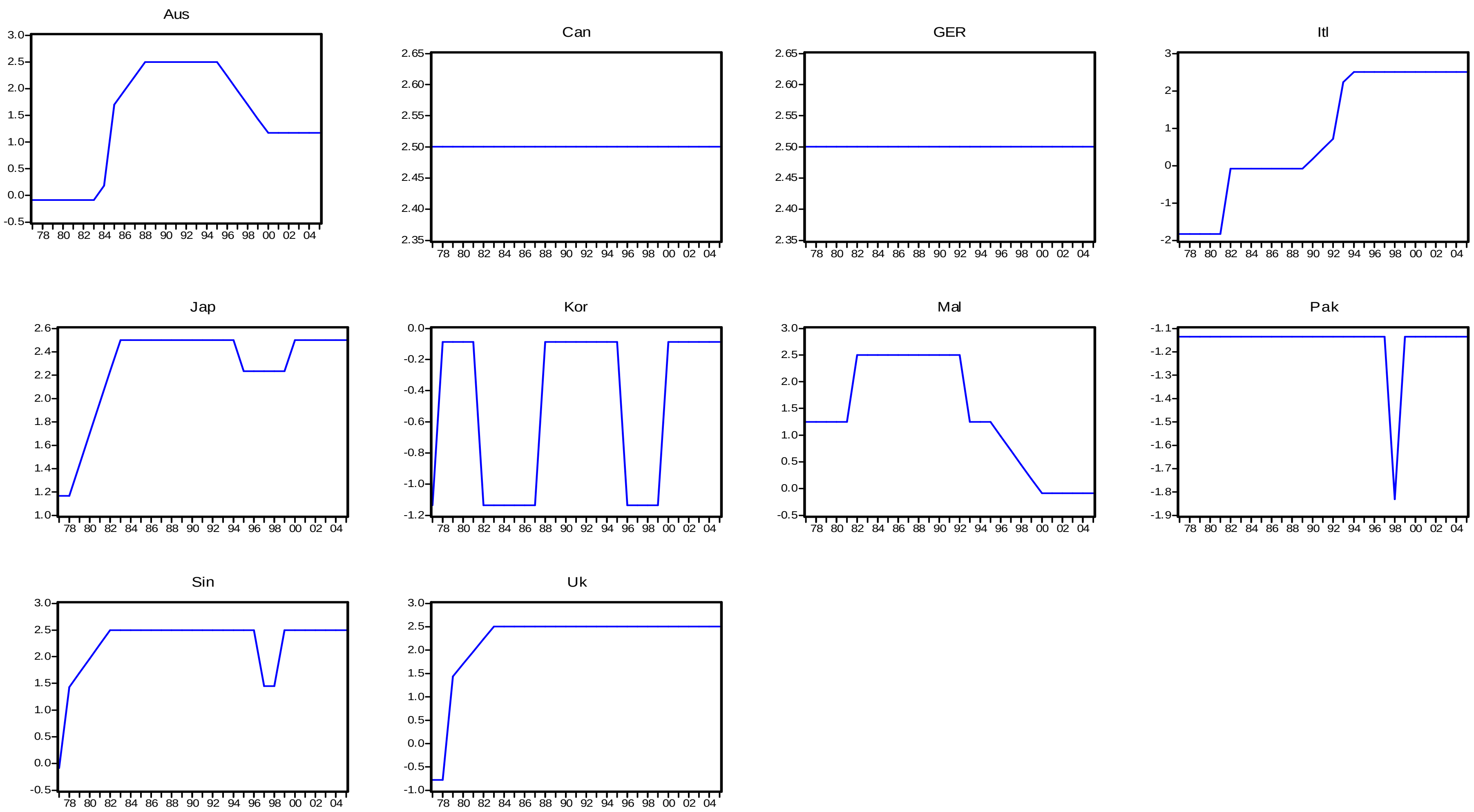


Figure 7.4 Remittances (Δrem_{it})

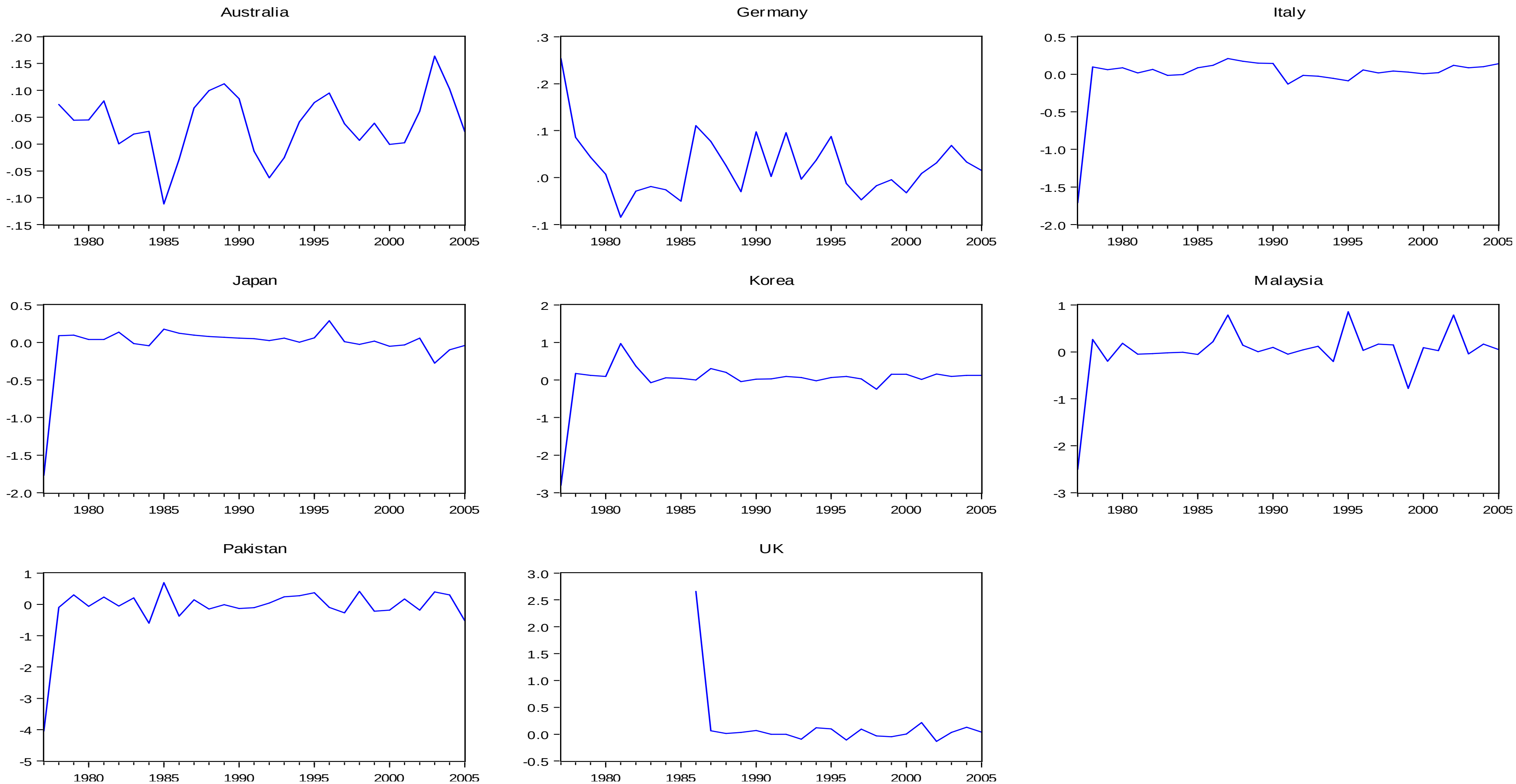


Figure 7.5 Reserve Import Ratio (rim_{it})

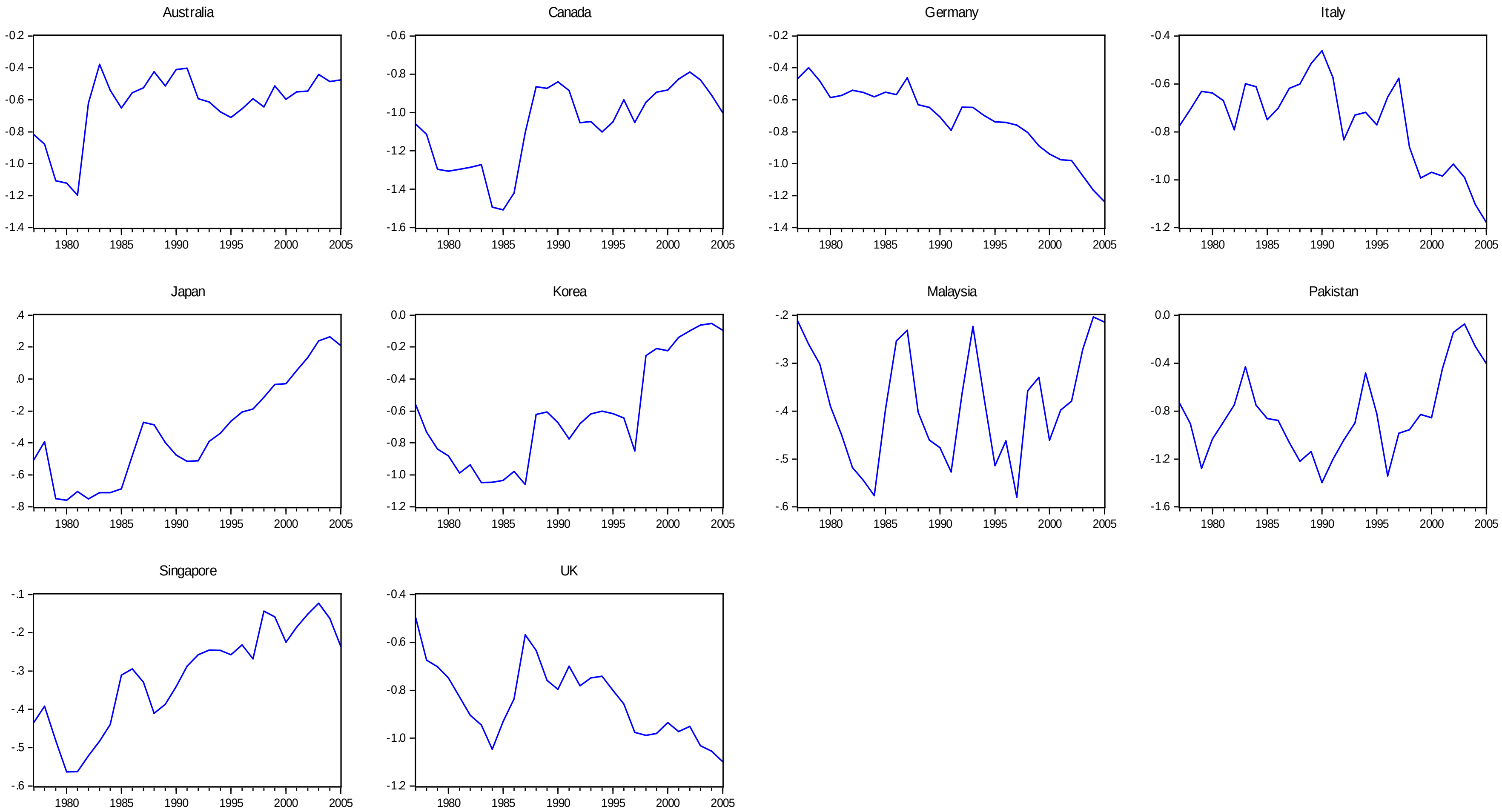


Figure 7.6 Real Exchange Rate (q_{it})

