Exchange Market Pressure and Monetary Policy in India

A Thesis submitted for the Degree of

Doctor of Philosophy in Economics

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Declaration

This is to state that the research work embodied in the thesis entitled **"Exchange Market Pressure and Monetary Policy in India"** submitted to the Department of Economics, University of Hyderabad for the award of degree of Doctor of Philosophy in Economics is original, carried out by me under the supervision of Dr. Vathsala Narasimhan, Reader, Department of Economics, University of Hyderabad.

I declare to the best of knowledge that no part of the thesis was earlier submitted for the award of any degree, diploma, fellowship or any other similar title of recognition to any university or institute.

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Mirza Allim Baig

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Chapter 1

Background, Issues and Objectives of the Study

1.1 Exchange Rate Management in the World

The international monetary system has undergone significant changes over the years. Historically, there have been different exchange rate systems. During the period 1870-1914 countries had gold standard system in which each currency had a specified official value in terms of gold. At the specified value, the central bank exchanged domestic bank notes for gold coins. This system continued to exist until World War I. But, thereafter, the gold standard started losing its importance as the post-war international monetary relations witnessed many changes. Though some developed countries attempted to restore the gold standard in the mid-1920s, it lost its relevance with the advent of the 'great depression'. The inter-war period (1918-1939) at first witnessed fixed, and later, managed or freely floating exchange rate regimes.

The ever-changing international monetary environment called for a new international monetary system. The Bretton Woods system was born out of that need. The essential features of the Bretton Woods agreement were drawn up in July 1944 with the hope to design an international monetary system that would foster full employment and price stability while allowing individual countries to attain external balance by imposing restrictions on international trade. However, it was not put into operation until 1959. During this period most of the currencies of the industrialized countries remained inconvertible. This period was marked by substantial control on foreign exchange transactions.

Under Bretton Woods agreement, US dollar was the intervention currency and it had a fixed parity with gold at $35 per ounce. The official exchange rate was allowed to vary within a narrow range of 1 percent around the fixed rate. The US dollar alone was allowed to convert into gold. while the remaining currencies were allowed to convert to dollar. Member countries held their official international reserves largely in the form of gold or dollar assets and had the right to sell the dollars to the Federal Reserve for gold at the official price. Subsequently, the system turned out to be a little flexible and the exchange rate was allowed to move within a narrow band, which could be more than one per cent of the official rate. This gave birth to the adjustable peg system. This system of Bretton Woods could not last long due to the lack of confidence in the dollar value arising out of inflationary pressure in US. This had unambiguously strengthened the currencies of other countries against US dollar and as a result, the leading countries deliberately destabilised the system. The Bretton Woods system finally collapsed in March 1973.

In March 1973, countries moved into market based exchange rate system wherein exchange rate was determined by market forces. But practically, most of the developing as well as developed countries continued with a sort of pegged exchange rate regime and eventually moved into a new system of stable but adjustable rates, called managed floating system. Today, most countries follow a managed float system in which market forces determine the exchange rate, but central banks intervene in the foreign exchange market to even out excess fluctuations in the exchange rate.

In reality there is a spectrum of regimes, such as, those with no separate legal tender (including formal dollarisation and currency unions), conventional fixed peg, pegged exchange rate with horizontal bands, crawling pegs, crawling bands, managed float with predetermined path for exchange rate, and independent floating regime where intervention is only to smooth out fluctuations in exchange rate arising out of speculations. The IMF in 1999 classified these regimes, on the basis of de facto policies followed, into three broad categories, namely, pegged, limited flexibility (within a range), and more flexible (managed or free float) exchange rate regimes.

It has been noted that indirect intervention in the form of foreign exchange controls and regulations has been increasingly relaxed, facilitating greater capital mobility, but various forms of pegged regimes remained the more dominant form of monetary arrangement. At the beginning of 1990s, 80 percent of the countries followed pegged regimes (at the end of 1997, only 46 out of the 184 member countries of the IMF permitted their currencies to float independently). At the end of 2001, the figure had come down to 56 percent following pegged regimes; but there has been a noticeable shift from softer to harder pegs. Fischer (2001) claims that intermediate regimes have decreased with countries shifting to either greater flexibility or greater fixity. Baula and Okker-Robe (2002) show that at the end of 1990, 15.7 percent of the member countries followed a hard peg, 69.2 percent followed intermediate regimes (comprising soft pegs and tightly managed floating regime), and 15.1 percent followed floating regimes (comprising independent floats and managed float with no predetermined exchange rate path). By the end of 2001, 25.8% followed hard peg, 38.7% followed intermediate regime and 35.5% followed floating regimes. Interestingly, the trend away from intermediate regimes towards greater flexibility or fixity is accounted for by developed countries and countries with emerging markets already or increasingly integrated with the international financial market. Developed countries are shifting towards hard peg arrangements and floating regimes, whereas both developing and emerging market countries are shifting more towards floating regimes.[1]

1.2 Exchange Rate Management in India

India has seen various changes in exchange rate policy. Under the Bretton-Woods system of exchange rates, the rupee was pegged to the pound sterling with a fixed parity. The pound sterling had a fixed parity with the intervention currency (dollar). As dollar-gold rate was fixed, the rupee had in turn a fixed parity with gold. The external value of rupee was maintained within a narrow band of ±1% and the exchange rates of the rupee with other currencies were determined on the basis of the cross rates. Following the collapse of Bretton-Woods, until 1975, the rupee continued to be pegged to the pound sterling except very briefly, when it was pegged to the dollar. But the external value of rupee was maintained within a wider ±2.25% range. Pegging of rupee to the floating pound sterling had some obvious disadvantages, since the movement of the rupee vis-à-vis other currencies became

[1] For detail see Baula A. and I. Okker-Robe (2002), "The evolution of exchange rate regimes since 1990: evidence from de facto policies", IMF Working Paper, WP/02/155.

dependent on factors relevant to the pound sterling rather than to the rupee. In fact, the pound sterling was continuously depreciating and India's trade share with UK was declining. Thus the pegging of rupee with the pound sterling caused depreciation of the rupee against other currencies. So, the rupee was delinked from the pound sterling and linked to a basket of currencies on September 25, 1975 in order to overcome the weaknesses of pegging to a single currency.

Under the basket link system, the exchange rate was being determined with reference to the daily exchange rate movements of the undisclosed basket of currencies of the countries that were India's major trading partners. The basket of currencies and weights were kept undisclosed mainly to protect the rupee from speculative attacks.

Over this period, particularly in the later half of the 1980s, the exchange rate management was conducted within the framework of macroeconomic policies for the external sector and activated to achieve a sustainable current account deficit by ensuring improvements in the price competitiveness of exports. But in spite of higher growth of exports, the current account deficit widened owing to internal imbalances and exchange rate misalignment. The Gulf War further widened the current account deficit, which stood at 3.2% of GDP in 1990-91. The nominal value of the rupee against dollar depreciated continuously during 1980-81 to 1990-91. The depreciation was around 127%. However, the nominal effective exchange rate (NEER) of the rupee (on the basis of 36-country trade-based weight) appreciated by 35%, whereas real effective exchange rate (REER) appreciated by 28% during the same period. As a result, capital outflows occurred in the form of withdrawal of NRI deposits. This led to a balance of payments crisis, manifested in low reserves. So in order to build up investors' confidence and also to improve domestic competitiveness, RBI effected two sharp downward exchange rate adjustments, in July 1991 (July 1 and 3), of the order of 18-19 percent in the external value of the rupee.[2]

[2] For details, see Report on Currency and Finance, 1998-99, RBI, pp. x-14 to x-15.

The existing market conditions in the early 1990s,[3] along with the growing openness of the economy and financial market integration necessitated a shift towards flexible exchange rate regime. In March 1992, the RBI introduced a dual exchange rate system in which 40 per cent of current transactions are carried out at official rate and the rest was determined by market forces. In March 1993, the exchange rate was unified, thus shifting to a market determined exchange rate system. Under this system, exchange rate is fully determined by market forces albeit with RBI's intervention in the market.

Since the introduction of a market based exchange rate regime, the RBI has been pursuing a package of policy measures including institutional reforms in the direction of current account and capital account convertibility. Overall, these measures provided tax concessions, repatriation benefits and larger freedom in deploying funds to encourage capital inflows. External funds were mobilized through schemes like Resurgent India Bonds to the tune of US$ 4.23 billion and India Millennium Deposits to the tune of US$ 5.51 billion. These policy measures, coupled with downward rigidity of domestic interest rates and persistent fall in foreign interest rates, have contributed to large inflows of foreign exchange reserves. Inflows of foreign exchange reserves put a pressure on the exchange rate, and the RBI has periodically intervened in the market to keep it at desired levels. For instance, during the period March 1993 to March 1995 the inflows to the country put pressure on exchange rate to appreciate and RBI directly intervened in the market through purchase of foreign exchange reserves. In the process nominal exchange rate was kept unchanged at around Rs. 31.37 per US dollar with 0.4% appreciation on an average. This order of appreciation induced a market correction over the second half of 1995-96. With a view to ensuring orderly conditions in the market, RBI made tactical intervention sales although claiming to simultaneously let the market forces to operate to a level consistent with the fundamentals.

With the restoration of normalcy in the market, there was a resumption of capital flows in 1996-97 continuing into early parts of 1997-98 and RBI absorbed

[3] The details of the market conditions in the external sector are discussed in the following section.

the excess supply of foreign exchange during April to September 1997 through net purchases of foreign currency. In the early parts of 1997-98, the contagion of the East Asian crisis was felt. During this crisis, the RBI strongly intervened in the market to cover the rupee from speculative attacks. The acute exchange market pressure during September 1997 to mid-January 1998 was moderated by sale of foreign currency. Reflecting the impact of economic sanctions following the Pokhran tests, exchange rate depreciated to 42.38 on 11 June from 40.47 in March 1998. In order to arrest volatility and restore orderly market condition in the foreign exchange market, the Reserve Bank announced a set of monetary and related policy measures on June 11, 1998 [RCF, 1998-99, p. x-19].

Then during the Russian financial turmoil, together with the fear of Chinese renminbi devaluation, there was turbulence in the foreign exchange market, which weakened the rupee. The Reserve Bank on August 20, 1998 undertook monetary measures, which induced confidence in the rupee. The corrections in the exchange rate during 1997-99 occurred despite the overall balance of payments surpluses in both the years. The RBI claims this was due to the exchange rate policy, which made tactical interventions, supported by appropriate monetary and other policy measures.

However, the substantial liberalization of foreign exchange market, current account convertibility and phased move towards capital account convertibility has increased the vulnerability of the economy to external shocks. As a result, the purpose of RBI's intervention in foreign exchange market has taken another dimension in recent times of financial turmoil. The RBI has stated that "with the changing profile of capital flows, the traditional approach of assessing reserve adequacy in terms of import cover has been broadened to include a number of parameters which take into account the size, composition and risk profiles of various types of capital flows as well as the types of external shocks to which the economy is vulnerable" (RBI Annual Report 2000-01, Para 6.28).

Reflecting these developments in the financial markets and policy framework regarding exchange rate management, the reserve management strategy has eventually seen some fundamental changes. For instance, The High Level Committee on Balance of Payments (1993) under the Chairmanship of Dr. C. Rangarajan had recommended that while deciding the adequacy of foreign exchange reserves attention must be given to ensuring confidence in the international financial and trading communities, uncertainties arising out of monsoon conditions, speculative tendencies or anticipatory actions amongst market players, and cost of carrying international liquidity etc.

Recognising these arguments the Annual Report of the RBI (1996-97) had stressed the need to take into account the external debt servicing obligations and flow of capital in assessing the stock of international reserves to be held. The Committee on Capital Account Convertibility (1997) under the chairmanship of Shri S.S. Tarapore has devised alternative mechanisms to decide the adequacy of reserves. The important factors that are inbuilt into such mechanisms are volume of trade with due consideration for leads and lags in export and import, debt service obligations, and domestic liquidity position.

In this context, Dr. Y.V. Reddy (1998), the former Deputy Governor, Reserve Bank of India, reiterated that exchange rate policy should focus on: (i) reducing excess volatility in exchange rates; while ensuring that the market correction of overvalued or undervalued exchange rate is orderly and calibrated; (ii) maintaining an adequate level of foreign exchange reserves; and (iii) eliminating market constraints with a view to the development of a healthy foreign exchange market. The conduct of monetary policy in this respect involves sales and purchases of foreign currency in the foreign exchange market; basically to even out lumpy demand or supply in the thin foreign exchange market with no predetermined target or band around the exchange rate.

Y.V. Reddy (2002) has further emphasized that it is essential to enhance the capacity to intervene in the foreign exchange market through appropriate foreign exchange reserve management. This would help limit external vulnerability and absorb shocks during times of crisis including national disasters or emergencies. These fundamental shifts in policy emphasis reflect the fact that capital flows and speculative activities of market players emerged as important determinants of exchange rate as against trade deficit and other fundamental factors. As a result of these shifts in policy emphasis, the net foreign exchange assets of the RBI has steadily grown from US$ 5.8 billion as on 31 March 1991 to US$ 57.96 billion as on 28 June 2002. In the words of Y. V. Reddy, "the period 1990 – 2002 has been a journey from *agony* to *comfort* in matters relating to foreign exchange reserves".

Overall, the monetary policy regarding exchange rate management during the market based exchange rate regime reflects the objective of keeping the foreign exchange market "orderly" and "calibrated".

1.3 Developments in the External Policy

Through the 1970s, the trade policy had been in the form of selective restrictions and controls on imports and on foreign investment flows. Through the 1980s there had been a gradual opening up of the economy. In the 1980s, there was a partial liberalization as a policy initiative for technological upgradation with a selective removal of restrictions. This had led to capital inflows, but this consisted largely of foreign direct investment (FDI) in certain restricted sectors, commercial borrowing and NRI deposits. Capital markets were closed to foreign investors and only a limited amount of portfolio investment took place.