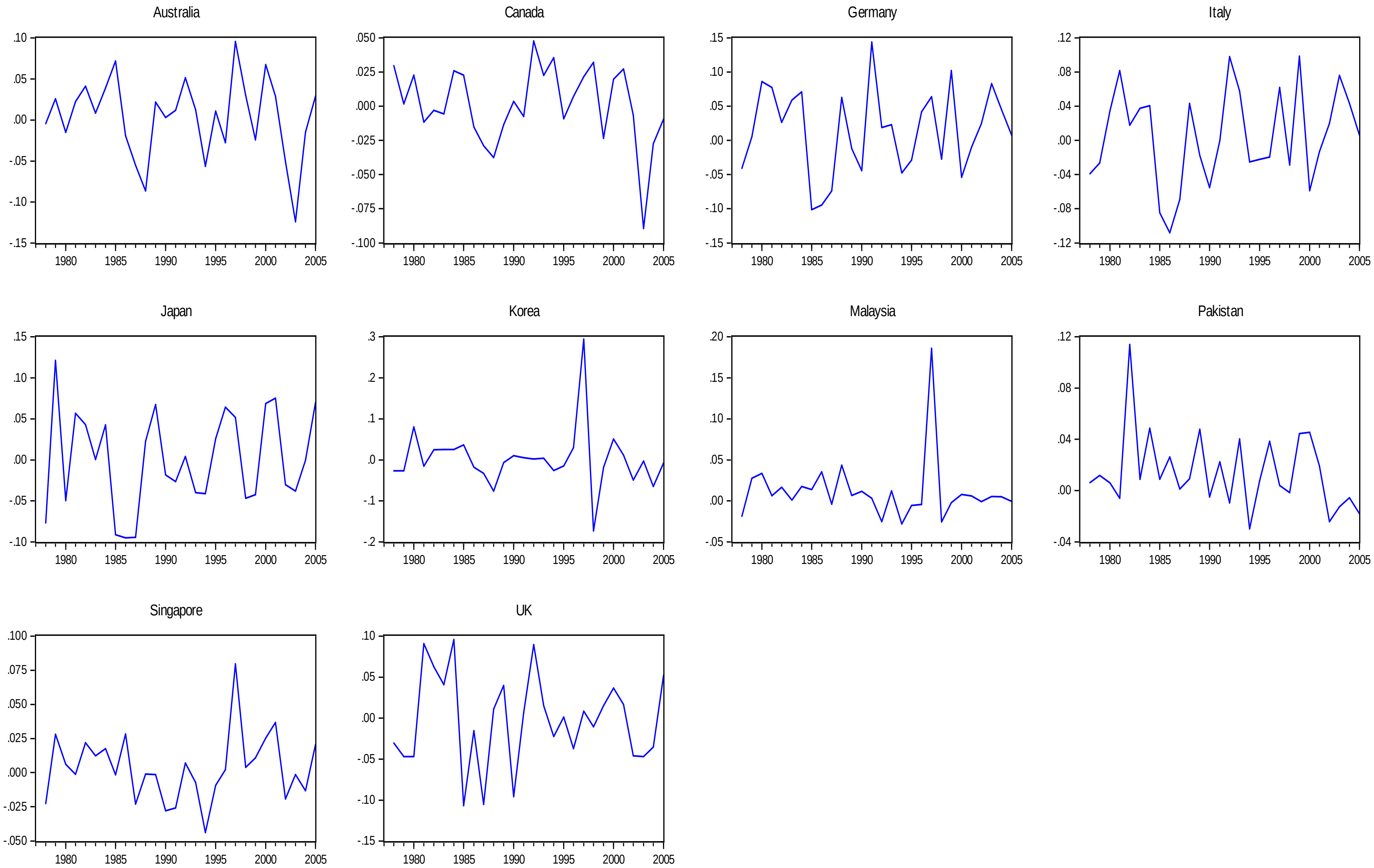


Figure 7.7 Real Domestic Income (Δy_{it})

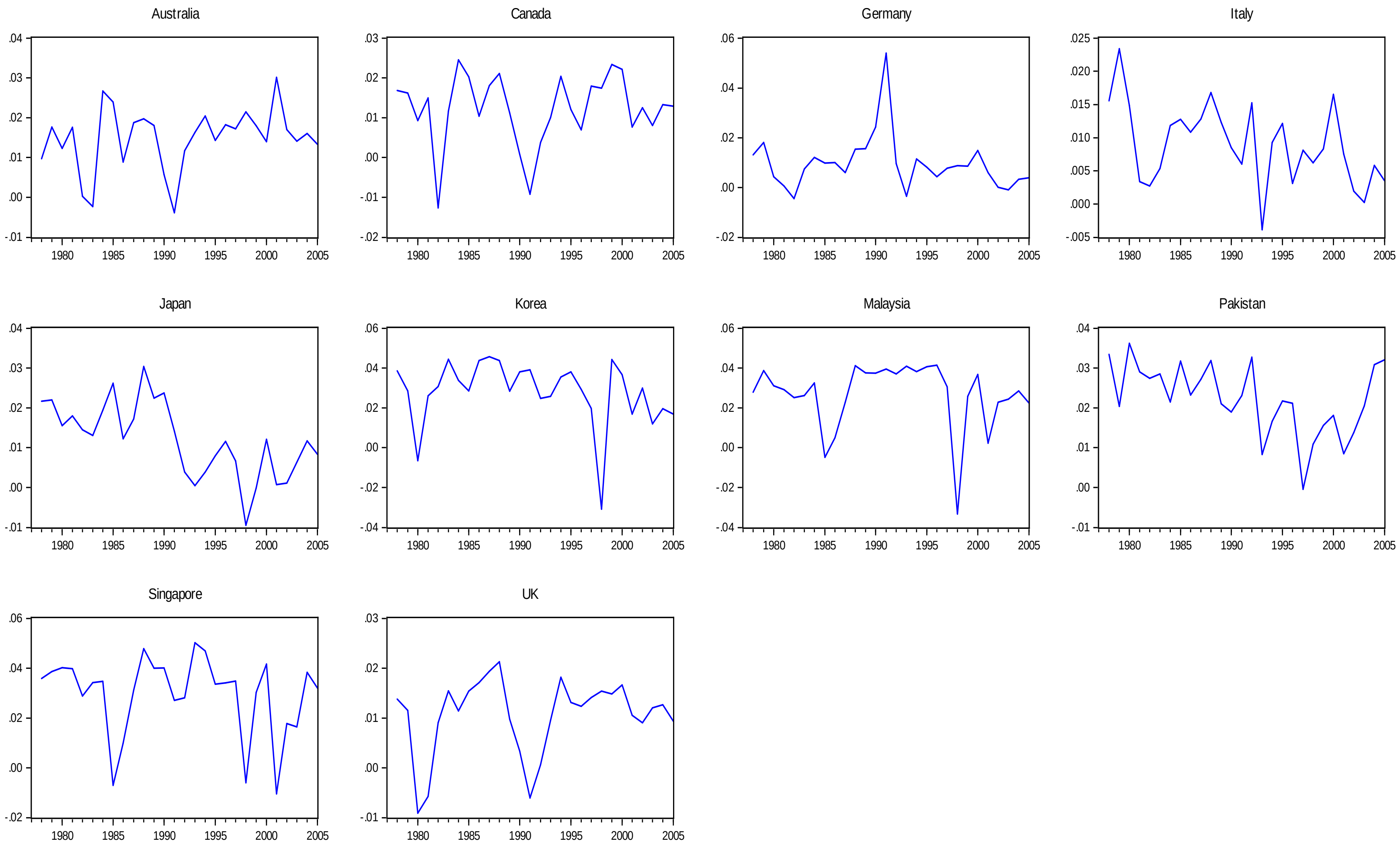
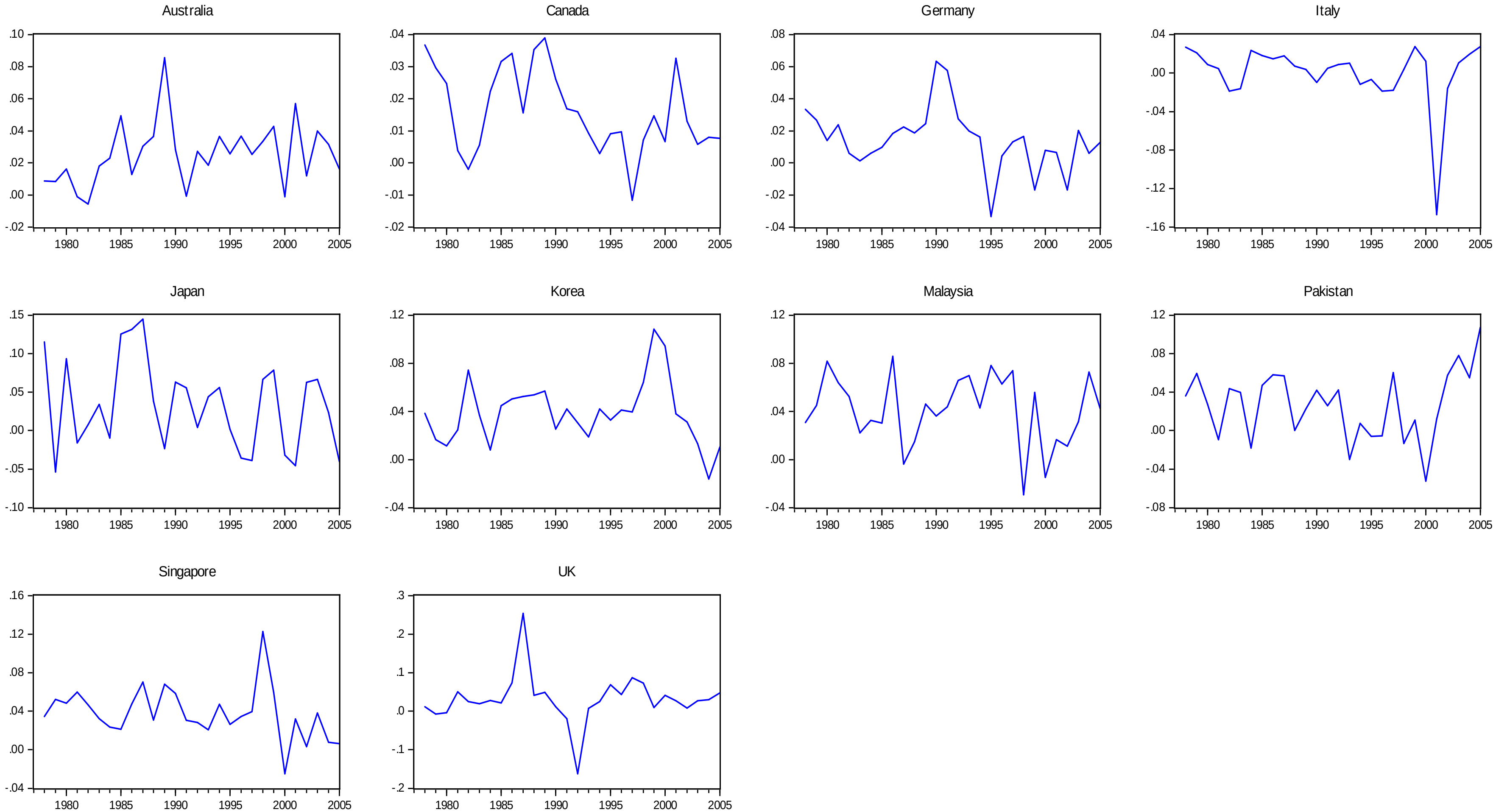