During early 1990s several other major steps were taken for the opening of the economy. After liberalisation government's policy was shifted from official borrowing to direct foreign investment. Measures were taken to attract foreign investment in the form of both FDI and portfolio investment. In February 1992, the government announced that Indian firms could also raise funds through equity and convertible bond issues in the Euro market.

Removal of exchange restrictions on imports through abolition of foreign exchange budgeting in the beginning of 1993-94 constituted the first step towards current account convertibility. A major step towards current account convertibility was taken in March 1993 when the foreign exchange budget was abolished, and transactions on trade account were freed from exchange control. The exchange rate was unified, thus shifting to a market determined exchange rate system.

In 1994-95 the next step in this direction was taken with the Reserve Bank announcing relaxations in payment restrictions in the case of a number of invisible transactions. In the budget announcement in February 1994, the liberalisation of exchange control regulations up to a specified limit relating to exchange earners' foreign currency accounts, basic travel quota, studies abroad, gift remittance, donations and payments of certain services rendered by foreign parties, were placed. The final step towards current account convertibility was taken in August 1994 by further liberalisation of invisibles payments and acceptance of the obligation under VIII of the IMF, under which, India is committed to forsake the use of exchange restrictions on current international transactions as an instrument in managing balance of payments. The major steps were more relaxation on current account payments; clarification that limits specified earlier were only indicative in nature and the RBI will favourably consider bona fide requests for additional exchange facilities; the foreign currency non-resident accounts (FCNRA) schemes, under which the maturities were gradually discontinued, was terminated with effect from Aug 15, 1994; interest accrued under non-residents (non-repatriable) rupee deposit scheme was made repatriable from the quarter beginning Oct 1, 1994; foreign currency (ordinary) non-repatriable deposit scheme (FCON) was discontinued with effect from Aug 20, 1994 and interest on existing FCONR deposits was made eligible for repatriation up to the maturity date of the existing deposits from Oct 1, 1994; repatriation of investment income by non-resident Indians was allowed in a phased manner over a 3 year period after the payment on tax as per the provisions of the income tax act.[4]

On the front of the capital account, during 1990s, removal of existing capital controls continued to be carried out slowly. Since 1991, several measures have been taken to shed direct and indirect barriers to foreign direct investment and foreign portfolio investment has been encouraged. In 1992, the government allowed Indian firms to raise funds through equity and convertible bond issues in the Euro market and also allowed portfolio foreign investment in the Indian capital market by

[4] For detailed discussion, see Economic Survey, 1994-95.

permitting foreign institutional investors (FIIs) to access capital markets on registration with the SEBI. In 1994 the SEBI permitted listed companies to make preferential allotment of equity shares to FIIs for an amount not exceeding 15 per cent of the equity of the Indian company, provided that the aggregate of FII, NRI and OCB investment does not exceed 24 per cent of the enlarged equity of the company. The ceiling of holding of a single FII in an Indian company was gradually widened from 5 per cent (1996 budget) to 10 per cent in 1997. In 1997, the capital account was further liberalized, allowing resident individuals (and companies) to invest part of their savings in foreign assets.

The external commercial borrowings (ECBs) are also on the rise, with many of the regulations on ECBs being removed gradually. In June 1996, the Finance Ministry announced all infrastructure projects would be permitted to access ECBs up to 35 per cent of their total project cost. In case of power and other infrastructure projects, even greater flexibility has been introduced. Indian corporates, especially those in the key infrastructural sectors, are given far greater flexibility in accessing commercial debt and equity funds from abroad. During 1997-98, further steps were taken to liberalise ECBs like, power to sanction up to US $3 million has been delegated to the RBI; corporations having foreign exchange earnings are now permitted to raise ECBs up to twice the average amount of annual exports during the previous three years, subject to a maximum of US $100 million (up from US $100 million); holding companies/promoters have been permitted to raise ECBs up to a maximum of US $50 million to refinance equity investment in a subsidiary/joint venture company implementing infrastructure projects; ECBs of 10 years average maturities is now outside the ECB ceiling; and the average maturity requirement for the shipping sector is reduced from seven years to five years for borrowing above US $15 million; prepayment facility would be permitted up to 20 per cent of the present balance outstanding of each ECB across the board for all maturities, etc.

Indian companies were permitted to issue rights/bonus shares and non-convertible debentures to non-residents subject to certain conditions. FDIs in all sectors, except for a small negative list, were placed under the automatic route.

Indian companies engaged in knowledge based sectors like information technology, pharmaceuticals, bio-technology and entertainment software were permitted to acquire overseas companies engaged in the same line of activity through stock swap options up to US $100 million or 10 times the export earnings during the preceding financial year on an automatic basis.

To sum up, there has been growing opening up of the economy, both on the current and capital account, through 1990s. Transactions in the current account are fully convertible and capital account is progressively being opened up. As a result, capital mobility is increased in the recent times.

1.4 Issues and Motivations of the Study

The growing openness of the external sector, particularly in a world environment with increased capital mobility exposes the economy to a great deal of turbulence. The excess capital flows put pressure on the foreign exchange market. Under fixed exchange rate system, the pressure is completely absorbed by a change in foreign exchange reserves. But under a floating exchange rate system the pressure is felt on the exchange rate. The movement in exchange rate directly affects macroeconomic variables like import, export (and therefore the trade balance), price, and output. If the origin of the changes lay in fundamental causes, this may have the beneficial and stabilising effect of bringing the economy in line with the fundamentals. However in a market based exchange rate system, the currency is frequently exposed to speculative attack. This is because a change in exchange rate could generate expectations of further changes, and lead to speculation. For example, if there is an expectation of currency depreciation, immediately the import demand will rise, while exporters would tend to delay their exports till the currency depreciates. This would increase the trade deficit, creating an artificial demand and therefore lead to currency depreciation. Thus, the expectations are self-fulfilling. But this depreciation leads to further changes: imports get restricted and exports rise, creating excess supply and therefore the currency begins to appreciate. Thus speculation increases volatility of the exchange rate movements, even when only the current account is open. The volatile movements in exchange rate also lead to instability of the trade balance and other macro economic variables.

If there is free movement of capital, the fluctuations in the exchange rate, and thus the instability could be further worsened. An expected appreciation of the domestic currency would generate capital outflows from the country leading to a currency crisis. The consequent loss of investors' confidence will have an adverse effect on direct investment as well.

Given the possibilities of all these destabilising movements, there is a need for the monetary authority to intervene to protect the economy. Indeed, the textbook notion of a completely free-floating exchange rate does not hold anywhere, and monetary authorities do intervene to protect the exchange rate whenever it is felt necessary. The intervention could be direct, taking the form of buying/selling foreign exchange both in spot and forward markets. Or, it could be indirect, in the form of various monetary policy measures such as changes in cash reserve ratios, bank rate, open market operations, etc. The direct intervention could in turn be sterilized or non-sterilized.

Clearly this makes the conduct of monetary policy complex. In a closed economy, monetary policy would be directed towards goals of internal stability, and would generally target inflation and output growth. In an open economy there is additional consideration of external stability, and steps are taken to prevent disruptive changes in exchange rate. Direct intervention by the monetary authority to stabilise exchange rate will change the base money, which in turn would affect price and output level. Indirect intervention too requires monetary policy to make a compromise between exchange rate stability, and inflation and output growth in the domestic economy.

The preceding discussion highlights some issues that arise in an open economy with managed floating exchange rates where monetary authorities intervene to keep exchange rate at a desired level, and which provide the motivation for our present study. If we are to study the conditions in the exchange market, it is useful to have a concise measure to characterise these conditions. In a completely market determined exchange rate regime, the total pressure in the market is reflected in observed changes in exchange rate. At the other extreme, in a completely fixed exchange rate regime, exchange market conditions are completely captured by changes in reserves. But in the presence of intervention, a part of the pressure is absorbed in reserve changes, and a part in exchange rate changes, so neither of these would on their own fully reflect market conditions. This points to the need of a summary statistic incorporating changes in both exchange rate and changes in foreign exchange reserves to characterise conditions prevalent in the exchange market. In other words, an index of exchange market pressure is required to study the conditions in the market in a managed float exchange rate regime, with extensive intervention by the monetary authorities. Further, since the conditions are dependent upon the precise extent and nature of intervention, a related need is to find an operational index of intervention activity. Both these measures must necessarily be obtained in the background of the actual economy to be studied, including the nature of monetary policies followed by the authorities. Indeed, the measures arrived at will then allow evaluation of the policies.

As noted in the previous section, these are points that are pertinent to the Indian economy as well. After shifting to the market-based regime, the RBI seems to intervene frequently in the market, both directly and indirectly, and has clearly acknowledged this as one of the related objectives of monetary policy. Besides targeting the growth rate of money stock with feedback from expected real growth and a tolerable level of inflation, the RBI has been paying increasing attention on ensuring orderly condition in the market and preventing disruptive changes in the exchange rate. RBI closely monitors the market to ensure exchange rate movement in alignment with the macroeconomic fundamentals.[5] Whenever the rupee is under pressure, the RBI has been resorting to a package of measures that either facilitates net capital inflow or hardens monetary policy to restore normalcy and confidence in the foreign exchange market.

[5] RBI Annual Report, 1995-96, pp. 6.24.

Stemming from this, the objectives of the thesis are summarised in the following section.

1.5 Objectives of the Study

Concisely stated, the objectives of this study are:

(1) To formulate and estimate a suitable open economy model for the Indian economy.

(2) To derive a measure of the exchange market pressure, and to construct an index of the intervention activity of the monetary authorities, based on this model.

(3) To use these measures to study the actual conditions prevailing in the exchange market, and to evaluate the policies followed by the monetary authorities in India, in the market determined exchange rate regime.

1.6 Methodology of the Study

We formulate a small open economy macro model, taking into consideration certain features of the Indian economy including a characterisation of monetary policy. The empirical investigation in the present study has been carried out using time series data at different frequencies for different sample periods. Annual time series has been used for the period 1975-76 to 2001-02, which covers the managed float regime in India, though it is often pointed out that this period has gone through basket link system, dual exchange rate system, and market based exchange rate system. The monthly time series has been used for the period 1993:04 to 2002:03 during which, the RBI followed market based exchange rate system with RBI direct intervention in the foreign exchange market.

The model has been estimated using two stage least square method (2SLS) and a measure of exchange market pressure and an index of intervention activity has been derived following methodology suggested by Weymark (1998). The estimated measures of EMP and IIA are then used to study the conditions prevailing in the exchange market in India over the period of study, and to evaluate the policies followed by the monetary authorities.

1.7 Data and Sources

For the monthly study we have collected data for the period 1993:01 to 2002:03 on the variables; index of industrial production and wholesale price index with base year 1993-94, reserve money, narrow money, broad money, net domestic assets of the RBI, net foreign exchange assets of the RBI, rupee-dollar exchange rate, domestic call money rate, US federal fund rate, US producer price index, libor rate, monthly average of imports. For annual study data on all the above variables are collected except gross domestic product at constant market price[6] for income variable with 1993-94 base, for the period 1973-74 to 2001-02.

All the above data on Indian economy are collected from the 'Handbook of Statistics on Indian Economy' (2001), Reserve Bank of India, Reserve Bank of India Bulletin and RBI Annual Reports of various years. The foreign interest rate (US fund rate) is collected from the website: www.stls.frb.org/fred/data/irates.html. The foreign price (US producer price index) and libor rate of one-month and one year maturities are collected from www.economagic.com/fedstl.htm#ppi.

1.8 Organisation of the Study

The current chapter motivates and introduces the study, spelling out the scope and objective, methodology, variables and data sources. The rest of the thesis is organised into six chapters. In chapter 2, we have critically analysed some theories of balance of payments and exchange rate determination, in section 2.2. From the review, it is found that a measure of exchange market pressure explains well the conditions in the foreign exchange market. We, therefore proceed to review the literature on the measures of exchange market pressure (and index of intervention activity) in section 2.3. Some empirical works in exchange market pressure are reviewed in section 2.4.

In chapter 3, we take a preliminary look at the behaviour of some of the fundamental macroeconomic variables vis-à-vis exchange rate movement in the period of the market based exchange rate regime. This helps us while formulating a

[6] As data on the GDP at constant market price for the later one year is not available we have used the growth rate of GDP at factor cost of that year.

suitable model for the Indian economy.

In chapter 4, we have formulated a suitable open economy macro model for India (in section 4.2), and derived a consistent measure of exchange market pressure (in section 4.3). We have also constructed an index of intervention activity in section 4.3. This is done for the purpose of examining the policy stance of the RBI.

The estimation procedure and empirical results are presented in chapter 5. We have used 2SLS method to estimate the model and estimation result is presented in section 5.3. The measures of exchange market pressure and index of intervention activity are presented and discussed in section 5.4.

Chapter 6 deals with discussion of results and its implications. Some precautionary statements are made in section 6.2. With these precautions, we examine the policy stance of the RBI in the light of our EMP and IIA, in section 6.3. The summary and implications of the study are given in section 6.4.

Finally, we presented the summary of the study followed by limitations of the study and scope for further research in the concluding chapter (chapter 7).

Chapter 2

Review of Literature

2.1 Introduction

Balance of payments disequilibrium and exchange rate determination are very old problems of any open economy and have been recorded quite early in the literature. Several attempts have been made to find out an appropriate theoretical framework to understand balance of payments adjustment and exchange rate determination. The first of these was the purchasing power parity theory, which made its appearance very early and has continued till today. Prior to 1930s, there was no comprehensive theory of balance of payments as such. Under gold standard, the exchange rate between the two currencies was determined by the relative weights of the gold content of the coin. It was fluctuating within a well-defined narrow limit set by the cost of shipping gold between the countries concerned. An automatic balance of payments adjustment was operating through price changes. This system continued up to the outbreak of the World War I in 1914. The attempts made by the leading countries to return to the gold standard in the mid-1920s proved unsuccessful and finally it collapsed with the advent of the 'great depression' of 1930s. Some theories have been developed since then to understand the determinants of balance of payments and exchange rates under different exchange rate systems.

Balance of payments disequilibria and exchange rate variations are seen to be two sides of the same coin. Under fixed exchange rate system the adjustment takes place in balance of payments whereas under floating exchange rate system the exchange rate tends to adjust. However, under intermediate regimes of managed floats, where both balance of payments (as captured through official reserve changes) and exchange rate can vary simultaneously, a new problem comes up as to how to arrive at a cardinal measure of the exchange market conditions. Once such a measure is notionally obtained, different frameworks can be used to explain it. Recent contributions to the literature have looked at this problem. This chapter reviews first the different theoretical frameworks of the exchange market, and then the more current literature on measuring exchange market pressure. It ends by looking at some of the empirical studies made in the Indian context on exchange market pressure.

2.2 Theoretical Approaches to Exchange Rate Determination

2.2.1 Purchasing Power Parity Theory

One of the oldest and most widely used frameworks for assessing long-term movements of exchange rates is derived from purchasing power parity (PPP) theory advocated by Cassell (1918). It simply asserts the relationship between exchange rates and prices. Any variation of PPP relies on the 'law of one price', which states that the price of any tradable good is the same in any place when the price is quoted in terms of the same currency under the assumption that there are competitive free markets, and no tariffs, no transport costs, and non-tariff barriers. There are two variants of this theory: the absolute version and relative version. The absolute version of PPP states that the exchange rate between the currencies of the two countries is equal to the ratio of price levels in the two countries. That is, $E_t = \frac{P_t}{P_t^*}$, where E_t, P_t, and P_t^* are the exchange rate, domestic price level and foreign price level respectively at time t. The PPP theory therefore predicts that when the domestic price level increases (decreases) relative to the foreign price, domestic currency depreciates (appreciates) proportionally. The basic idea is that goods markets are integrated, and hence if there is price differential across the countries then arbitrage takes place and finally the price levels get equalised.[1]

However, in reality, most of the traded goods are differentiated products and the consumption baskets across countries differ. This questions the empirical validity of the absolute version of PPP theory at aggregate level. This problem is overcome by reverting to the relative version of PPP, which states that the percentage variation in the exchange rate equals the percentage variation in the ratio

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[1] It is to be noted that, if the law of one price holds for every commodity in the commodity basket then PPP holds automatically but the reverse may not be necessarily true.

of the price levels of the two countries. It can be written as: $\frac{E_t - E_{t-1}}{E_{t-1}} = \frac{P_t - P_{t-1}}{P_{t-1}} - \frac{P_t^* - P_{t-1}^*}{P_{t-1}^*}$.

Another major problem with the PPP as stated is that it is supposed to hold for all types of goods. A more general version distinguishes between traded and non-traded goods. Arbitrage being possible only with traded goods, the PPP would hold only for these. Since the aggregate price index is a weighted average of traded and non-traded goods' prices, PPP does not necessarily hold for it. In fact, the relative price of non-traded to traded goods in each country can be shown to influence the exchange rate. Changes in the real prices and hence the exchange rate could be caused by differing rates of productivity in the traded and non-traded sectors, and changing consumption demand patterns.

Empirically, there has not been any clear-cut evidence for the PPP theories in any form. Some of the reasons advanced for this are differences in inflation rates, impediments to trade, the effect of exchange market intervention, etc. This has led to the developments of other models of exchange rate determination, which also look at the balance of payments.

2.2.2 Balance of Payments Approach

The balance of payments approach was motivated by the question of what happens to current account balance when a country devalues its exchange rate. It asserts, basically, that the equilibrium exchange rate is determined when the net inflow (outflow) of foreign exchange arising from current account transactions equals the net outflow (inflow) of foreign exchange arising from capital account transactions. This approach built upon Keynesian models of the economy, and came into existence initially in an era of limited capital mobility. In trying to explain the balance of payments/ exchange rate changes, they view the current account items as autonomous, and the capital account items as accommodating. So these models try to explain factors behind current account deficit. This gave rise to the well-known elasticity approach (Robinson, 1937) and absorption approach (Alexander, 1952). According to the first, the exchange rate necessary to correct a balance of payments imbalance will depend on price elasticities of supply and demand for imports and exports, and particularly on the critical value of the sum of the demand elasticities, known as the Marshall-Lerner condition.

The elasticity approach, however, can be considered to be only a partial equilibrium approach as it ignores other variables that affect the balance of payments. This was taken into account in the absorption approach developed by Alexander. This approach portrays a deficit in current account balance as arising out of an excess of absorption over income. The basic criticism against this approach is that it neglects relative prices of exports and imports, which are taken to be constant.

Different versions of balance of payments flow model, keeping the Marshall-Lerner conditions inbuilt, were developed during the Bretton Woods regime. Of these, the Mundell-Fleming model (Mundell, 1962, 1963; Fleming, 1962) was widely used in theoretical and empirical studies. The Mundell-Fleming model extends the standard closed economy Keynesian IS-LM model to incorporate the role of the balance of payments in an open economy. The model shows that the changes in monetary and fiscal policy, by changing domestic money supply or interest rate, lead to changes in output that cause temporary balance of payments surpluses or deficits. The Keynesian Mundell-Fleming model assumes that price is fixed in the short run. So this leads to changes in exchange rate, which in turn work to restore the balance of payments equilibrium.

While the Mundell-Fleming model took into account international capital flows, the emphasis remained on the current account balance. As such the exchange rate was taken to equilibrate the flows of foreign exchange passing through the exchange market. This aspect came in for criticism in the1970s. It was argued that this flow supply and demand was relevant only for determining the price of non-durable goods, while the exchange rate was determined by the stock equilibrium in the asset market. Hence, the actual volume of domestic and foreign currencies that changes hands in foreign exchange transactions is not relevant for the determination of the equilibrium exchange rate. What is relevant is that, once the exchange rate has changed, the outstanding stock of domestic and foreign currencies is willingly held by the market participants at the new market price.

2.2.3 Monetary Approach

This is an alternative approach to the balance of payments framework, first propounded by Frenkel and Johnson (1976). The basis of this approach is that monetary flows in the exchange market are a consequence of disequilibrium in stock demand and supply of money. Thus balance of payments disequilibrium is essentially a monetary phenomenon, reflecting disequilibrium in the money market. In a fixed exchange rate system, a balance of payments surplus, measured by a fall in the official reserves, reflects an excess demand for money. In a floating exchange rate system, the balance of payments is always in balance, with the excess demand /supply of money leading to a rise/fall in the exchange rate.

The simplest version of the monetary model has a few key assumptions. These are a stable money demand function based on the Quantity Theory of Money, an exogenous money supply assumed to be completely controlled by the central bank, a vertical aggregate supply curve, and PPP holding continuously. Prices are taken to be flexible even in the short run, keeping the economy at full employment. So any disequilibrium in the money market affects aggregate demand and hence the domestic price level. The consequent arbitrage in goods leads to a flow of money through exchange market, which affects exchange rate in case of flexible exchange rate regime or the balance of payments in case of a fixed exchange rate regime. In equilibrium, price level is determined by money supply; and given the PPP relationship, the exchange rate is determined by the relative supply of and demand for the different national money stocks.

This simple model, based upon PPP theory, is concerned with arbitrage in goods alone, and does not say anything about international capital movements. However, the second half of the twentieth century saw tremendous growth of money and capital markets, which allows investors to transfer large amounts of money from one currency to another very quickly. This results in arbitrage in assets denominated in different currencies, based on the expected rate of return on each currency. This has led to the development of sophisticated variants of the monetary model. One major modification is to allow arbitrage in financial assets as well as goods. This is brought in through the interest parity condition that states that the domestic interest rate is equal to the foreign interest rate plus the expected appreciation of the exchange rate. This allows for foreign bonds to be held, but under the assumption that domestic and foreign bonds are perfect substitutes. That is, there is perfect capital mobility and foreign and domestic bonds are equally risky. The other assumption of the simple monetary model are retained except that the money demand function here is taken to be a stable function of interest rate and price. In this version, disequilibrium in the money market affects the domestic interest rate and price level, and therefore the demand for foreign goods and assets leading to monetary flows through the exchange market. Equilibrium is re-established through changes in the exchange rate, till both the interest parity and PPP conditions hold.

This framework, in its simple and more sophisticated versions, has certain implications. In a flexible exchange rate system, the exchange rate is determined entirely by the money market disequilibrium. In a fixed exchange rate regime, money market disequilibrium causes a temporary change in the balance of payments, which results in a change in the official reserves that corrects the original disequilibrium. It does not matter how the disequilibrium occurs. So if the central bank wants to set some exchange rate level, it must change money supply consistently with that objective. In other words, it loses its monetary autonomy. This gives rise to Mundell's (1963) 'Impossible Trinity' argument, which posits the incompatibility of free capital movements, fixed exchange rate and monetary independence. Also, since domestic and foreign bond markets are regarded as a single market, foreign exchange policy conducted through foreign exchange intervention and through domestic credit expansion has exactly the same effect. Yet another implication is that sterilised foreign exchange interventions will have no effect on the exchange rate, since they leave the money supply unchanged. Finally, real variables affect the exchange rate only indirectly through changes in the demand for money.

The fundamental assumptions of the monetary approach have been criticised. One criticism has been that the PPP does not hold continuously. This has given rise to 'sticky price' monetary models (Dornbusch, 1976), which give up this assumption in the short-run, though holding on to it in the long run. Other criticisms are that it is misleading to regard balance of payments imbalances/exchange market disequilibrium as arising exclusively due to monetary decisions, since the causation could be from elsewhere. However, the monetary approach to exchange rate determination does not claim that exchange rate is determined only in money market but it emphasises stock rather than flow variables as being relevant for determining the exchange rate. It claims that whatever the direction of causation, the disequilibrium in the exchange market is ultimately a reflection of money market disequilibrium, and that monetary policy is the only effective means of influencing the exchange rate.

There are however some noticeable omissions in the monetary approach. These are, first, the absence of an explicit role for the current account to influence the exchange rate, and second, the lack of recognition that domestic and foreign bonds may not be perfect substitutes. These are taken into account in the portfolio balance approach to the exchange market.

2.2.4 Portfolio Balance Approach

The monetary approach is essentially an asset market approach. The exchange rate in it is viewed as an asset price that depends on current and expected future values of domestic as well as foreign financial assets. But apart from money, the only assets considered are bonds, with foreign and domestic bonds being considered perfect substitutes. The portfolio balance approach is another version of asset market model, which is a development over monetary approach to exchange rate determination in that it recognises the presence of assets different from money and bonds. In fact the distinguishing feature of this class of models is that it differentiates between domestic and foreign bonds mainly due to the presence of country risk. Given that investors are risk averse, they will require a higher expected return on more risky assets. Thus, the uncovered interest parity is no longer taken to hold, but a risk premium is allowed to drive a wedge between the rate of return on domestic and foreign bonds. Equilibrium in these models requires that participants in the markets should willingly hold the stock of all financial assets.

The basic idea behind portfolio models is that individuals hold their wealth in the form of a portfolio of different financial assets (which, for the present purposes can be thought of as money, domestic and foreign bonds). The demand for these assets depends upon wealth, the real rate of return on all the assets and the risk characteristics of the different assets. The asset market as a whole is in equilibrium when market for each individual asset clears. In practice, this requires the domestic rate of interest and the exchange rate to be at levels that make the expected rate of return on the foreign assets equal to the domestic rate of interest, up to the risk premium. A disequilibrium in any asset market leads first to a change in the rate of return on that asset, which in turn affects demand for other assets and thence their rate of return. Since, a change in the total value of the portfolio (i.e., wealth), or in its composition entails an initial disequilibrium in some asset market, it affects the demand for money and other assets, leading to changes in rates of interest and the exchange rate. One implication of the framework is that the current account plays a prominent role in exchange rate determination, since a change in current account balance implies a change in the holding of net foreign assets. This changes the composition of the portfolio, leading to changes in all asset prices and exchange rate till equilibrium is once again reached.

In the portfolio balance approach, as in the monetary approach, an increase in money supply would lead to exchange rate changes. However, in contrast to the monetary approach, where exchange rate is a purely monetary phenomenon, non-monetary assets and the goods market also play important roles in determining the equilibrium exchange rate in the portfolio approach. Changes in risk perceptions of domestic bonds can also change the demand for foreign assets, and so affect the exchange rate. Finally, in complete contrast to monetary models, a given change in the money stock can have different effects depending on how it is carried out. In particular, intervention in the foreign exchange market through sale or purchase of reserves could affect exchange rate differently from an equivalent change in money supply through open market operations. this is because the two operations affect the composition of the portfolio in different ways. This implies that sterilised intervention can also have an effect. Portfolio balance models allow two channels through which this can happen. One is the signalling effect, which can change market participants' expectations and risk perceptions. The other channel works through a change in the composition of asset portfolio.

2.3 Measures of Exchange Market Pressure and Index of Intervention Activity

The different theoretical approaches to the exchange rate determination discussed in the earlier section give rise to different structural models of the open economy. These models may be applied to explain the exchange rate in a flexible exchange rate regime and the balance of payments (or changes in official reserves) in fixed exchange rate regimes. However, in intermediate regimes of managed floats, changes in exchange rates and foreign exchange reserves occur simultaneously as a result of the policy followed. So exchange market conditions are not captured fully by changes in either of these variables taken alone.[2]

This points to the need for a single quantitative measure to characterise conditions in the exchange market, which takes into account changes in both exchange rate and foreign exchange reserves. One of the earliest and best-known measures in this context is given by Girton and Roper's exchange market pressure formula, which is the simple difference of percentage changes in exchange rate and official foreign exchange reserves. Girton and Roper used the term 'exchange market pressure' to refer to the extent of money market disequilibrium that must be removed through reserve or exchange rate changes. They specified a simple monetary model with the assumption that policy authorities do not employ net

[2] It is of interest to look at empirical studies that have attempted to study the relevance of the different structural models to different economies. In earlier periods, different studies have claimed support for one or the other of the structural models. But in the post-Bretton Woods era, the general conclusion is that all structural models explain little of the observed changes in exchange rate or in balance of payments (see Meese and Rogoff, 1983 and Macdonald and Taylor, 1992). This is true of studies in India as well. Joshi, Sahadevan and Kamaiah find that models using some measure of exchange market pressure perform better.

domestic credit changes to influence exchange rate levels. In the context of this model, their exchange market pressure formula measures the magnitude of external imbalance. Later, Roper and Turnovsky used a different model specification, and allowed intervention in the form of domestic credit changes as well as changes in reserves. They found that in this model the excess demand for money is given by a linear combination, with unequal weights, of changes in exchange rate and monetary base. Given their assumptions, this measures the magnitude of international excess demand for domestic currency. They also called this exchange market pressure.