Figure 7.8 Real Monetary Aggregates (Δm_{it})



during July 1998 to November 2004. This was a period in which the Korean Central Bank intervened in foreign exchange market to smooth undesirable exchange rate changes. Since December 2004 to December 2007, Korea has maintained a de facto crawling band around the US dollar with a +/-5% fluctuating band. A similar pattern is visible in Malaysian exchange rate policy. Malaysia pursued a de facto band of +/-2% around the US dollar, which was followed by free float. However, in the post East Asian currency crisis period, Malaysian exchange rate arrangements are characterised as pegged to US dollar.

Initially, Pakistan pursued a fixed exchange rate system and pegged its currency to the US dollar. Between January 1982 and July 1998, Pakistan followed a de facto crawling peg with a varying band around the US dollar. From 22nd July, 1998 to May 19th, 1999, multiple exchange rate arrangements characterised Pakistan's exchange rate regime. This was replaced by de facto crawling peg to US dollar for the remaining period. Singapore is a unique case in the sample countries. It has followed de facto moving band around the US dollar with +/-2% moving band over the entire sample period. On the other hand, the UK initially followed managed float, which was followed by preannounced band of +/-6% around the Deutschmark. In the Post Exchange Rate Management crisis period, UK adopted a managed float which was replaced by a de facto moving band of +/-2% around Euro in January 2001.

7.5 Econometric Methodology

In the empirical study of the determinants of Exchange Market Pressure, we use fixed effects Panel Estimation also known as Least Square Dummy Variable (LSDV) estimation. Our specification is a linear regression model that allows intercept (c_{it}) to vary across individual countries. It is given as follows:

$$EMP_{it} = c_i + \theta x_{it} + u_{it}, \qquad u_{it} \sim IID(0, \sigma_u^2) \qquad (7.2)$$

where x_{it} is a vector of independent variables [k] and θ denotes vector of parameters [h]. u_{it} is an error term with zero mean $E[u_{it} = 0]$ and constant variance Furthermore, it is assumed that all x_{it} are independent of all u_{it} that is $E[x_{it}u_{it} = 0]$. Subscript i on intercept term suggests that intercept is allowed to vary across countries to take account of differences in the structure of their economies.

Equation 7.2 is a Fixed Effect Panel estimation method due to the fact that although it allows intercept to vary across different countries, each individual country intercept is not allowed to vary over time that is it is time invariant. After introducing a dummy variable for each country to denote differences in the structure in their economies, we write equation 7.2 as:

$$EMP_{it} = \sum_{j=1}^{N} c_j d_{ij} + x_{it}^{'}\theta + u_{it} \tag{7.3}$$

However, the introduction of too many regressors renders regression model unattractive. In order to avoid this problem, we estimate regression model in deviation from individual means which enables us to eliminate the individual effects α_i. The regression model in deviation form is as follows:

$$\overline{EMP}_i = c_i + \overline{x}_i^{'}\theta + \overline{u}_i \tag{7.4}$$

where $\overline{EMP}_i$ is a mean of the dependent variable and is defined as $\overline{EMP}_i = T^{-1}\sum_{t=1}^{T} EMP_{it}$ and $\overline{x}_i$ and $\overline{u}_i$ are defined in similar way. Therefore, we can write equation 7.3 as:

$$EMP_{it} - \overline{EMP}_i = (x_{it} - \overline{x}_i)\theta + (u_{it} - \overline{u}_i) \tag{7.5}$$

Equation (7.5) is a regression model in deviation from individual means and does not contain individual country effects θ_i. The ordinary least square estimate of θ obtained from this transformed model is called a fixed effect estimator and is given as:

$$\hat{\theta}_{FE} = \left(\sum_{i=1}^{N} \sum_{i=t}^{T} (x_{it} - \overline{x}_i)(x_{it} - \overline{x}_i) \right)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} (x_{it} - \overline{x}_i)(EMP_{it} - \overline{EMP}_i) \qquad (7.6)$$

7.6 Results

7.6.1 Empirical Specification

In this section, we specify the fixed effects panel estimates for the determinants of Exchange Market Pressure. Given the aggregation of data, we evaluate the effect of exchange rate regime, monetary policy regime, monetary aggregates, trade openness, capital openness and macroeconomic variables on exchange market pressure. We construct dummy variables D1 using different exchange rate regime data from Rogoff and Reinhart (2004). It takes a value of 1 for de facto peg, pre-announced crawling peg, de facto band and managed float, and zero otherwise. The estimated model is given as:

$$EMP_{it} = c_i + \theta_1 ERR_{it} + \theta_2 IT_{it} + \theta_3 OPK_{it} + \theta_4 \Delta rem_{it} + \theta_5 \Delta m_{it} + \theta_6 q_{it} + \theta_7 \Delta resm_{it} + \theta_8 \Delta y_{it} + OP_{it} \qquad (7.7)$$

ERR_{it} denotes a dummy variable that denotes different exchange rate regime. We construct it using different exchange rate regime data from Rogoff and Reinhart (2004). It takes a value of 1 for de facto peg, pre-announced crawling peg, de facto band and managed float, and zero otherwise.[74] The proponents of a bipolar view pronounce soft peg exchange rate arrangements as unsustainable.[75] They are an attempt by a country open to capital inflows to have a fixed exchange rate and monetary independence. Sooner or later a conflict arises between domestic objectives and stable exchange rate which results in the collapse of exchange rate regime as is in the model of a currency crisis (See Krugman, 1979). Another possible explanation of the nonviability of pegged exchange rate is that it raises the belief that the exchange rate regime

[74] We assign zero value to freely floating and freely falling exchange rate regime.

[75] Soft peg exchange rate arrangements include fixed exchange rate pegs, adjustable exchange rate pegs, and narrow band exchange rate systems (Fischer, 2001, pp. 6).

will remain unaltered. This reduces the perception of risk borrowing in foreign exchange market and removes the need for hedging. Then when exchange rate crises struck, it is devastating in terms of over all economy (Fischer, 2011). Thus we expect θ_1 to be positive when the country is following a soft peg exchange rate regime.

IT_{it} denotes inflation targeting monetary regime. An inflation targeting regime is defined as the numerical value to which Central Bank commits and implements forward looking monetary policy to minimise the difference between the actual and targeted inflation rate.[76] A well functioning inflation targeting regime is conditional upon floating exchange rate regime (Mishkin and Savastano, 2001). It is argued that due to the impossible Trinity, a Central Bank can not maintain the twin objectives of stable exchange rate and domestic prices. Thus under an inflation-targeting monetary regime, domestic monetary authorities give more weight to stable domestic prices to the benign neglect of stable exchange rate. It is argued that a shift in the focus of monetary policy on domestic objective of stable price may increase exchange market pressure (Petursson, 2009). However, empirical evidence shows that inflation targeting reduces instead of increases pressure on the domestic currency (Edwards, 2006 and Petursson, 2009). This may be due to the fact that inflation targeting is a transparent and predictable monetary policy framework that reduces the possibility of unexpected shocks. This in turn increases exchange rate stability.[77]

The theoretical literature suggests that Exchange Market Pressure and monetary aggregates are positively correlated. This can be explained that a rise in money supply reduces foreign currency backing of short-term domestic liabilities of banking system (Glick and Hutchison, 2005). This makes it difficult for domestic monetary authorities to defend the currency if the monetary perception turns against it. Second, a rise in money supply increases

[76] See Bernanke and Mishkin (1997) and Mishkin and Savastano (2001) for a detailed discussion on inflation targeting monetary policy.
[77] Our variable for inflation targeting regime takes a value of one for such a regime, and zero otherwise.

domestic prices. This makes domestically produced goods less competitive in the international market, which deteriorates the current account deficit and puts pressure on domestic currency to loose its value against foreign currency. In addition, an increase in domestic monetary aggregates increases nominal cash balances of domestic residents which they swap for foreign currency. This increases pressure on domestic currency to depreciate (Girton and Roper, 1977).