Both the studies mentioned above were not primarily concerned with a general measure of exchange market pressure per se. Girton and Roper were interested in investigating the extent to which monetary policy can be formulated independently, while Roper and Turnovsky focused on optimal stabilisation policy in a small open economy. In fact, a general definition of the concept of exchange market pressure is not given by either of them, and the measure each study calls the exchange market pressure was obtained in the context of the specific models and purpose of the study.

Weymark (1995, 1998) uses the formulae derived by Girton and Roper, and Roper and Turnovsky as a starting point to develop a general approach to measure exchange market pressure. She introduced a general definition of exchange market pressure as *"exchange market pressure measures the total excess demand for a currency in international markets as the exchange rate change that would have been required to remove this excess demand in the absence of exchange market intervention, given the expectations generated by the exchange rate policy actually implemented."* This definition has two important features. First, unlike the Girton and Roper measure, which implicitly defines exchange market pressure as the excess demand for money in the domestic money market, Weymark's measure defines exchange market pressure as the excess demand for domestic currency in international markets. Consequently, the definition of exchange market pressure introduced here can be used to obtain model consistent measures of exchange market pressure from models that do not emphasise the monetary approach to exchange rate determination as well as from those that do. Second, Weymark's definition measures the excess demand for currency associated with the expectations held under the policy actually implemented by the policy authority. Consequently, her definition of exchange market pressure measures the actual external imbalance experienced by the economy rather than the external imbalance that would have occurred under a pure float.

This general definition can be applied to a structural model to yield indices of exchange market pressure specific to the model, which can then be calculated through observed data. For example, when intervention takes only the form of purchases and sales of foreign exchange reserves, the exchange market pressure, EMP_t, formula, for a log-linear open economy model takes the form:

$$EMP_t = \Delta e_t + \eta.\Delta r_t$$

where Δe_t is the percentage change in exchange rate and Δr_t is the change in official reserves expressed as a percentage of inherited monetary base. The formula will be modified for other forms of intervention policy. If the intervention in the foreign exchange market is sterilised, then,

$$EMP_t = \Delta e_t + \eta.(1-\lambda).\Delta r_t$$

where λ is the sterilisation coefficient, i.e., the proportion of foreign exchange inflows that are sterilised. Sometimes policy authorities use domestic credit changes to influence exchange market conditions, i.e., indirect intervention. In this case, exchange market pressure is relieved partly by a change in the domestic money base, and the formula would then be:

$$EMP_t = \Delta e_t + \eta.[\Delta d_t^f + \Delta r_t]$$

where Δd_t^f is the percentage change in domestic monetary base carried out for the purpose of indirect intervention in the exchange market.

In each case, η converts the observed changes in monetary base carried out for the purpose of intervention in the exchange market, into equivalent exchange rate units. The conversion factor, η, is not directly observable but must be calculated on the basis of the structural parameters of the model. It is therefore model specific, for the effect of a change in reserves on the exchange rate works itself out through all the other markets in the economy. Weymark (1998) shows that the formulae given by Girton and Roper and Roper and Turnovsky may be obtained by applying her general definition to the specific models they use.

Weymark stresses the model specific nature of the measure of exchange market pressure. But there is an alternative view that argues against model dependence, given the well-known difficulties of finding a structural model that explains the relationship between exchange rate and economic fundamentals. Eichengreen, Rose and Wyplosz (1995) argue that an operational index should be model-independent. They suggest an index to measure exchange market pressure that is a linear combination of the interest rate differential and the percentage changes in exchange rate and foreign exchange reserves. The weights of the components are chosen to equalise their conditional volatilities. This is felt necessary because of the problem of widely differing volatilities of the components of the measure. The components included in the index are chosen because they represent the channels through which exchange market disequilibrium is removed.

Model independence might appear to be a desirable characteristic, but Weymark points out that the magnitudes of the different components required to relieve disequilibrium in fact depend upon the structure of the economy, and this is reflected in their relative volatilities. So any model independent measure, like the Eichengreen, Rose and Wyplosz index, cannot really be used as a cardinal measure of exchange market pressure, and one has to derive a model dependent measure.

The exchange market pressure measure characterises conditions in the exchange market in the presence of intervention. A related measure, required in order to evaluate intervention policies, is one that allows a characterisation of the extent of intervention. Weymark has proposed an index of intervention activity as the proportion of exchange market pressure relieved by exchange market intervention. This would take the following formulae under different forms of intervention:

$$IIA_t = \frac{\eta.\Delta r_t}{EMP_t} \text{ when only direct intervention is in operation,}$$

$$= \frac{\eta(1-\lambda).\Delta r_t}{EMP_t} \text{ when sterilised intervention is in operation,}$$

$$= \frac{\eta.[\Delta d_t^f + \Delta r_t]}{EMP_t} \text{ when direct and indirect intervention are used in}$$

tandem.

This index of intervention activity is based on the measure of exchange market pressure obtained through a model of the economy, and is therefore specific to that model.

There have been other measures of intervention proposed in the literature. One of these is the index of managed float proposed by Frenkel (1980) and Frenkel and Aizenmann (1982). The Frenkel and Aizenmann index characterizes exchange rate policy in terms of the ratio $\vartheta_t = \frac{\Delta e_t}{\Delta e_t(float)}$ where $\Delta e_t(float)$ is the exchange rate that would have been observed in the absence of intervention. They used this in the context of looking for optimal intervention policies. This index is conceptually similar to that of Weymark. However, it has a problem from an operational standpoint. The denominator of this index is counterfactual, and cannot be directly observed. It must therefore be imputed on the basis of an analytical model. This problem does not arise in Weymark's index, since, in that, exchange market pressure itself is obtained from observed values.

2.4 Empirical Studies on Exchange Market Pressure

The concept of exchange market pressure being relatively new, empirical studies on it are scanty, particularly in the Indian context. Most studies follow the Girton and Roper formulation, but a few recent studies have applied the Weymark definition.

The studies in the Girton-Roper tradition are generally not all concerned with the measurement of exchange market pressure as such. A number of them use the Girton-Roper measure to test the monetary model of the open economy, in various modified forms, to different countries. Some of these are briefly reviewed here.

Girton and Roper (1977), as noted, defined exchange market pressure as the simple sum of the percentage changes in exchange rates and official reserves obtained from a simple monetary model. This study estimated the model using annual data for the period 1952-74, to obtain a bilateral estimate of exchange market pressure for Canada vis-à-vis the US in the context of monetary autonomy. The model specification implies that the sum of the two components is independent of the composition. This was independently tested, and the test of sensitivity shows that exchange market pressure is not sensitive to its components. This implies that the sum of these two variables as a measure of exchange market pressure provides potential information, which could be used to determine the volume of intervention required to meet the exchange rate targets.

Hodgson and Schneck (1981) examined the relationship between monetary variables and exchange market pressure in the framework of standard monetary model for seven advanced countries using quarterly data. The sample period for six of the countries: Canada, France, West Germany, Belgium, the Netherlands and Switzerland is 1959-II to 1976-I, and for United Kingdom is 1964-II to 1976-I. They found that the relationship between the demand for money and exchange market pressure was not stable, especially during the period of disruptive international monetary relations. The relationship between monetary variables and exchange market pressure is more consistent with a weak rather than a strong version of the monetary approach, indicating that the factors other than monetary variables may be important as well to explain the variations in exchange market pressure.

Modeste (1981) examined the external imbalance of Argentina under a managed float system for the period 1972-1978 based on quarterly data. A modified version of the Girton and Roper model due to Connolly and Silveira (1979) was used to test the hypothesis that an excess demand for money will cause a combination of currency appreciation and/or an inflow of international reserves. The applicability of Girton and Roper model of exchange market pressure to Argentina in the seventies is justified on the grounds that a large proportion of exchange market pressure in the 1970s was absorbed by depreciating the Argentine peso, and the Argentine economy can be regarded as a small economy in the sense that world monetary conditions and world prices for goods, services, and capital are considered to be given. The empirical analysis suggests that during 1970s Argentina alleviated the imbalance in the external sector by combining changes in both reserves and exchange rates.

Goldsbrough and Zaidi (1989) estimated a monetary model of exchange market pressure for Philippines. The results suggest that even after the adoption of a floating exchange rate system, the authorities allowed changes in foreign reserves to continue to absorb most of the exchange market pressure.

Costa-Fernandes (1990) derived and empirically tested a modified version of the monetary model, with exchange market pressure in the Girton and Roper formulation as the independent variable. Lags in the adjustment process were incorporated both with respect to the balance of payments and to exchange rate and prices were taken to be fixed in the short-run. Furthermore, given the embryonic character of the Portuguese capital markets and all sorts of government controls, great importance is attached to exchange rate expectations. The model performs reasonably well when tested and the study concludes that domestic credit growth should be kept under strict control, and the absence of well developed capital markets may lead to a deterioration of the balance of payments and to exchange rate problems through speculation in foreign currency.

Wohar and Lee (1992) applied a refined and expanded version of the Girton and Roper model to the Japanese economy using yearly data for the period 1959 through 1991. This paper develops and estimates a less restrictive and more expanded version of the models previously estimated. The evidence clearly indicates that their unrestricted model performs significantly better than the restricted models used in previous works. On the basis of the estimated signs, and significance of the price, income, and interest rate variables and other tests, they conclude that the monetary approach is favoured over the Keynesian alternative.

Thornton (1995) applied the Girton-Roper monetary model of exchange market pressure to the economy of Costa Rica during the period 1986-92. The results provide strong evidence of a negative relation between domestic credit creation and exchange market pressure and indicate that the central bank absorbed most of the exchange market pressure by adjustments in foreign reserves.

Burdekin and Burkett (1990) examined the performance of Girton and Roper model for Canada/US using quarterly data for the period 1963:I-1988:I. The results supported the hypothesised negative impact of domestic credit growth on exchange market pressure. Also the result strongly favoured the overall policy relevance of the short-run monetary model that gave unitary trade-off between exchange rate and foreign exchange reserve movements for Bank of Canada.

There have also been some studies in the Indian context, using the Girton-Roper framework. **Pradhan *et al* (1989)** examined the applicability of the monetary approach to exchange rate determination for India along the lines of Girton and Roper model of exchange market pressure, using quarterly data for the period 1976-85. The results strongly support the monetarists' hypothesis that an increase in money supply leads to reserve losses and exchange rate depreciation. However exchange market pressure was found to be sensitive to its composition. In other words, the policy authorities in India do make a choice between changes in reserves and exchange rates in response to any disequilibrium in the money market. This does raise questions about the applicability of the model.

Joshi (1990) empirically tested three models of the monetary approach to balance of payments and exchange rate determination for India under different exchange rate regimes. The tested models include standard reserve flow equation with annual data for the period 1953-72, standard exchange rate equation based on purchasing power parity doctrine for the period 1970-82 with annual data, and the exchange market pressure equation using quarterly data for the period 1976 II – 1983 I. The results show that the performance using exchange market pressure is better compared to others. It was also found that exchange market pressure is sensitive to its composition. It is pointed out that, among other things, the absence of well-developed money market, exogeneity assumption of the variables, long-run nature of monetary approach, arbitrary nature of rupee rates management might be the reasons for weak results.

Sahadevan and Kamaiah (1995) examined the monetary approach to the balance of payments separately under fixed exchange rate regime (1950-75) and managed floating regime (1976-90) using annual data. Under the fixed exchange rate regime, they estimated the reserve flow and sterilisation equations in a simultaneous equation framework using 3SLS procedure. The results do not support the monetarist proposition, implying that the monetary model cannot explain India's reserve movements. The possible reasons, according to them, are low degree of openness of the Indian economy, controlled foreign exchange policy and a relatively inflexible financial market. The estimated results of the exchange market pressure equation show that it fits reasonably well to the Indian data over the period under consideration. Further, the exchange market pressure is not sensitive to its distribution unlike in Pradhan *et al* (1989).

Mathur (1999) used a modified version of the Girton and Roper model to explain both exchange rate movements and official intervention and evaluated the measures of the degree of monetary autonomy within the framework of a bilateral model comprising India and rest of the world over the period 1980:01 to 1998:06. Expected exchange rate was generated by using three forecasting techniques – the random walk model, Box-Jenkins methodology and the VAR procedure and was incorporated as a new independent variable to the Girton and Roper original model. It was found that inclusion of the new variable gives a better result than the original Girton and Roper model in explaining exchange market pressure.

Sahadevan (1999) analysed the impact of monetary policy on the behaviour of rupee exchange rate and international reserves during the period 1992:04 to 1999:03. The study analysed how the RBI offsets the pressure that monetary shocks exert on exchange rate and reserves. Based on the estimates of Girton-Roper model of exchange market pressure the study examined the RBI's policy of maintaining exchange rate and reserves over the study period. The values of the offset coefficient ranging between –0.81 to –0.93 signify that the pressure on exchange rate is not completely offset by the domestic monetary expansion (contraction) either by depreciation (appreciation) of rupee or by running down (accumulating) foreign exchange reserves or by some combination of both, but is partially being neutralised by some other means. The controls on international trade and capital flows do provide significant insulation from exchange market pressure. When exchange rate and reserve levels are considered to be the indicators of government's performance and when they are being maintained at 'politically correct' levels, the economic reasoning underlying the model becomes irrelevant. The statistically significant intercept term as against the postulation of the model is a manifestation of these institutional realities.