It is argued that increased capital openness can affect Exchange Market Pressure. The literature on international capital inflows has focused on two types of controls on cross border capital movements: (a) restriction on capital inflows and (b) controls on capital outflows.[78] However, the idea of restricting capital inflows has grown much in popularity. Stiglitz (1999) argues that "volatile markets are an inescapable reality. Developing countries need to manage them. They will have to consider policies that help stabilise the economy and help it absorb some of the shocks that volatile markets cause. These could include sound bankruptcy laws and Chilean–style policies that put some limits on capital flows".[79] Krugman (1998) also support the imposition of exchange controls in order to avoid destabilising impact of sudden capitol outflows. Tobin (1978) went a step further and suggested the imposition of a global tax on all spot conversions of one currency into another, proportional to the size of the transaction. Eichengreen et al. (1993) support Tobin's (1978) idea and favour the imposition of a Tobin tax to avoid destabilising effect of short term capital inflows. On the other hand, McKinnon (1993) argued that increased capital inflows lead the real exchange rate to appreciate. This makes domestic exports less competitive in the international market and increase current

[78] There are two types of controls on capital outflows: (a) Preventive controls and (b) curative controls. Preventive controls take the form of taxes on funds remitted abroad, dual exchange rates and outright prohibition of funds transfers (Edwards, 1999). On the other hand, curative controls are imposed when the country is facing crisis-like circumstances. These controls enable the country to lower the interest rate and put in place pro growth policies (Krugman, 1998).

[79] Chile imposed capital controls on two occasions: in 1978 – 1982 and 1991 – 1998. In both periods, investors wishing to bring their capital to Chile were required to make some non-interest bearing deposits with the Chilean Central Bank (Edwars, 1999)

account deficit of the country. This in turn puts pressure on the domestic currency to depreciate in the foreign exchange market. Moreover, capital openness increases the vulnerability of a country to external shocks even in the absence of weak fundamentals. This occurs due to investor’s herding behaviour, boom-bust cycles and the fluctuating nature of capital inflows (Schmukler, 2004). On the other hand; capital controls also have distortionary effects. Dooley and Isard (1980) and Fischer (2001) argue that investors aware of being unable to withdraw their funds will not be willing to invest in the country. This will increase downward pressure on domestic currency in the foreign exchange market.

The empirical literature overwhelmingly rejects the hypothesis that restrictions on capital controls insulate the economy from external shocks. Capital controls acts like investment irreversibility. Investors being unable to withdraw their capital would not be willing to invest in the country (Dooley and Isard, 1980). Furthermore, capital controls signal inconsistency between pegged exchange rates and macroeconomic policies. Thus the capital controls intended of restricting capital outflows may infact provoke capital outflows due to loss of investor’s confidence in the economy (Bartolini and Drazen, 1997). Moreover, foreign investors would be less likely to withdraw their capital from the country if they knew that the controls on capital would not be imposed. Empirical literature that rejects the null that capital controls do not insulate economy from external shocks measure pressure in foreign exchange market in terms of dummy variables that takes either zero or one value (Edwards, 2005; Glick et al. 2006; Glick and Hutchison, 2011). Furthermore, they use restrictions on capital transactions to denote capital account openness.

Previous theoretical studies provide conflicting views on the effects of trade openness on Exchange Market Pressure. The first view emphasises that trade openness makes countries more vulnerable to external shocks. A weakening in a country’s export market results in a sudden stop in capital inflows and thus makes it more vulnerable to speculative attacks on its currency. Secondly, trade openness and financial openness go hand–in-hand. Increased trade requires multinational corporations which in turn need to be able to move their capital across borders freely. In such an environment, it would be difficult for countries to effectively enforce capital controls (Frankel and Cavallo, 2004). Similarly, the view that the countries more open to international trade experience less pressure on their currencies works through different channels. Rose (2005) argues that a strong trade link reduce countries default probabilities. International investors aware of countries reduced default probabilities due to increased trade/GDP ratio would be less willing to withdraw their capital. This will reduce downward pressure on their currencies. In this chapter, we test this relationship and identify which effect of trade openness is more dominant.

A rise in remittances sent by domestic residents living abroad should expected to be associated with a fall in Exchange Market Pressure. Hence more capital inflows are associated with stronger currencies and less downward pressure. Similarly, a higher reserve import ratio suggests country's ability to repay its foreign currency liabilities. Increased reserve import ratio is thus associated with lessening pressure in foreign exchange market. Hence we expect a negative sign for the reserve import ratio. Furthermore, the theoretical literature suggests that an over-valued exchange rate is associated with a rise in pressure on the domestic currency. An over-valued real exchange rate makes it difficult for domestic exporters to compete in the international market. This deteriorates current accounts and thus puts pressure on domestic currency to depreciate.

7.6.2 Empirical Evidence

In this section, we provide empirical evidence for the determinants of Exchange Market Pressure (equation 7.7) in a panel of ten countries. Particularly, we test if the empirical evidence confirms the theoretical predictions as discussed in the previous section. We adopt a general to specific approach, by eliminating insignificant estimates. The panel estimates of

Table 7.4 Panel Estimates of EMP Determinants

	Model 1	Model 2	Model 3	Model 4	Model 5
C	-0.462	0.087	-4.669	-4.541	**-4.337** [a]
	(-0.06)	(0.01)	(-1.890)	(-1.85)	(-3.30)
ERR_{it}	-0.201				
	(-0.33)				
IT_{it}	-0.162				
	(-0.32)				
OPK_{it}	0.107	0.115	0.087		
	(0.68)	(0.77)	(0.60)		
Δm_{it}	0.268	0.191	-0.653	-0.69	
	(0.17)	(0.13)	(-0.72)	(-0.77)	
Δrem_{it}	0.310	0.344	0.143	0.171	
	(0.62)	(0.71)	(0.362)	(0.44)	
$resm_{it}$	**-1.121**	**-1.063**	-1.054	-1.053	**-1.176**
	(-2.10 [a])	(-2.24 [a])	(-1.92)	(-1.93)	(-2.511 [a])
OP_{it}	**-7.876**	**-7.917**	**-7.907**	**-7.875**	**-6.267**
	(-4.56 [a])	(-4.62 [a])	(-4.62 [a])	(-4.61 [a])	(-4.05 [a])
Δq_{it}	**4.727**	**4.752**	**3.967**	**3.902**	**3.386**
	(2.63 [a])	(2.67 [a])	(2.83 [a])	(2.79 [a])	(2.78 [a])
Δy_{it}	-2.084	-2.222			
	(-0.66)	(-0.72)			
R^2	0.21	0.21	0.21	0.20	0.15
F-statistic	3.425	3.936	4.209	4.544	4.12
Prob(F-statistic)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DW statistic	1.60	1.59	1.59	1.59	1.65

Note: This table investigates the determinants of Exchange Market Pressure, using LSDV approach. a denotes significance level at 5 percent level. The variables include in the analysis are: monetary aggregate (m_{it}), trade openness (OP_{it}), capital openness (OPK_{it}), real exchange rate (q_{it}), remittances (rem_{it}), reserve import ratio ($resm_{it}$) and real Gross Domestic Output (y_{it}). ERR_{it} denotes fixed exchange and managed floating exchange rate arrangement. Similarly, IT_{it} refers to inflation targeting monetary regime. Δ refers to difference operator. DW denotes Durbin Watson statistic. Small letters denote logged values. *t* values are given in parenthesis.

of Exchange Market Pressure using fixed effect parameter approach are given in Table 7.4.

It is argued that soft peg exchange rate regimes are unsustainable and therefore, increase pressure on domestic currency to depreciate. Thus we expect θ_1 to be of positive sign. Contrary to our expectation, Table 7.4 shows insignificant estimate of exchange rate regime (ERR_{it}) suggesting that exchange rate regime does not have any significant effect on

Exchange Market Pressure. Thus our results are different from those obtained by Mandilaras and Bird (2008) who found that fixed and intermediate exchange rate regime reduce pressure for Latin American & Caribbean (LAC) countries. This indicates that some kind of exchange rate management in these countries would reduce market pressure on their currencies.

Similarly, theoretical literature suggests that a shift in the focus of monetary policy from exchange rate stability to inflation targeting would increase pressure on domestic currency to depreciate.[80] However, our estimate of Inflation Targeting Regime (IT_{it}) is insignificant, which suggests that inflation targeting monetary policy does not explain variation in Exchange Market Pressure. A rise in domestic monetary aggregates increases the holding of nominal cash balances of domestic residents which they swap for foreign currency. This increases pressure on domestic currency to depreciate. Contrary to the theoretical predictions, our estimate of monetary aggregate although positive, is insignificant. This implies that domestic monetary aggregates do not influence Exchange Market Pressure.

The previous theoretical literature provides conflicting arguments about the effects of trade and capital openness on Exchange Market Pressure. One strand of literature argues increased trade and capital openness of country will increase pressure on its currency to depreciate. The other strand of literature supports the view that increased trade and capital openness of a country would reduce downward pressure on its currency. Our estimate of capital openness although positive but is insignificant implying that capital openness is not associated with an increase in exchange market pressure. The differences between our findings and those of earlier empirical literature may be attributed to our having measured pressure in the foreign exchange market in terms of continuous instead of binary variables taking either zero or one value. Furthermore, we used Chin and Ito (2008) index instead of restrictions on capital accounts to denote capital account openness. Chin and Ito (2008) measured capital

[80] Our variable for inflation targeting regimes takes a value of one for such a regime and zero otherwise.

account restrictions in terms of continuous variables. It has the advantage of conveying more information then the binary variable that takes either zero or one value.

On the other hand, a significant negative estimate of trade openness shows that a country's openness to trade reduces pressure on their currencies to depreciate. Our finding is similar to Rose (2005), who argues that strong trade links reduce a country's default probabilities. Since investors, being aware of countries' reduced default probabilities, would not withdraw their capital, this in turn reduces pressure on their currencies to depreciate. Frankel and Cavallo (2004) also obtained results that provide evidence that countries with open trade are less prone to market pressure on their currencies. Similarly, Sachs and Williamson (1985) compared Latin American and East Asian countries and showed that the latter were less prone to market pressure due to their higher trade to GDP ratio. This is because East Asian countries invested their borrowing in export industries. This resulted in far greater exports for East Asian countries than for their counterparts in Latin America. The resources generated from increased exports were enough for East Asian countries to service their future debt payments.