Studies using the Weymark conceptualisation have been fewer. These studies are directly concerned with measuring exchange market pressure and the index of intervention activity in the context of specific models. These measures are then used to evaluate exchange rate management policy. **Weymark (1995)** used a simple monetary model with unsterilised intervention to obtain a model consistent expression for exchange market pressure. A bilateral model, using quarterly data over the period 1975:II 1990:IV, was estimated and used for calculating exchange market pressure and an index of intervention activity for Canada and the US. A multilateral version was also estimated. The results show that the weight attached to the change in official reserves was as high as –3.089 for the bilateral, and –7.9189 for the multilateral case. Thus, the Girton and Roper measure, with a unitary trade-off between exchange rate changes and official reserves, would have given a misleading picture. Both the bilateral and multilateral estimates of exchange market pressure show that there was sustained downward pressure on the Canadian dollar over the period 1975:II-1984:IV. But 1985 onwards, 18 out of 24 quarterly estimates have negative signs indicating that there was pressure for the Canadian dollar to appreciate. The large positive values obtained for 1989:II and 1990:I are taken to be evidence of speculation against the Canadian dollar. The results also show that, the Bank of Canada responded strongly to counteract the speculative attack on Canadian dollar.

Weymark (1997) elaborated the general discussion of the index of intervention activity. This is illustrated in the context of a small open economy model, different from the one used in her 1995 study. The exchange market pressure and index of intervention activity are calculated using quarterly data for the same period as the earlier study, for both the bilateral and multilateral models. The coefficient attached to a fall in official reserves is now lower (-2.0860 for the bilateral and –1.8370 for the multilateral case) than was obtained with the earlier model. This highlights the model specificity of these measures, and raises the question of sensitivity of the results to model specification.

Spolander (1999) adapted the Weymark definition to a monetary model that explicitly brought in the impact of monetary policy through a money supply function. Monetary policy is taken to be conducted through changes in the monetary base, and foreign exchange interventions are partly sterilised. The model is estimated for Finland, from September 1992 to October 1996 with monthly data, using 2SLS method and model-consistent measures of exchange market pressure and index of intervention activity are derived. The weights attached to official reserves in this case too are very different from the unitary weights of the Girton and Roper measure. The results show that neither depreciation nor appreciation pressure was clearly dominant. Exchange market pressure decreased over time during the markka's float, but the Bank of Finland was seen to actively intervene in the exchange market.

Patra and Pattanaik (1998) carried out an empirical evaluation of exchange rate management in India. They adopted the monetary model used by Weymark (1995), over the period 1990-98 with monthly data. The calculated values of exchange market pressure show that there was market pressure on exchange rate to depreciate and appreciate at different points of time. The results also show that the index of intervention activity values were close to one, which suggests that the exchange rate regime was highly managed and the observed exchange rates would have been quite different in the absence of intervention. They claim that the exchange rate policy in India has been actively supportive of the external sector target in terms of sustainable level of current account deficit. It is however, to be noted that, there is a measurement error in the conversion factor.

Baig *et al* (1999), using a similar monetary model to Weymark (1995), estimated exchange market pressure, and index of intervention activity for India over the period 1975-98 using annual data. The findings show that during the study period the exchange market pressure has fluctuated with positive (negative) values indicating upward (downward) pressure from the US dollar. The RBI was found to counter this pressure by intervening extensively in the foreign exchange market as indicated by large index of intervention activity values. From 1991 onwards, when the exchange market is supposedly free from controls, the RBI has been intervening even more in the foreign exchange market as indicated by higher index of intervention activity values. It is reasoned that with the removal of controls from foreign exchange market RBI has had to intervene strongly to counteract the speculation in the market, and protect rupee from appreciation because of large inflows. A cross check was also carried out by calculating a monetary conditions index for this period. The values of the monetary conditions index suggest that monetary authorities seem to intervene in the market through monetary policy in response to exchange market pressure.

2.5 Concluding Remarks

The discussion in this chapter shows that there are several approaches to studying the exchange market, and within each approach many specific structural models may be constructed. Further, the discussion also brought out the need for arriving at a model specific measure of the exchange market pressure. Obviously, the credibility of the measure depends upon how good the model is. Most of the studies in Indian context have used Girton and Roper measure; a few have used the Weymark definition. As we noted, the Girton and Roper measure itself is specific to a simple monetary model. The studies using the Weymark definition have also used a simple monetary model, where monetary authorities do not use domestic credit changes, which have concentrated on the money market only. This suggests that there is a need and a scope for constructing a suitable model of the Indian economy to get a measure of exchange market pressure.

Chapter 3

Exchange Rate Management in India
Some Stylised Facts

After the collapse of Bretton Woods system, intervention by the policy authorities in the foreign exchange market has been increased. The nature and the degree of intervention have varied from one country to another, but main intention has been to prevent excessive fluctuations in exchange rate. In the international economy, during eighties, there was a prolonged current account deficit and massive fiscal deficits along with large capital flows. This raises a serious doubt on the complete monetary autonomy of the policy authorities to secure internal stability under pure float system. India, after switching over to the market determined exchange rate regime, was closely monitoring the market to ensure orderly conditions in the market through various policy measures in addition to direct intervention. However, internal stability has been the ultimate concern of the policy authorities. In an economy with a market determined exchange rate regime and a lot of capital inflows, exchange rate management while ensuring internal stability has been a challenging task for the RBI.

International experiences, particularly of developed countries, show that the exchange rate volatility is highly pronounced under market based exchange rate regime. In contrast, the experience in India shows that the exchange rate behaviour during the market based regime seems to be relatively calm. However, as compared to earlier regime, the exchange rate witnessed a sharp rise in the 1990s, but volatility has not risen much (see Fig 3.1). This could be a reflection of the management of exchange rate by the RBI since a stable exchange rate is one of the explicit objectives of monetary policy. In the market determined exchange rate regime, reserves changes are much higher than in the previous period, which is very clear from the Fig 3.2. This reflects both the fact of management of exchange rate, and the liberalisation of trade and removal of foreign exchange controls in the later period. Further, the optimal holding of foreign exchange reserves increases in an economy with autonomous flows of capital. This has meant that the building up of reserves is one of the objectives of RBI's actions in the foreign exchange market.

In this context, this chapter takes a preliminary look at the behaviour of some of the fundamental macroeconomic variables vis-à-vis exchange rate movement in the period of the market based exchange rate regime.

The movement of exchange rate is plotted in Fig 3.3. During March 1993 to March 1995 exchange rate was stable around Rs.31.37 per dollar. After 1995, it has been rising steadily. In the latter period, there have been two sub-periods of extreme volatility between September 1995 and June 1996, and again between August 1997 and June 1998.

Fig 3.4 shows the changes in net foreign exchange assets (NFA). Between 1993 and 1995, this takes both positive and negative values. After 1995, it is mainly positive indicating net purchase of foreign assets except for two phases. Between September 1995 and June 1996 negative and positive values are seen; and once again between September 1997 and May 1998. Again in mid-2000 it has been negative. Overall, the volume of purchases has been much larger after 1995, and net foreign exchange assets holding of the RBI has steadily increased (Fig 3.5). This suggests that exchange rate has been managed tightly between 1993 and 1995, with considerable intervention by the RBI. Later it has been allowed to depreciate in line with the market with no intervention, except in the periods of extreme volatility.

Fig 3.6 shows the trade balance deficit. During the period 1993 to 2000, on an average, there has been a continuous increase in the deficit but after that there has been a fall in the trade balance deficit. Between March 1993 and March 1995, there had been a large capital inflow into the country, which could have put pressure on exchange rate to appreciate. Throughout this period there were net purchases by the RBI from the market (see Fig 3.4) reflecting an effort to prevent exchange rate appreciation.

The high trade balance deficit could explain why the policy authorities have been undertaking exchange rate depreciation. Immediately after switching over to a market based exchange rate regime, increasing export competitiveness has been a major concern.

After 1995, policy authorities have allowed depreciation, perhaps even aiding it, as long as it is stable. But in periods of marked instability they appear to have actively intervened in the market. All this is consistent with trying to improve the trade balance. The government has stated that its "focus (is) on smoothing out excessive volatility in the exchange rate to ensure that the exchange rate remains consistent with the economic fundamentals"(Economic Survey, 1997).

The facts also suggest that there has been a focus on building up reserves after 1995 (particularly in recent years). To understand this we first note that both the periods of volatility after 1995 have corresponded to speculative attacks. In September 1995, this was perhaps triggered by expectations of depreciation, given that the rupee was out of synchronisation with the fundamentals. During this period the RBI intervened to defend the rupee initially, but after allowing a readjustment, it withdrew.

The second period of volatility corresponds to the south-east Asian crisis. This attack probably originated in expectations of future depreciation in line with south-east Asian countries, and not because of any changes in the fundamentals. This kind of crisis shows that in recent years, the financial market in India has, witnessed frequent inflow and outflow of short-term capital, change in payment technology, and integration of worldwide markets across different time zones. With increasing capital flows and dismantling of foreign exchange restrictions, the scale of intervention required, in order to be effective, is very high. Thus building up a significant level of reserves would be a valid policy objective. This seems to have brought "a fundamental shift in the policy emphasis reflect the fact that capital flows and speculative activities of market players emerged as important determinants of exchange rate as against trade deficit and other fundamental factors" (Reddy, 2002).

Since exchange rate management in line with the fundamentals is a stated focus of the RBI, it is of interest to see the movement of other related variables.

The movement of domestic and foreign interest rates are shown in Fig 3.7. From the figure it is seen that domestic interest rate (call money rate) was quite high and volatile till 1997. With the introduction of liquidity adjustment facilities the call money rate was stabilised at lower levels. But the foreign interest rate has been stable around 5 per cent. However since 1999, both the rates are moving in the same direction indicating that the movement of the domestic interest rate is allowed in the line with the movement of foreign interest rate. This co-movement may also reflect the stability of the expected exchange rate appreciation and reduction in risk premium. This suggests that the RBI policy of reserve accumulation has succeeded in sending the right signal.

In Fig 3.9 monthly movements of exchange rate (nominal) and the ratio of domestic to foreign prices (the 'PPP rate') are shown. The purchasing power parity theory says that the inflation differential between the countries will be offset by exchange rate changes. So in a market determined exchange rate regime it is expected that PPP rate and market rate should coincide. However, from the figure, it is seen that quite often the two series move in opposite directions. This suggests that relative rates of inflation do not provide a satisfactory explanation for the exchange rate behaviour during the study period. So PPP does not seem to hold in the short run, indicating sluggishness of the output prices.

If exchange rates move more than the national price levels, there should be a high correlation between nominal and real exchange rates. Monthly percentage changes in nominal and real exchange rates are portrayed in Fig 3.10. The figures show that nominal and real exchange rates are moving in the same direction (correlation is 0.76), but magnitude is different. This suggests that output prices move more slowly, and is evidence against PPP in the short run.

However the differential between nominal exchange rate and the PPP rate seems to be decreasing over time, and so also the differential between nominal and real exchange rate. This suggests that the RBI is guided by the PPP rule in the long run.

The aims of building up reserves, ensuring exchange rate stability in line with the fundamentals and maintaining export competitiveness may lead to conflicts in the conduct of monetary policy. One way of resolving the conflict is to sterilise the reserve inflows. To see whether this is being done, the movements in the changes in NDA and NFA are examined from Fig 3.8. It is clear from the figure that both changes in NDA and NFA quite often move in opposite directions. There is a negative correlation (-0.32) between these two variables. This suggests that indirect intervention and direct intervention are not used in a coordinated way to stabilise exchange rate. This could be treated as evidence of sterilised intervention. But it may also mean that direct intervention is used merely to smooth out exchange rate changes caused by autonomous changes in domestic credit.

We may summarise the above in terms of the following stylized facts. (1) The RBI uses direct intervention to manage the exchange rate. (2) The reserve flows that this involves are sterilised. (3) Purchasing power parity does not hold in the short run. (4) Domestic interest rates move in line with foreign interest rates. We draw upon these facts while formulating the model of the economy in the next chapter. This also helps us in the discussion and interpretation of our results in chapter 6.