Table 7.4 further shows that although the estimate of remittances is positive, it is not significantly different from zero. However, the estimated parameters of reserve import ratio and the real exchange rate are significant and are of negative and positive signs. The significant negative estimated parameter of reserve import ratio confirms their theoretical predictions that increase in foreign capital inflow is associated with decrease in pressure on domestic currency. Similarly, a positive and significant estimated parameter of real exchange rate suggest that an over-valued real exchange rate reduces competitiveness of domestic exporters in the international market and thus puts pressure on domestic currency to depreciate.

Table 7.5 Panel Estimates of Exchange Market Pressure Determinants (Uses Lagged Regressors)

	Model 1	Model 2	Model 3	Model 4
C	0.024	0.339	0.336	0.302
	(0.02)	(0.30)	(0.30)	(0.28)
ERR_{it} (-1)	0.239			
	(0.64)			
IT_{it} (-1)	0.078			
	(0.20)			
OPK_{it} (-1)	**-0.216**	**-0.214**	**-0.215**	**-0.211**
	(-1.65 ^{b})	(-1.65 ^{b})	(-1.98 ^{a})	(-2.09 ^{a})
Δm_{it} (-1)	-0.083	-0.022	-0.023	
	(-0.35)	(-0.10)	(-0.118)	
Δrem_{it} (-1)	0.081	0.098	0.097	0.096
	(0.56)	(0.69)	(0.72)	(0.72)
$resm_{it}$ (-1)	0.006	-0.100	-0.100	-0.101
	(0.014)	(-0.26)	(-0.26)	(-0.26)
OP_{it} (-1)	**-3.361**	**-3.367**	**-3.367**	**-3.378**
	(-1.97 ^{a})	(-2.00 ^{a})	(-2.01 ^{a})	(-2.02 ^{a})
Δq_{it} (-1)	-0.131	0.005		
	(-0.37)	(0.02)		
Δy_{it} (-1)	-0.011	-0.171	-0.167	**-0.177**
	(-0.03)	(-0.57)	(-1.29)	(-1.916 ^{a})
R^2	0.44	0.44	0.44	0.44
F-statistic	3.884	4.136	4.2285	4.442
Prob(F-statistic)	(0.000)	(0.000)	(0.000)	(0.000)
DW statistic	1.89	1.90	1.91	1.90

Note: This table uses one period lagged variables on the right hand side for evaluating the determinants of Exchange Market Pressure. a and b denotes significance level at 5 and 10 percent level. The variables included in the analysis are: monetary aggregate (m_{it}), trade openness (OP_{it}), capital openness (OPK_{it}), real exchange rate (q_{it}), remittances (rem_{it}), reserve import ratio ($resm_{it}$) and real Gross Domestic Output (y_{it}). ERR_{it} denotes fixed exchange and managed floating exchange rate arrangement. Similarly, IT_{it} refers to inflation targeting monetary regime. Δ refers to difference operator. DW denotes Durbin Watson statistic. Small letters denote logged values. *t* values are given in parenthesis.

It is evident from Table 7.4 that R^2 values range between 0.15 and 0.21. It shows that the estimated models explain fifteen to twenty-one percent variations in the dependent variable. We cannot reject the null of no serial correlation due to higher Durbin Watson statistics. Furthermore, F-statistic values are quite high, with zero probability of obtaining

Table 7.6 Panel Estimates of EMP Determinants (uses lagged variables as instruments)

	Model 1	Model 2	Model 3	Model 4
C	-0.248	0.053	0.076	0.075
	(-0.19)	(0.05)	(0.07)	(0.07)
ERR_{it}	0.230			
	(0.58)			
IT_{it}	-0.003			
	(-0.006)			
OPK_{it}	**-0.229**	**-0.227**	**-0.221**	**-0.219**
	(-1.67 ^{b})	(-1.67 ^{b})	(-1.96 ^{a})	(-2.14 ^{a})
Δm_{it}	-0.062	-0.014	-0.006	
	(-0.25)	(-0.066)	(-0.04)	
Δrem_{it}	0.102	0.117	0.120	0.119
	(0.69)	(0.81)	(0.861)	(0.87)
$resm_{it}$	-0.010	-0.133	-0.132	-0.124
	(-0.022)	(-0.33)	(-0.33)	(-0.31)
OP_{it}	**-4.802**	**-4.712**	**--4.703**	**-4.706**
	(-2.08 ^{a})	(-2.138 ^{a})	(-2.14 ^{a})	(-2.15 ^{a})
Δq_{it}	-0.159	-0.023		
	(-0.44)	(-0.08)		
Δy_{it}	0.001	-0.148	-0.171	**-0.175**
	(0.01)	(-0.49)	(-1.37)	(-1.94 ^{a})
R^2	0.45	0.46	0.46	0.46
F-statistic	3.884	4.141	4.290	4.442
Prob(F-statistic)	(0.000)	(0.000)	(0.000)	(0.000)
DW statistic	1.82	1.82	1.82	1.82

Note: This table uses one period lagged variables on the right hand side for evaluating the determinants of Exchange Market Pressure. a and b denotes significance level at 5 and 10 percent level. The variables included in the analysis are: monetary aggregate (m_{it}), trade openness (OP_{it}), capital openness (OPK_{it}), real exchange rate (q_{it}), remittances (rem_{it}), reserve import ratio ($resm_{it}$) and real Gross Domestic Output (y_{it}). ERR_{it} denotes fixed exchange and managed floating exchange rate arrangement. Similarly, IT_{it} refers to inflation targeting monetary regime. Δ refers to difference operator. DW denotes Durbin Watson statistic. Small letters denote logged values. *t* values are given in parenthesis.

them. This can be interpreted as being able to reject the null that all estimated parameters are equal to zero. These test statistics suggest that we have a reasonably well-specified model.

Table 7.4 uses fixed effects panel estimates along with stationary data on domestic macroeconomic variables. However, the estimates of the determinants of exchange market pressure given in table 7.4 suffer from potential endogenity issue since all variables are contemporaneously correlated. Further, two of the significant variables namely reserve import ratio and real exchange rate share terms with exchange market pressure. This makes contemporaneous correlation among these variables highly likely. We adopt two approaches to address this issue. First, we estimate equation (7.7) using lagged variables on the right hand side. Second, we use lagged variables to instrument the endogenous variables.

The estimates of the panel determinants of exchange market pressure lagged regressors and instrumental variable approach are different from those obtained from Fixed Effect panel approach.[81] Contrary to table 7.4, table 7.5 and 7.6 shows exchange market pressure is well explained by trade openness (OP_{it}), capital openness (OPK_{it}) and real domestic income (Δy_{it}). The negative sign of trade openness, capital openness and real domestic income suggest that an increase in these variables reduce pressure on the currencies of the sample countries to depreciate. Hence the countries that want to avoid pressure on their currencies have to keep their trade and capital account open with the rest of the world. They also have to keep in check the developments in domestic real income in order to avoid pressure on their currencies.

7.7 Conclusion

In this chapter, we examined the determinants of Exchange Market Pressure in a panel of ten countries. We used Eichengreen et al.'s (1996) statistical approach to construct Exchange Market Pressure. It has the advantage of not being based upon the assumptions of macroeconomics models used by Girton and Roper (1977) and Weyamrk (1995), which could be problematic for such a large number of countries. Our basic objective was to evaluate the effects of a range of macroeconomic indicators, policy variables and measures of trade

[81] Standard instrumental variable was unsuccessful due to limited number of observations. Similarly, we also used Generalised Method of Moments approach. However, the results obtained from this approach were unsatisfactory.

openness on Exchange Market Pressure. Prior to this study, Bird and Mandilaras (2006) evaluated the effects of fiscal deficit, exchange rate regime, federal fund rate, short-term to total debt ratio and domestic credit from banks as percent of GDP on Exchange Market Pressure for the East Asia & the Pacific and Latin American & Caribbean (LAC) regions in a panel framework. Mandilaras and Bird (2008) on the other hand, focused on Latin American & Caribbean (LAC) countries and found foreign debt, intermediate and fixed exchange rate regime, US interest rate and domestic credit as the significant determinants of Exchange Market Pressure for these countries. This shows that ours is a first study to examine the effects of a range of macroeconomic indicators, policy variables and measures of openness (both trade and capital openness) on Exchange Market Pressure in a panel of ten countries.

Insignificant estimates of exchange rate regime and inflation-targeting dummies indicate that policy variables do not have any significant effect on market pressure. The theoretical literature argues that more open economies have more exposure to speculative attacks. This may increase their vulnerability to foreign currency speculative attacks. However, empirical evidence is at odds with the theoretical literature. It shows that more open economies are less prone to speculative pressure. The fixed effect panel estimates of exchange market pressure equation indicate insignificant and significant estimates of capital and trade openness. However, when we take account of the endogenity issue, we get significant negative estimates on both these variables. This shows that an increase in trade and capital openness reduces pressure on the currencies of the sample countries.

Similarly, the fixed effect estimates of exchange market pressure shows significant negative and positive estimates of reserve import ratio and real exchange rate. On the other hand, the endogenity adjusted estimates of exchange market pressure shows insignificant estimates for all variables apart from domestic real income. This implies that an increase in domestic real income is associated with decrease in market pressure. Thus, we conclude from our empirical estimate that some macroeconomic variables along with trade and capital openness are important determinants of exchange market pressure in a panel framework. On the other hand, policy regime variables such as inflation-targeting monetary policy and exchange rate regime do not have any significant effect on the build up of foreign exchange market pressure for the panel of ten countries that we have included in our analysis.