Fig 3.1: Movement in Exchange Rate (Annual Series)

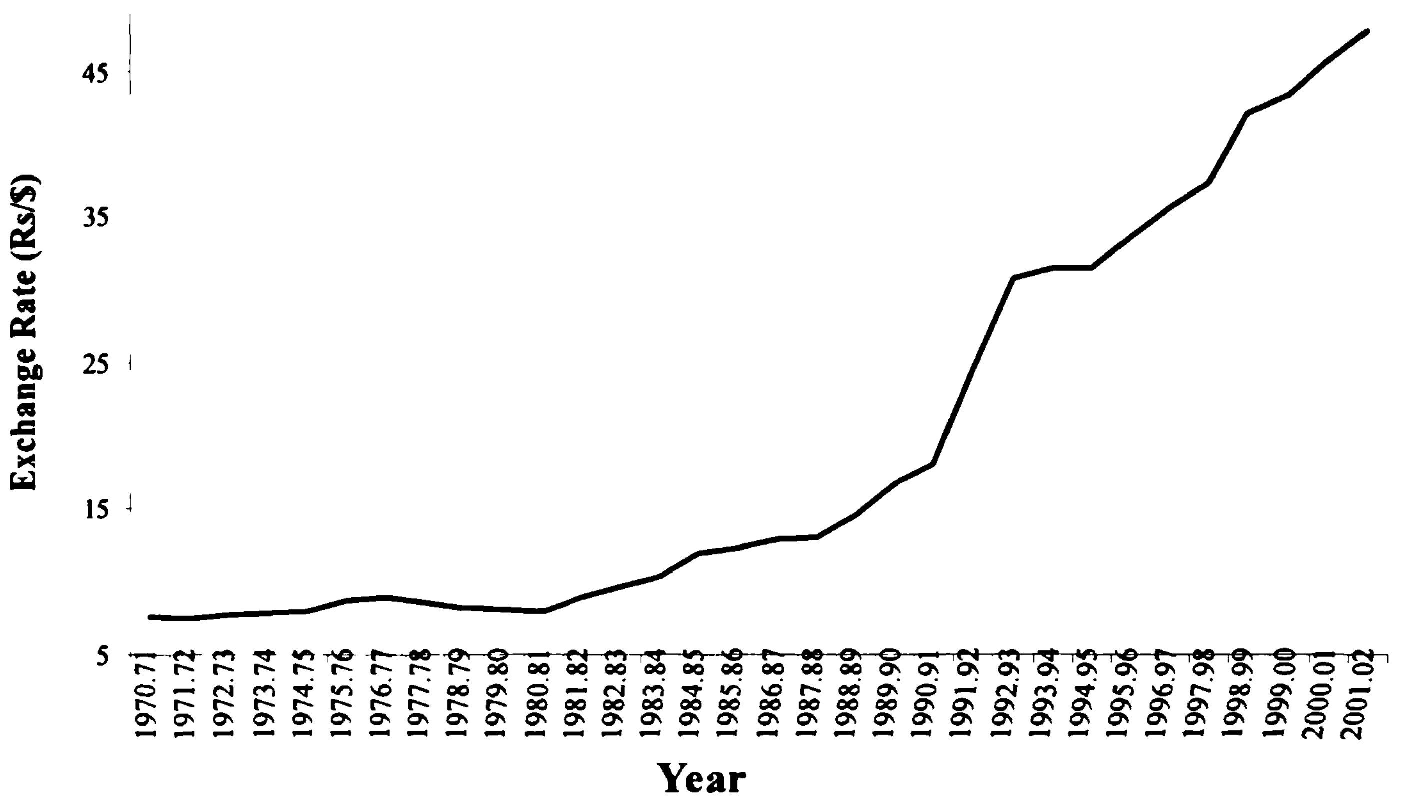


Fig 3.2: Movement in Changes in NFA (Annual Series)

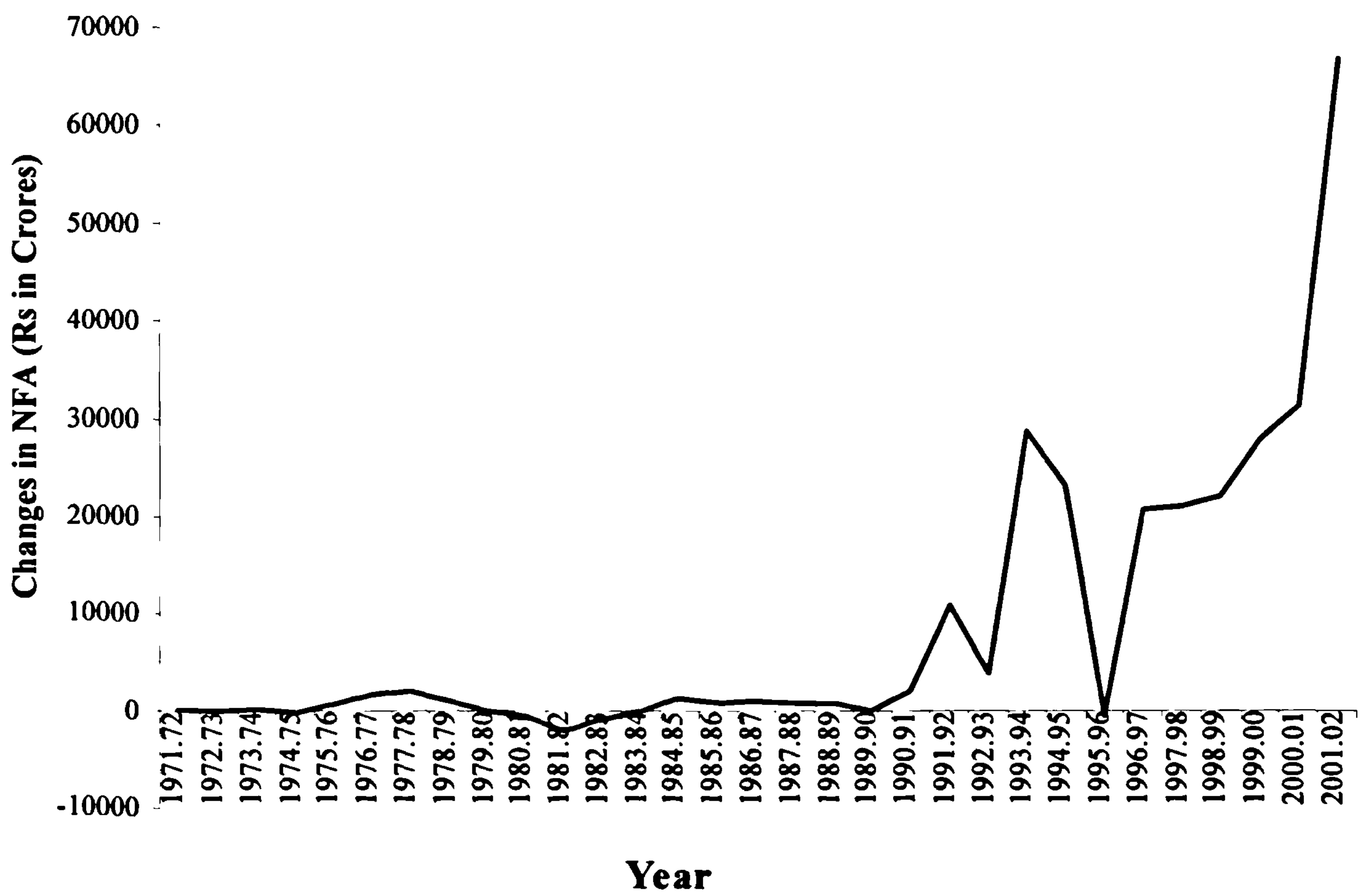


Fig 3.3: Movement in Exchange Rate (Monthly Series)

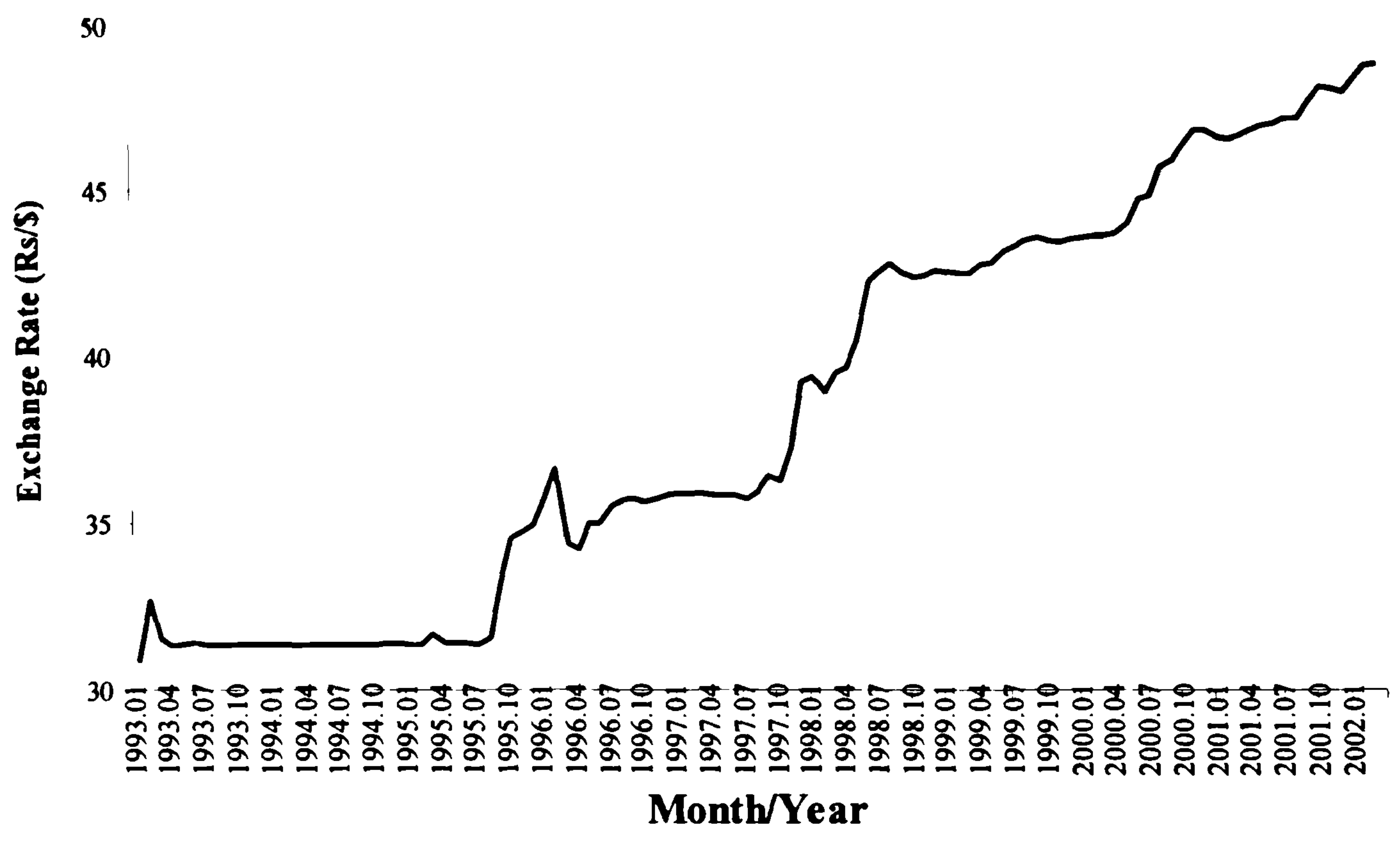


Fig 3.4: Movement in Changes in NFA (Monthly Series)

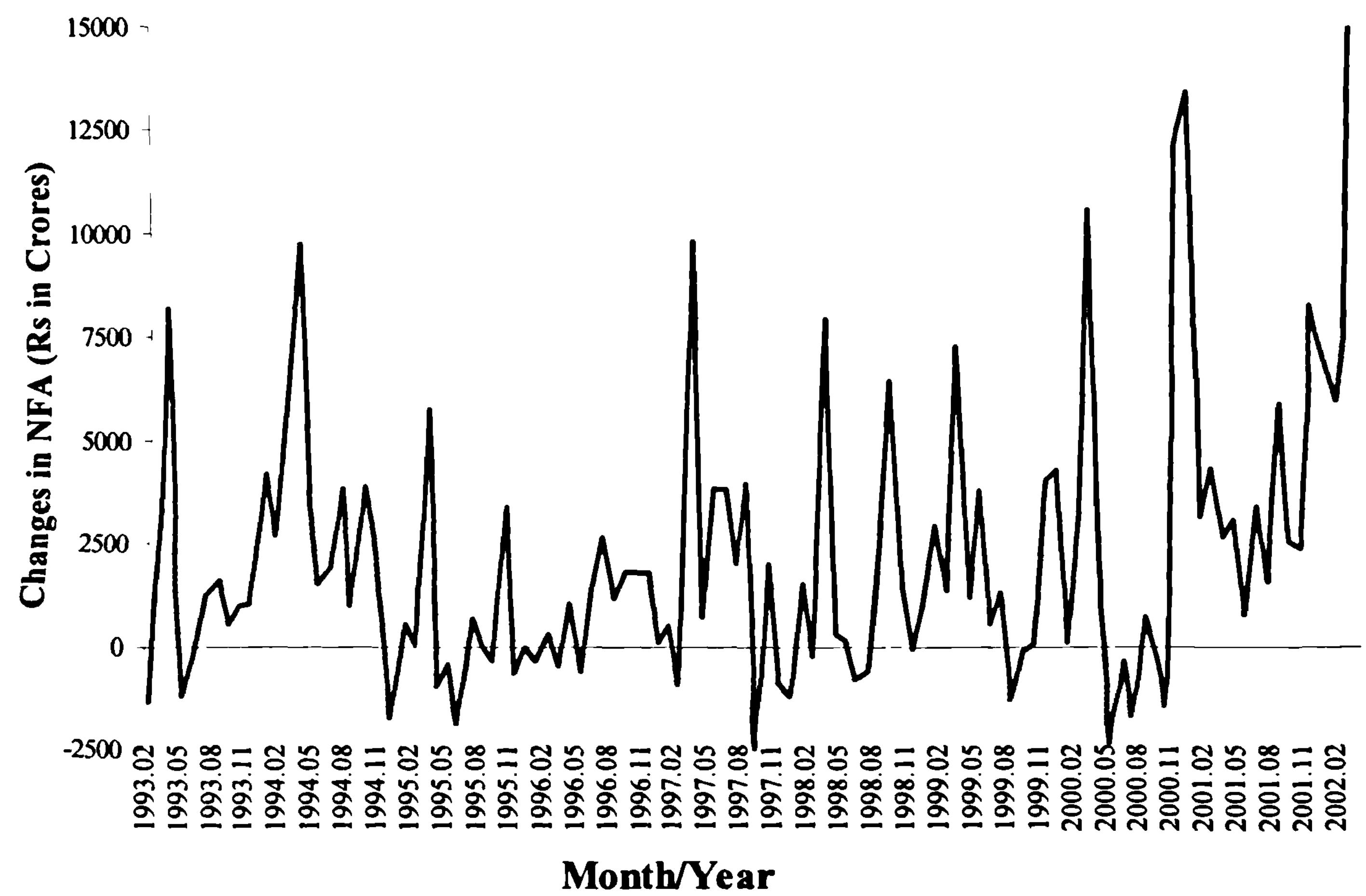


Fig 3.5: Movement in NFA (Monthly Series)

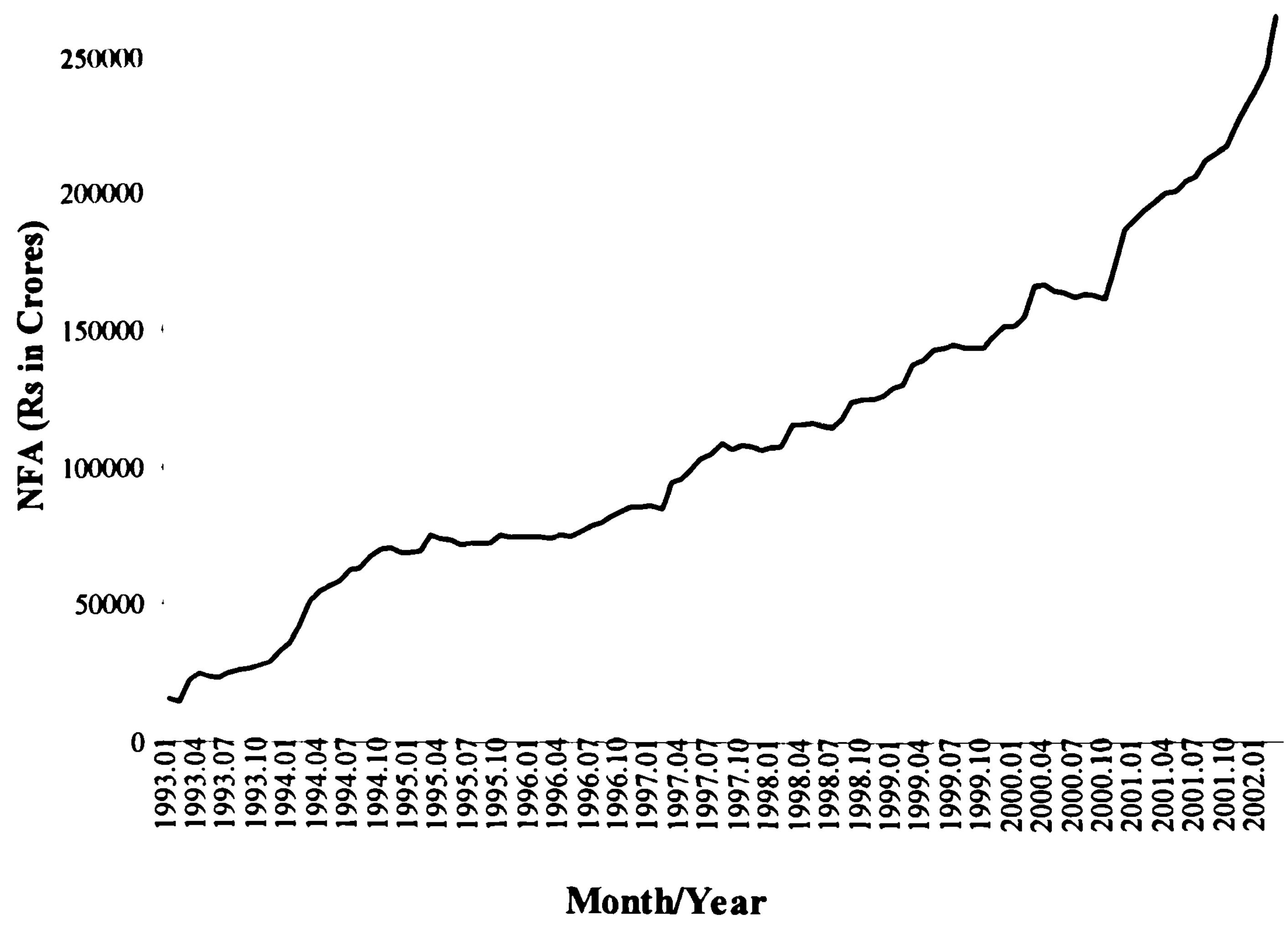


Fig 3.6: Movement in Trade Balance (Monthly Series)

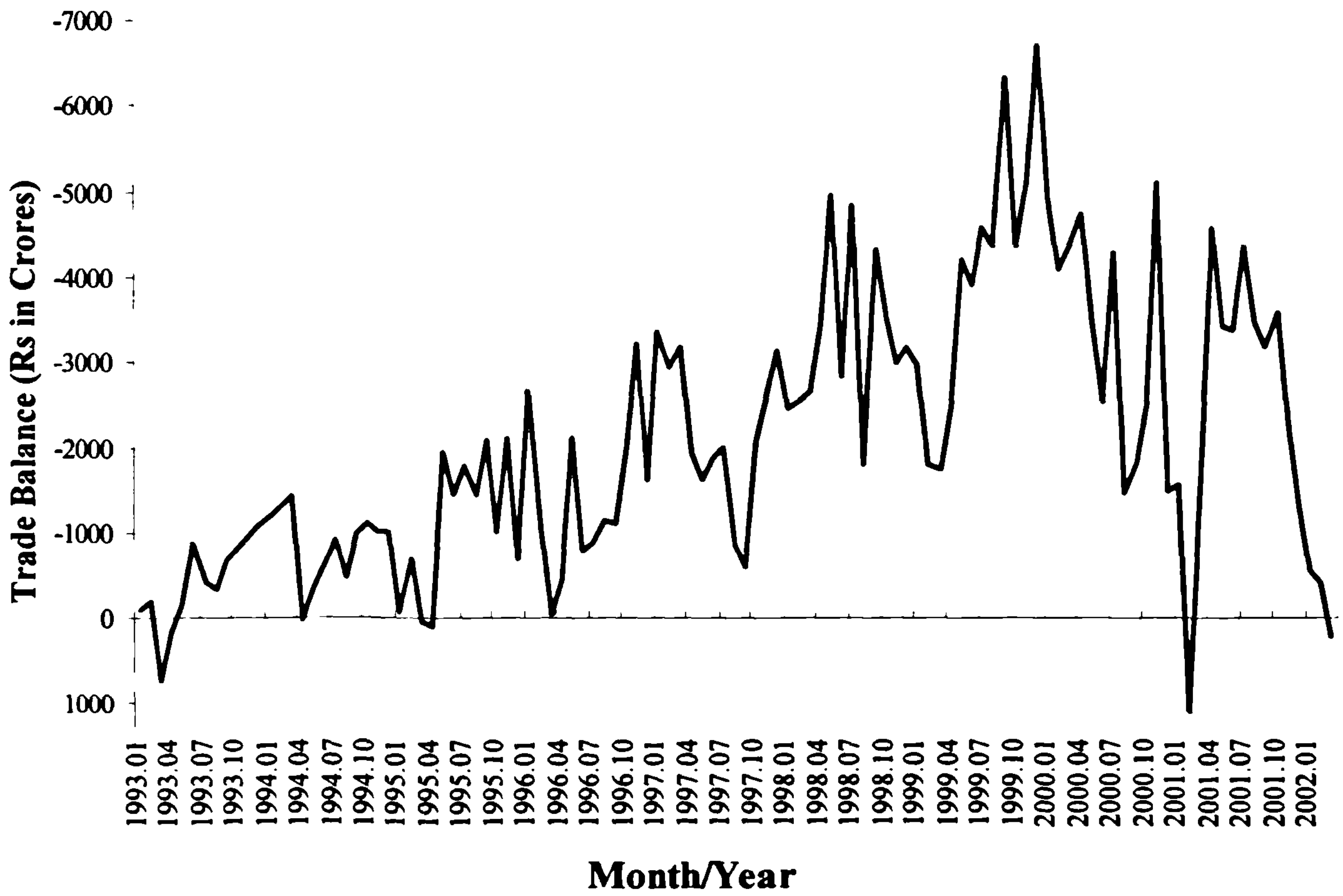


Fig 3.7: Movements in Interest Rates (Monthly series)

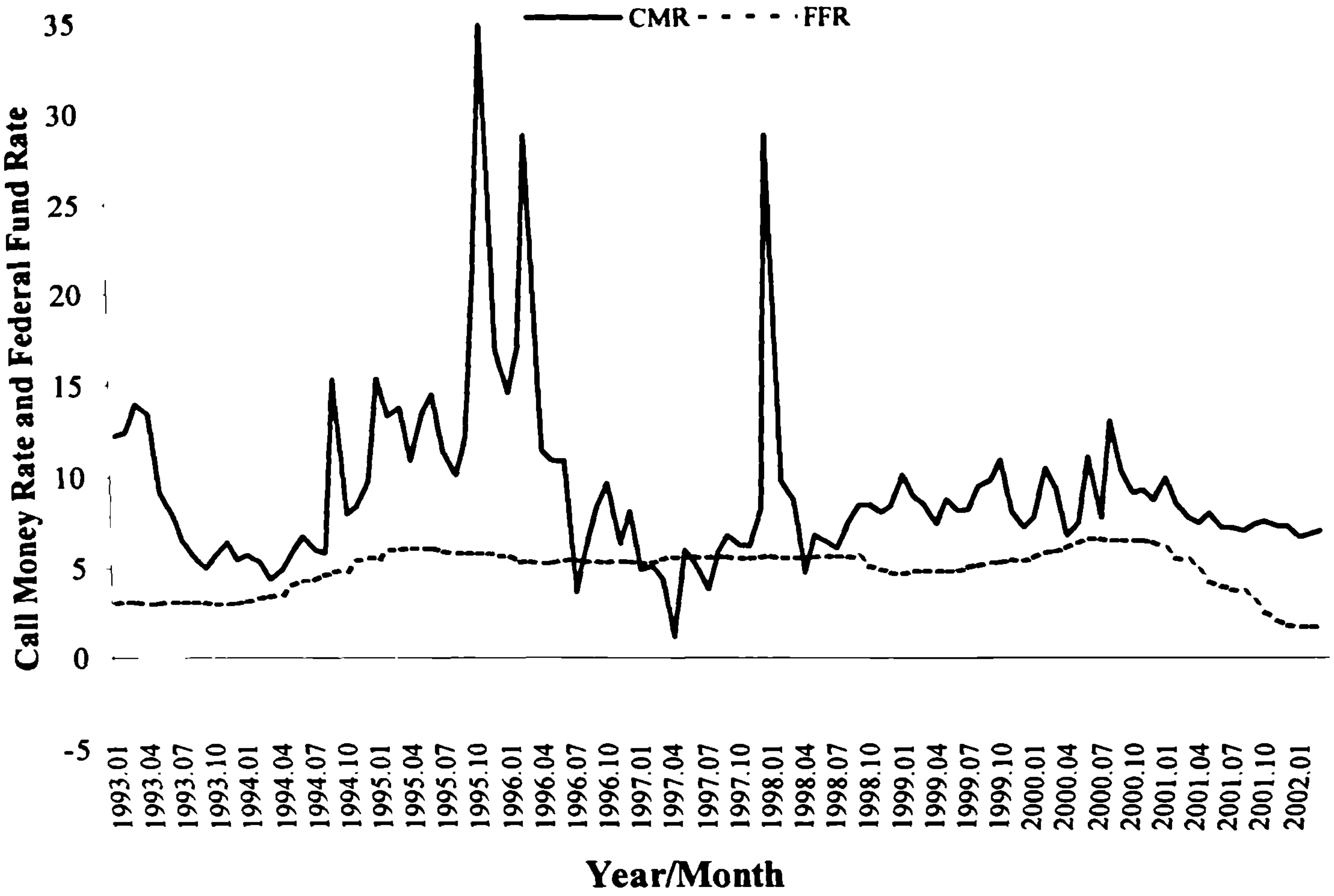


Fig 3.8: Movements in Changes in NDA and NFA (Monthly Series)

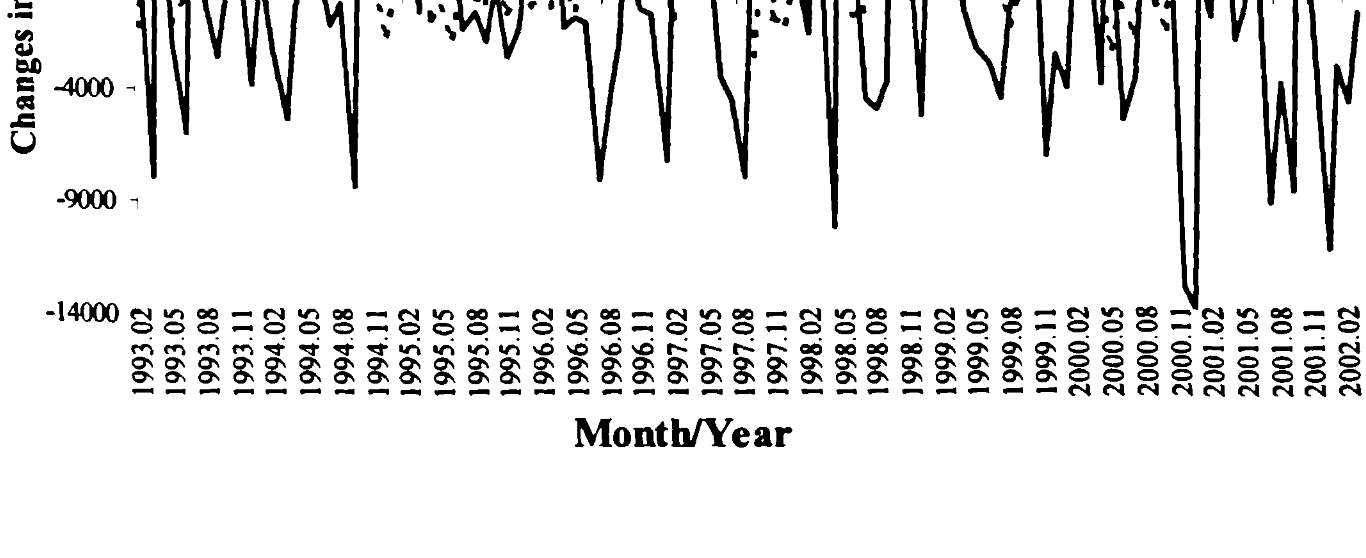


Fig 3.9: Movements in Changes in Exchange Rate and PPP (Monthly Series)