Appendix A1

Monetary Policy Review

There are wide differences in the monetary policies pursued by the countries included in the analysis. In this section, we briefly discuss the objectives and evolution of the monetary policy of each member country. Output growth and stable prices remained the ultimate objectives of monetary policy in Australia from 1977 to 1992. In order to attain these objectives, the Reserve Bank of Australia (RBA) targeted the growth of M3 from 1977 to January, 1985. Later, the focus shifted to a number of economic variables. However, there was no articulated monetary policy from 1988 to 1992. In 1993 inflation targeting replaced output and price stability as the ultimate objectives of monetary policy. The Canadian monetary authority initially targeted the growth of M1 monetary aggregate. The Canadian monetary authorities started targeting exchange rate stability on April 3rd, 1978. This policy remained in practice until the second quarter of 1984. During the mid-1980s, the Bank of Canada emphasised the importance of both inflation and exchange rate stability and yet the monetary policy lacked any clear framework. This ended in 1991, when the Bank of Canada and the Canadian Government agreed on targeting the inflation rate as the sole objective of monetary policy (Dodge, 2004). After the break down of the Bretton Wood system, the German monetary authorities started targeting the growth of monetary aggregates. An annual monetary target was first announced for 1975. It targeted the growth of Central Bank Money Stock, a weighted sum of currency held by non-banks, and demand, time, and saving deposits at statutory notice. In 1988, however, the Bundesbank switched to the simple sum M3, that included currency held by non-banks, demand, time, and saving deposits at statutory notice as

Table A.1 Monetary Policy of Sample Countries

Country	Time Period	Monetary Policy
Australia	April 1976 to January 1985	Treasurer on the joint advice of Treasury and the Central Bank set the target for M3 monetary aggregate (Macfarlane, 1999). The ultimate objective was output growth and stable prices.
	February to April 1985	No guiding principle for monetary policy.
	May 1985 to 1987	A number of economic variables were taken into account in the formulation of monetary policy. However, more attention was given to exchange rate stability (Greenville, 1997).
	1988 to 1993	There was no articulated monetary policy framework. Discretionary monetary policy framework was in place.
	May 1993 onwards	Stable prices became the sole objective of monetary policy.
Canada	Fall 1976 to March 1978	Targeted the growth of M1 monetary aggregate with a view of stabilising domestic prices.
	April 3rd, 1978 to June, 1984.	Monetary authorities used stable exchange rate target as an explanation for the conduct of Monetary policy.
	1984 to 1990	There was an increased emphasis on price stability and exchange rate stability yet the monetary policy lacked any clear framework (Howitt, 1993).
	February, 1991 onwards	Bank of Canada and Canadian Government agreed on inflation targeting as the sole objective of monetary policy (Dodge, 2002).
Germany	1975 to 1987	Monetary authorities targeted the growth of Central Bank Money Stock.[82]
	1988 to 1998	Monetary authorities targeted the growth of M3 monetary aggregate.[83]
Italy	1975 to 1994	Monetary authorities targeted the growth of total domestic credit which suggests the supremacy of fiscal policy over monetary policy.[84]
	1994 to 1998	Bank of Italy was made fully independent.[85] However, in the post independent period, it pursued multiple and conflicting objectives.

[82] Central Bank Money Stock comprised of a weighted sum of currency held by non-banks, and demand, time, and saving deposits at statutory notice (Neumann and Von Hagen, 1993).

[83] M3 consisted of currency held by nonbanks, demand, time, and saving deposits at statutory notice.

[84] During this period, Bank of Italy remained subservient to Treasury. It accommodated fiscal policy. In 1981, it was freed from its obligation of acting as residual buyer of Treasury Bills. Yet its autonomy was not complete. Over draft facility made it necessary for the Italian Central Bank to finance fourteen percent of Treasury Annual expenses. Even until February 1992, power to change discount rate vested with Treasury (Bartolini, 2002, Fratianni and Spinelli, 1997 and Spinelli and Tirelli, 1993).

[85] On 26th November, 1992, Parliament passed the law that restricted Treasury to borrow from Bank of Italy (BI). The same law authorised BI to change reserve requirement ratio. Finally, as of 1st January, 1994, BI was not required to participate in the Treasury auctions (Fratianni and Spinelli, 1997).

Table A.1 Monetary Policy of the countries included in the analysis (continued)

Country	Time period	Monetary Policy
Japan	1976 to 1985	Monetary targeting (M2 + currency deposits) aimed at stabilising exchange rate and price stability.
	February, 1985 to 1998	Bank of Japan followed both loose and tight monetary policy with a view of recovering economy from recessionary conditions, strengthening exchange rate against US dollar and controlling rise in prices.
	April 1998 onwards	Bank of Japan was given the mandatory power to stabilise prices.[86]
Korea	1976 to 1978	Bank of Korea (BOK) targeted the growth rates of M1 monetary aggregate (Kim and Park, 2005).
	1979 to 1997	Korean monetary authorities targeted M2 and M2 plus MCT.[87]
	1998 to 2005	The revised BOK act which was implemented 1998 empowered the bank to target inflation rate.[88]
Malaysia	Prior to 1994	Central Bank targeted the growth of monetary aggregate to stabilise domestic output and prices.[89]
	1995 to 1998	Interest rate targeting.
	1998 to 2005	Monetary policy aimed at maintaining fixed exchange parity against US dollar.
Pakistan	Prior to 1981	Monetary policy targeted fixed exchange rate parity against US dollar.
	1982 to 2005	Monetary policy has been targeting the growth of monetary aggregates.[90]
Singapore	1976 to 2005	Monetary Authority in Singapore targets exchange rate stability with a view of stabilising domestic prices and output growth (Parrado, 2004).
UK	1976 to 1990	From 1976 to 1985, monetary authorities targeted the growth of broad monetary aggregates. In 1986, focus shifted from broad monetary aggregates to narrow money M0.[91]
	October 1990 to September 1992.	Sterling entered into Exchange Rate Mechanism (ERM) and monetary authorities targeted at maintaining fixed exchange rate against member currencies.
	October 1992 to 2005	A new monetary framework was established with the sole objective of controlling inflation rate.

[86] From February 1999 to August 2000, Bank of Japan adopted zero interest rate policy. Later on from 19th March, 2001 till the end of the sample period, it pursued the policy of quantitative easing. The objective was to recover the economy from recessionary conditions and stop downward trend of domestic prices.

[87] MCT includes currency deposits and trust cash.

[88] The Act was implemented on 1st April, 1998. In the year 1998, BOK based Consumer Price Index set the target inflation rate of $9 \pm 1\%$ (Kim and Park, 2005, and Bank of Korea: Monetary Policy in Korea).

[89] Central Bank relied on statutory reserve requirement, minimum liquidity requirement, volume and direction of credit, interest rate ceiling, discount operations and moral suasion for implementing monetary policy.

[90] Prior to 1991, State bank of Pakistan implemented monetary policy using ad hoc changes in reserve requirements, direct credit and regulated interest rate for its implementation. In the post 1991 period, SBP has relied on market based interest rate for carrying out its monetary operations (Bushra and Abbas, 2008).

[91] Refer to King (1997) for further discussion on the switch of monetary aggregates from £M3 to £M0

its monetary targets (Neumann and von Hagen, 1993).

The Italian Central Bank remained subservient to the Federal Treasury and targeted credit growth. It was required by law to act as a residual buyer of the Central Government treasury. However, it was granted full autonomy in 1994. Despite this, the Italian Central Bank did not adopt the single objective of either monetary or inflation targeting. Instead it pursued multiple and often conflicting objectives until the implementation of European Monetary System in 1999. On the other hand, the Bank of Japan from the very beginning has targeted the growth of monetary aggregates with a view to stabilising domestic prices and output. However, the Bank of Japan Act was revised in 1997 and implemented on 1st April, 1998. The Bank of Japan was given a mandate to stabilise domestic prices and there was no mention of stable output or full employment (Ito, 2006). However, instead of targeting stable prices, the Bank of Japan followed the policy of zero interest rate and quantitative easing. The objective was the recovery of the economy from recession and the halting of deflationary pressures. The Bank of Korea has followed a monetary policy similar to bank of Japan. Initially it targeted the growth of M1 monetary aggregate. Later, in 1977 it switched to M2 plus MCT.[92]. However, the revised Bank of Korea Act 1998 gave it more autonomy and enabled it to pursue the single objective of inflation targeting. Malaysian monetary policy can be divided into three phases. Initially it targeted the growth of monetary aggregates. However, in 1994, it shifted its focus from monetary targeting to interest rate targeting which continued till 1998 when country adopted fixed exchange rate parity against US dollar.

Pakistan's monetary policy was initially targeted at maintaining fixed exchange rate parity. However, in 1982 it shifted its focus from the exchange rate to monetary targeting to stabilise domestic prices and output. Singapore is a unique case. Monetary authorities in Singapore, instead of inflation or monetary aggregates, have targeted the exchange rate to stabilise domestic prices and output. There are three phases of the United Kingdom's

[92] MCT includes currency deposits and trust cash.

monetary policy. Initially it targeted the growth of monetary aggregates. In 1990, the UK formally entered into exchange rate management and the monetary policy was aimed at maintaining fixed exchange rate parity against member countries. From 1992 onwards, the monetary authorities in UK have been targeting the growth of domestic prices (King, 1997; Cobham, 1997).

The main message that we derive from the above discussion is that except for Italy, the monetary policy of the sample countries has either targeted the growth of monetary aggregates or inflation controls. Conversely, the Italian Central Bank neither pursued monetary targeting nor inflation targeting. It remained subservient to the Central Government treasury and acted as a residual buyer of Central Government securities. Singapore is a unique case; it targeted exchange rate stability.

Monetary targeting ultimately aims at attaining the twin objectives of stable output and prices. Similarly, stable output and domestic prices have remained the ultimate objective of the Singapore Monetary Authority, which targeted exchange rate. On the other hand, inflation- targeting monetary policy has the sole objective of controlling domestic price. It is also called constrained discretionary monetary policy. In the short-term, inflation-targeting Central Banks can direct their monetary policy to respond to shocks hitting the economy. However, in the long term they have to conduct their monetary policy under the constraint that the actual inflation rate remains close to the targeted one.

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Appendix A2

The data on all variables except monetary aggregates (m_{it}) and Capital Openness are taken from the International Monetary Fund's *International Financial Statistics* dataset. Foreign exchange reserves (Line 1L.DZF) refers to total reserves minus gold in US dollars. Similarly, nominal bilateral exchange rate (Line DE-ZF) for Australia, Canada, Germany, Japan, Korea, Malaysia, Pakistan, Singapore and United Kingdom refers to national currency per unit of US dollar. Hence a rise in the exchange rate denotes the depreciation of domestic currency against the US dollar. The short-term interest rate (Line 60.BZF) is the rate on short-term lending between financial institutions. *M*2 (Line 35 L.ZF) refers to money plus quasi-money and is taken from IMF's *IFS* data set for Australia, Korea and United Kingdom. For the remaining countries, *M*2 is taken from Thomson Data-Stream. For Italy and Germany, the Thomson data set contained M2 data up to 1999. For the remaining period, German and Italian *M*2 were taken from Bundesbank and Italian Central Bank Monthly and Annual Reports. Bundesbank Annual reports reported *M*2 data up to 2002. We converted monthly *M*2 data to get annualised data for Germany for the remaining three years using Eviews 6.0 student version default frequency conversion setting. For Pakistan, due to the absence of *M*2, we used *M*1 data. We generated a trade openness proxy by taking the ratio of current account (Line 78ALD) to nominal GDP (Line 99BCZF). Similarly, we used Chin and Ito's (2008) index to measure financial openness. Real GDP is simply a ratio of nominal GDP (99B.CZF) to GDP Deflator (Line BRZF). Similarly, reserve import ratio refers to reserve (Line 1LDZF) to imports (71DZF). Remittance data for all countries except the UK (after 1987), Canada and Singapore are taken from World Bank's *World Development Indicators* data set and refer to Workers Remittances and Compensation of Employees Paid (Line B.M.TRF.PKWR.CD.DT). Real exchange rate refers to nominal exchange rate times price ratio.

Appendix A3

Country Specific Descriptive Statistics

Australia	EMP_t	m_t	OP_t	OPK_t	rem_t	$resm_t$	q_t	y_t
Mean	0.197	3.466	-0.032	1.373	8.779	-0.629	0.142	3.762
Median	0.118	3.463	-0.033	1.434	8.752	-0.592	0.129	3.746
Maximum	4.193	3.864	-0.010	2.500	9.376	-0.379	0.296	3.985
Minimum	-3.510	3.152	-0.052	-0.086	8.319	-1.196	0.041	3.569
Std. Dev	1.821	0.239	0.009	1.020	0.286	0.211	0.069	0.127
	0.001	2.291	0.185	2.833	1.406	11.796	1.759	1.729
JB	(0.997)	(0.318)	(0.912)	(0.243)	(0.495)	(0.003)	(0.415)	(0.421)
Canada	EMP_t	m_t	OP_t	OPK_t	rem_t	$resm_t$	q_t	y_t
Mean	0.142	3.785	-0.014	2.500		-1.067	0.095	-14.039
Median	0.212	3.839	-0.016	2.500		-1.047	0.088	-14.044
Maximum	2.386	3.970	0.027	2.500		-0.789	0.196	-13.864
Minimum	3.499	3.521	0.041	2.500		-1.508	0.018	-14.206
Std. Dev	1.373	0.140	0.041	0.000		0.210	0.050	0.102
	1.012	2.688	2.652			2.558	1.421	1.512
JB	(0.603)	(0.261)	(0.266)			(0.278)	(0.491	(0.469)
Germany	EMP_t	m_t	OP_t	OPK_t	rem_t	$resm_t$	q_t	y_t
Mean	0.318	4.004	0.011	2.500	9.847	-0.719	0.148	4.520
Median	0.483	4.078	0.006	2.500	9.839	-0.649	0.150	4.559
Maximum	5.194	4.162	0.079	2.500	10.097	-0.399	0.386	4.641
Minimum	-4.216	3.753	-0.019	2.500	9.556	-1.238	-0.062	4.373
Std. Dev	2.119	0.139	0.026	0.000	0.164	0.216	0.122	0.095
	0.730	3.427	5.949		2.262	3.097	0.545	3.239
JB	(0.694)	(0.180)	(0.051)		(0.323)	(0.215)	(0.761)	(0.198)
Italy	EMP_t	m_t	OP_t	OPK_t	rem_t	$resm_t$	q_t	y_t
Mean	0.094	3.967	-0.023	0.818	9.168	-0.757	3.234	6.337
Median	0230	4.006	-0.045	0.447	9.336	-0.719	3.235	6.348
Maximum	4.982	4.061	0.315	2.500	9.882	-0.461	3.382	6.442
Minimum	-3.483	3.886	-0.275	-1.831	8.385	-1.178	3.089	6.191
Std. Dev	2.144	0.052	0.170	1.671	0.417	0.181	0.082	0.077
	0.413	3.036	1.362	2.587	2.178	2.075	0.659	1.999
JB	(0.813)	(0.219)	(0.506)	(0.274)	(0.337)	(0.354)	(0.719)	(0.368)

Note: In this table we see descriptive statistics for Exchange Market Pressure (EMP_t), monetary aggregate (m_t), trade openness (OP_t), capital openness (OPK_t), real exchange rate (q_t), remittances (rem_t), reserve import ratio ($resm_t$), and real Gross Domestic Product (y_t). Std. Dev. and *JB* Denotes standard deviation and Jarque-Berra normality test. Probability values are given in parentheses.

Descriptive Statistics of Individual Countries

Japan	EMP_t	m_t	OP_t	OPK_t	rem_t	$resm_t$	q_t	y_t
Mean	-0.893	4.421	0.022	2.270	8.972	-0.330	2.012	6.578
Median	-0.332	4.561	0.024	2.500	9.108	-0.389	2.002	6.635
Maximum	3.449	4.812	0.040	2.500	9.559	0.264	2.189	6.700
Minimum	-5.404	3.854	-0.009	1.167	8.114	-0.759	1.876	6.365
Std. Dev	2.264	0.315	0.012	0.401	0.459	0.319	0.080	0.106
	0.372	3.341	6.493	21.917	2.156	1.652	1.134	3.373
JB	(0.830)	(0.188)	(0.038)	(0.000)	(0.340)	(0.438)	(0.567)	(0.185)
Korea	EMP_t	m_t	OP_t	OPK_t	rem_t	$resm_t$	q_t	y_t
Mean	0.061	6.209	0.001	-0.484	8.353	-0.618	3.021	6.577
Median	0.213	6.206	-0.008	-0.086	8.592	-0.645	3.004	6.618
Maximum	2.144	6.759	0.097	-0.086	9.523	-0.052	3.259	6.937
Minimum	-2.558	5.670	-0.093	-1.136	6.301	-1.059	2.915	-6.155
Std. Dev	1.018	0.364	0.043	0.518	0.868	0.338	0.075	0.254
	3.025	1.959	0.121	4.907	6.311	2.299	9.890	2.392
JB	(0.217)	(0.375)	(0.941)	(0.086)	(0.043)	(0.317)	(0.007)	(0.302)
Malaysia	EMP_t	m_t	OP_t	OPK_t	rem_t	$resm_t$	q_t	y_t
Mean	-0.029	3.244	0.008	1.354	8.282	-0.384	0.428	3.360
Median	0.149	3.211	-0.003	1.246	8.312	-0.390	0.423	3.359
Maximum	5.845	3.789	0.159	2.500	9.754	-0.204	0.583	3.718
Minimum	-4.241	2.630	-0.133	-0.086	7.024	-0.579	0.237	2.969
Std. Dev	2.100	0.357	0.084	1.031	0.931	0.117	0.111	0.236
	1.158	2.019	1.559	2.595	2.205	1.583	1.771	1.159
JB	(0.560)	(0.364)	(0.458)	(0.273)	(0.332)	(0.453)	(0.413)	(0.308)
Pakistan	EMP_t	m_t	OP_t	OPK_t	rem_t	$resm_t$	q_t	y_t
Mean	0.753	3.949	-0.028	-1.160	6.155	-0.846	1.633	4.521
Median	0.634	4.021	-0.036	-1.136	6.095	-0.886	1.666	4.551
Maximum	5.349	4.250	0.051	-1.136	7.000	-0.076	1.837	4.781
Minimum	-3.391	3.603	-0.084	-1.831	5.608	-1.397	1.379	4.188
Std. Dev	1.894	0.174	0.030	0.131	0.365	0.343	0.143	0.177
	0.251	1.793	5.837	735.995	1.266	1.831	1.959	2.063
JB	(0.882)	(0.408)	(0.054)	(0.000)	(0.531)	(0.400)	(0.375)	(0.356)

Note: In this table we see descriptive statistics for Exchange Market Pressure (EMP_t), monetary aggregate (m_t), trade openness (OP_t), capital openness (OPK_t), real exchange rate (q_t), remittances (rem_t), reserve import ratio ($resm_t$), and real Gross Domestic Product (y_t). Std. Dev. and *JB* denote standard deviation and Jarque-Berra normality test. Probability values are given in parentheses.

Descriptive Statistics of Individual Countries

Singapore	EMP_t	m_t	OP_t	OPK_t	rem_t	$resm_t$	q_t	y_t
Mean	-0.326	2.868	0.071	2.246		-0.315	0.159	2.932
Median	-0.039	2.902	0.096	2.500		-0.288	0.162	2.932
Maximum	5.648	3.342	0.229	2.500		-0.124	0.234	3.319
Minimum	-5.341	2.278	-0.130	-0.086		-0.563	0.076	2.491
Std. Dev	1.827	0.346	0.106	0.572		0.129	0.044	0.256
	19.233	2.029	2.014	108.303		1.815	1.081	2.152
JB	(0.000)	(0.363)	(0.365)	(0.000)		(0.404)	(0.582)	(0.341)
Korea	EMP_t	m_t	OP_t	OPK_t	rem_t	$resm_t$	q_t	y_t
Mean	0.116	3.756	-0.010	2.182	9.338	-0.845	-0.197	3.938
Median	-0.077	3.818	-0.012	2.500	9.309	-0.836	-0.203	3.933
Maximum	5.455	4.211	0.029	2.500	9.588	-0.497	-0.004	4.098
Minimum	-6.398	3.326	-0.051	-0.782	9.138	-1.099	-0.294	3.803
Std. Dev	2.043	0.296	0.018	0.861	0.119	0.153	0.062	0.094
	12.530	2.336	0.043	109.274	0.921	1.018	7.265	1.847
JB	(0.002)	(0.311)	(0.979)	(0.000)	(0.631)	(0.601)	(0.026)	(0.397)

Note: In this table we see descriptive statistics for Exchange Market Pressure (EMP_t), monetary aggregate (m_t), trade openness (OP_t), capital openness (OPK_t), real exchange rate (q_t), remittances (rem_t), reserve import ratio ($resm_t$), and real Gross Domestic Product (y_t). Std. Dev. and *JB* denote standard deviation and Jarque-Berra normality test. Probability values are given in parentheses.

Chapter Eight

Conclusion

In this thesis, we have examined Exchange Market Pressure and monetary authorities' response to market pressure on Pakistan. Exchange market pressure refers to money market disequilibrium that arises due to non-zero excess demand of money. It is therefore not directly observable; the channels that restore money market equilibrium are used for measuring the extent of foreign exchange market disequilibrium. In a fixed exchange rate system, money market operations denoted as Central Bank's buying and selling of foreign exchange reserves are used for measuring foreign exchange market disequilibrium. On the other hand, exchange rate changes reflect foreign exchange market disequilibrium under a flexible exchange rate system. Simultaneous changes in exchange rate and foreign exchange reserves characterise foreign exchange market disequilibrium under a managed float.

Pakistan's exchange rate regime has evolved in different phases. After its emergence, Pakistan adopted a fixed exchange rate regime. This system continued till 8th January, 1982, when Pakistan switched from a fixed exchange rate to a managed float system. Since its switch to managed float, the exchange rate of Pakistan has consistently depreciated against US dollar, but at the same time, the country's foreign exchange reserves have also increased substantially. This makes Pakistan a suitable country to evaluate whether it is upward or downward pressure that has remained dominant over the entire sample period and evaluate the monetary authority's response by constructing exchange market pressure and the intervention index over the given sample period. We adopt Weymark's (1995) approach to evaluate the pressure on Pakistan's domestic currency and the monetary authority's response to exchange rate fluctuations. This approach has the advantage of enabling us to examine what fraction of pressure the Central Bank relieves through the purchase and sale of foreign exchange reserves. The intervention index values are then used to identify the extent that the Central Bank allows the exchange rate to adjust to its market determined value. It is therefore ideally suited to single country analysis.

In Chapter Four we used difference data and the two-stage least square approach. Difference data is used to overcome a non-stationary problem that yields spurious regression when used with the ordinary least square technique. In addition, we used the two-stage least square approach to address the endogenity problem. The endogenity problem arises when the dependent and one or more independent variables are simultaneously determined. This does not yield unbiased parameter estimates. We used the instrumental variable technique to overcome the endogenity problem. It is argued that the instruments used must be correlated with endogenous variables but not correlated with the model's error term. The results indicate weakening pressure and active Central Bank intervention. The intervention index mean value of 0.61 suggests that Central Bank relieved sixty one percent of the pressure by the sale and purchase of foreign exchange reserves. Exchange rate changes absorbed the remaining thirty one percent of the pressure. The use of difference data, although overcomes the non-stationary issue, results in the loss of vital information about a long-term relationship if one exists. It is argued that the linear combination of non-stationary variables yields a non-stationary outcome. It may be the case that a linear combination of non-stationary variables may result in stationary variables. Such an outcome provides evidence for the presence of a long-term relationship. The fifth chapter tests the presence of a long-term relationship using Johansen's (1988) and Johansen and Juselius' (1990) approach. The results indicate the presence of a long-term relationship among the variables of interest. The exchange market pressure and intervention index based on Johansen's (1988) and Johansen and Juselius' (1990) approach show dominant depreciating pressure and active Central Bank intervention. The intervention index mean value of 0.73 shows that exchange rate and foreign exchange reserve changes relieved twenty-seven and seventy-three percent of the pressure respectively. The evidence thus gathered from the cointegration approach further supports the Chapter Four's finding of dominant downward pressure during the 1980s, 90s and 2000s for Pakistan and active Central Bank intervention.

The preceding two chapters used a fixed parameter approach. However, a fixed parameter approach is considered to be one of the important factors in the poor performance of exchange rate models. It is argued that economic conditions do not remain time invariant. They keep changing with the passage of time. A fixed parameter approach has the disadvantage of not taking into account of the effects of structural changes on parameter constancy. This is an issue that we addressed in Chapter 6, uing the Kalman filtering approach. The basic objective is to evaluate the effects of structural changes on parameter constancy. The structural changes that have taken place over the given sample period include: Pakistan's switchover from a fixed to a managed float exchange rate system, the introduction of an interest-free banking system in 1981 and the subsequent replacement of interest-bearing deposits with a system based on a profit and loss sharing principle on July 1st, 1985 (Khan, 1994; Ahmad and Khan, 1990), the denationalisation of public sector banks, the enhancement of Central Bank authority over the financial system, the imposition of sanctions on the country in the wake of nuclear explosions and the lifting of these sanctions after Pakistan's decision to cooperate with the international community in its war against terrorism. The results indicate parameter instability over the entire sample period. The Kalman filter estimates of exchange market pressure and intervention index show dominant depreciating pressure and active Central Bank intervention. The intervention index mean value suggests that the Central Bank relieved seventy-five percent of the pressure by the purchase and sale of foreign exchange reserve. Exchange rate changes absorbed rest of the pressure. This further confirms our earlier finding in Chapters

Four and Five that provide evidence of weakening pressure and active Central Bank intervention.

In the last three chapters, we used Weymark's (1995) approach and constructed exchange market pressure and intervention indices for Pakistan. We were primarily interested in checking the direction of pressure and the fraction of pressure that the Central Bank relieved through the purchase and sale of foreign exchange reserves. In these chapters, we assumed direct foreign exchange intervention that is reflected in foreign exchange reserve changes. It may be the case that the Central Bank intervenes indirectly by changing the interest rate to influence prevailing pressure on domestic currency. In such a situation, the interest rate constitutes another channel that monetary authorities can use for warding off pressure. In such a case, interest rate constitutes a valid component of exchange market pressure index and the studies that drop the interest rate do not reflect the true extent of the pressure.

There is ample evidence that Central Banks do use interest rates for fending off speculative attacks. Dominguez and Kenen (1992) and Edison (1993) show that governments that adhered to the exchange rate rules of the European Monetary System used the interest rate as a monetary policy instrument for keeping the exchange rate within the band prescribed by the European Monetary System. Shah et al (2009) and Hussain and Jalil (2007) use pure intervention data and show that Central Bank intervention is effective as it affects exchange rate level and reduces exchange rate volatility.[93] Eichengreen et al. (1996) constructed an Exchange Market Pressure index that consists of percent changes in exchange rate, relative interest rate differential changes and relative percent changes in foreign exchange reserves. They use the inverse of variance approach for assigning weights to the components of Exchange Market Pressure. This ensures that more volatile components do not dominate the pressure index.

[93] Pure intervention refers to a Central Bank's purchase and sale of foreign exchange reserves aimed at targeting exchange rate stability.

Chapter Seven used Eichengreen et al.'s (1996) approach and examined the determinants of the Exchange Market Pressure index in a panel of ten countries. It examined whether Exchange Market Pressure is affected by a range of macroeconomic indicators, policy variables and measures of openness. The results indicate that exchange market pressure is negatively related to reserve import ratio, trade openness and the real exchange rate. This has an important policy implication for countries that want to avoid pressure on their currencies, i.e. they have to keep in check the developments of macroeconomic indicators and measures of openness. Particularly, they have to maintain a high reserve import ratio, keep their external trade open to the rest of the world and maintain a competitive real exchange rate to avoid speculative attacks on their currencies.

To summarise, this thesis has found that downward pressure has remained dominant over the entire sample period for Pakistan and active Central Bank intervention. It further shows that the Central Bank allowed limited flexibility for the exchange rate to adjust to its equilibrium value. This may be due to the fear of the monetary authorities that exchange rate changes may influence domestic macroeconomic variables. Particularly, it may reflect their fear that exchange rate changes may increase domestic prices and the foreign debt burden of the country. Finally, panel determinants of exchange market pressure show that reserve import ratio, trade openness and real exchange rate explain exchange market pressure. This implies that in order to avoid pressure on domestic currency, monetary authorities have to keep in check the developments in these variables.

Contribution to the Literature

This thesis contributes to the literature by finding that it is downward pressure that has remained dominant over the entire sample. Further, it finds active Central Bank intervention. This may reflect monetary authorities fear that exchange rate changes may influence country's foreign debt burden and domestic price level. Further, we find active Central Bank intervention. It shows the extent that Pakistan's Central Bank allows to market forces in the determination of domestic currency's value in the foreign exchange market. This has an important policy implication that monetary authorities are not independent in formulating an independent monetary policy. Lastly, we find that trade openness; capital openness and real domestic income are the important determinants of exchange market pressure in a panel of ten countries.

Policy Recommendations

In this thesis, we have used Weymark's (1995) and Eichengreen et al.'s (1995) approaches. We used Weymark's (1995) approach to identify the direction of pressure and evaluate monetary authorities' response function. The results indicate downward pressure and active Central Bank intervention. Furthermore, we found evidence that Central Bank intervention is successful in reducing exchange rate volatility. This shows that Central Bank intervention is of considerable importance in reducing exchange rate volatility.

The estimates of panel determinants of Exchange Market Pressure show that Exchange Market Pressure is explained by trade openness, capital openness and domestic real income. This has policy implications, in that the countries that want to avoid pressure on their currencies have to monitor the developments of these variables. They should keep their trade and capital account open with the rest of the world. At the same time, they have to monitor the growth of domestic real income. This will enable them to avoid pressure on their currencies in the foreign exchange market.

Limitations of the Study

In this study we used general changes in foreign exchange reserves to proxy Central Bank foreign exchange market intervention. However, this is not a perfect proxy to represent Central Banks' foreign exchange market intervention. This is evident from Mastropasqua et al. (1988), who report that for the period 1983-1985, French Central Bank intervention in the foreign exchange market amounted to US $2.7 billion. For the same period, there were US $9.6 billion changes in foreign exchange reserves. This shows the extent of the difference between the general changes in foreign exchange reserve and the changes that occur due to a Central Bank's foreign exchange intervention policies. It may even be the case that a Central Bank may use a stand-by credit facility (SCF) provided by the International Monetary Fund to countries to meet their short term financial needs.[94] In such a case, it is not necessary for the Central Bank to raise the interest rate or change foreign exchange reserves to restore foreign exchange market equilibrium. Even Central Banks do not provide information about off balance sheet transactions and forward market intervention aimed at relieving market pressure.

Another issue is of frequency of data. Quarterly data is not a suitable proxy to approximate Central Bank intervention. Central Banks relieve pressure within hours or days by either raising interest rates or changing foreign exchange reserves. In such a case, quarterly data may not be of sufficient periodicity to measure the extent of the market pressure and Central Bank's intervention policy. Sometimes countries may even restrict capital movements across countries to avoid defaulting on foreign payments or the collapse of exchange rate regime. Given these data limitations, it is important to be cautious in interpreting the results of this study.

[94] SCF is offered by the International Monetary Fund to low-income countries that have attained a certain level of economic development but need financial support to cope with short-term financial needs. It helps countries to continue the programmes that are aimed at fostering economic growth and macroeconomic stability in the country.

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