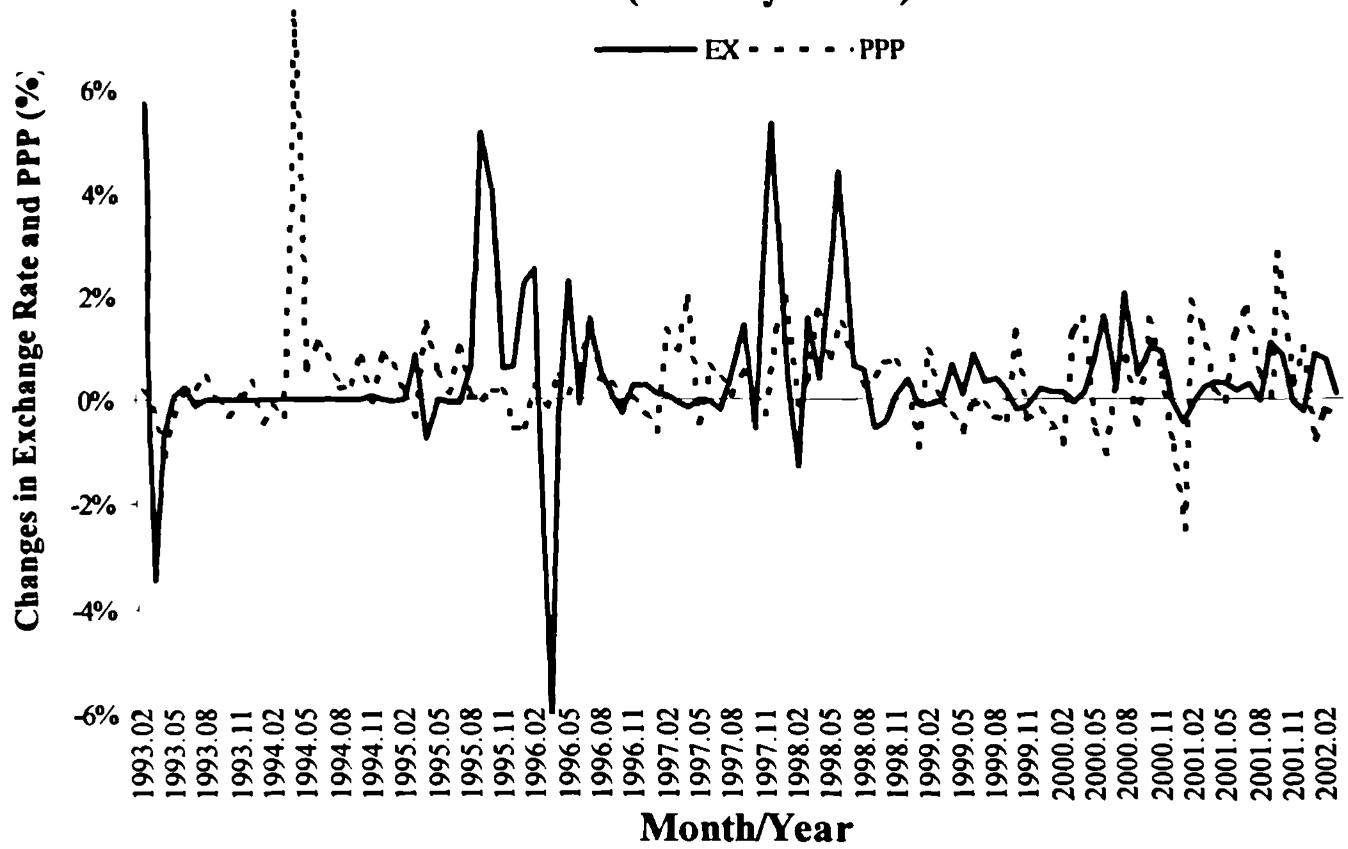
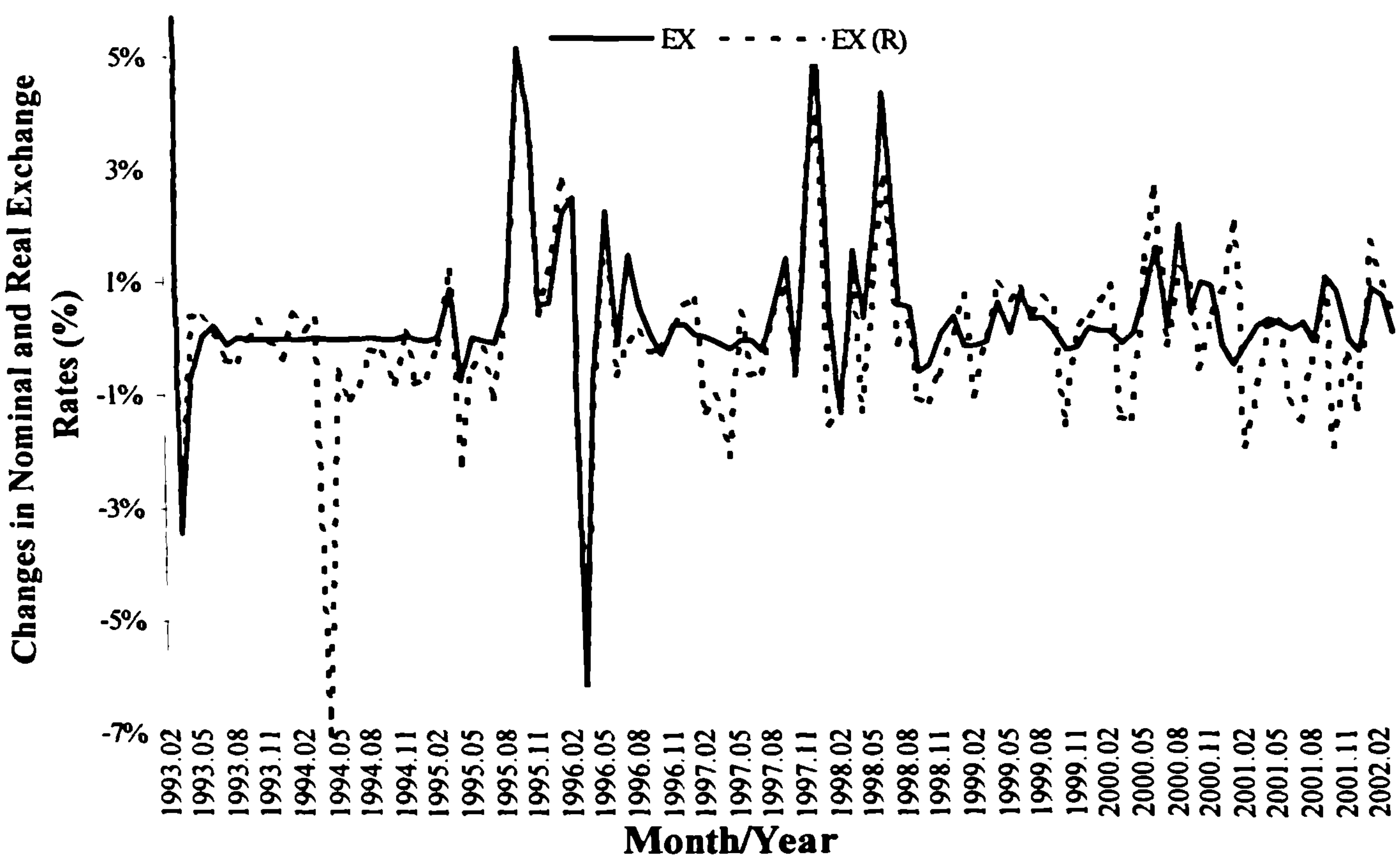


Fig 3.10: Movements in Changes in Nominal and Real Exchange Rate (Monthly Series)



Chapter 4

Formulation of the Model and Derivation of Measures of EMP and IIA

4.1 Introduction

In this chapter, we have formulated a small open economy macro model taking into consideration certain features of the Indian economy. The model is used to derive a consistent measure of exchange market pressure (EMP) and index of intervention activity (IIA). The model takes into account the interactions between the product market and the asset market. The domestic price is assumed to be flexible and determined by demand and supply conditions in the domestic product market. The standard assumption of purchasing power parity of monetary model is given up here. The assets considered are money, domestic bonds and foreign bonds. We recognise that capital is only imperfectly mobile across the Indian border, and that domestic and foreign bonds are not perfect substitutes, because of differing risk characteristics. So the interest parity condition is taken in an inexact form, and only up to a risk premium. In the money market, it is assumed that money supply (base money) is under the control of the monetary authorities. The monetary policy rule followed by the monetary authorities is explicitly brought into our model through money supply equation. Throughout, private agents are assumed to form expectations rationally. The exchange rate is determined through the interaction between product market and asset markets.

4.2 The Model

The Product Market

The output supply function is characterised by

$$y_t^s = y_t^P + \alpha\{p_t - E_{t-1}(p_t)\}, \qquad \alpha \geq 0 \qquad (4.1)$$

where y_t^s is the logarithm of supply of output, y_t^P is the logarithm of potential level of output, p_t is the logarithm of domestic price level, $E_{t-1}(p_t)$ is the expectation of the logarithm of the price for time period t conditional on the information available in time period $t-1$, and the subscript t refers to the current time period. This is the standard Lucas supply function[1] that describes that in short-run the output directly varies as price (p_t) differs from the expected price level, $E_{t-1}(p_t)$.

The output demand function of the economy is characterised by

$$y_t^d = \beta_0 + \beta_1\{e_t + p_t^* - p_t\} - \beta_2\{i_t - E_t(p_{t+1}) + p_t\}, \quad \beta_1, \beta_2 \geq 0 \qquad (4.2)$$

where y_t^d is the logarithm of demand for output, e_t is the logarithm of nominal exchange rate, p_t^* is the logarithm of foreign price, i_t is the domestic nominal interest rate, and $E_t(p_{t+1})$ is the expectation of the price, p_{t+1}, conditional on the information available in time period t.

The demand for output is taken as a function of the real exchange rate and the real interest rate. Here the domestic price level is the average price level of all goods and it is determined by supply and demand for domestic output in the market. This is a clear departure from the standard monetary model, in which output is assumed to be at full employment level, brought about through flexible wages, and prices are determined through purchasing power parity (PPP).[2]

[1] The same form of supply function is obtained, following Dornbusch, based on the Phillips curve together with Okun's Law. Here, in short-run, the output varies as the rate of inflation, π_t differs from the expected rate of inflation, $E_{t-1}(\pi_t)$. That is, $y_t^s = y_t^P + \alpha\{\pi_t - E_{t-1}(\pi_t)\}$, $\alpha \geq 0$. With approximation, $\pi_t - E_{t-1}(\pi_t) = \Delta p_t - E_{t-1}(\Delta p_t)$, where Δp_t is the first difference in log of price and $E_{t-1}(\Delta p_t)$ is the expectation of the Δp_t at time period $t-1$. Thus, $\pi_t - E_{t-1}(\pi_t) = (p_t - p_{t-1}) - \{E_{t-1}(p_t) - p_{t-1}\} = p_t - E_{t-1}(p_t)$. Using this relationship the above equation reduces to equation *(4.1)*.

[2] An alternative demand specification would be obtained by separating out prices of traded goods and non-traded goods. The price of non-traded goods could be taken as exogenous and the price of traded goods is determined under market conditions. Then the demand for output function can be written as:

$$y_t^d = \beta_0' + \beta_1'\{e_t + p_t^{tr*} - p_t^{tr}\} - \beta_2'\{i_t - E_t(p_{t+1}) + p_t\}, \quad \beta_1', \beta_2' \geq 0, \qquad (4.2)'$$

and $$p_t = \omega . p_t^n + (1-\omega)p_t^{tr} \qquad 0 \leq \omega \leq 1 \qquad (4.2a)$$

Product Market Equilibrium

It is assumed that price and output are determined simultaneously and the product market is always in equilibrium. That is,

$$y_t^d = y_t^s \qquad (4.3)$$

The Money Market

We have used the conventional demand for nominal money function (m_t^d), which can be written (in logarithm form) as:

$$m_t^d = \gamma_0 + p_t + \gamma_1 y_t - \gamma_2 i_t \qquad (4.4)$$

In equation (4.4), it is assumed that there is no money illusion and hence price elasticity of nominal money demand is unity.[3] Therefore, the demand for real cash balances is assumed to vary positively with real income and negatively with the domestic rate of interest.

The money supply, however defined, is assumed to be a policy determined variable and defined as a multiple of base money. The change in base money is the

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where p_t^{tr} and p_t^{tr*} are respectively the logarithm of the price of traded goods in the domestic and foreign country in period t. Other variables are defined as it is in the text. The general price level, p_t, is then a weighted average of the price of traded goods, p_t^{tr}, and the price of non-traded goods, p_t^n, measured in logarithms and the weights are the proportions of traded and non-traded goods respectively, in the GDP.

Yet another alternative is to take traded goods price as determined through PPP and non-traded goods price as determined under the demand and supply condition in the domestic market. In this case, the demand for output function would be,

$$y_t^d = \beta_0'' - \beta_2''\{i_t - E_t(p_{t+1}) + p_t\} \qquad (4.2)''$$

and $p_t^{tr} = e_t + p_t^{tr*}$ (4.2b)

As before p_t is a weighted average of p_t^{tr}, and p_t^n. Now demand for output is only a function of real interest rate.

The advantage in this is that it allows us to look at the effect of changes in the price of non-traded goods on our EMP measurement. Because of the non-availability of data on traded and non-traded goods we could not carry out empirical estimation on this. But the model consistent measure of EMP is given in appendix.

[3] The empirical estimate confirms that the price elasticity is unity.

sum of the changes in net domestic assets and net foreign assets. Assuming constant money multiplier, we can write change in money supply as:

$$\Delta m_t^s = \Delta d_t + \Delta r_t$$

where Δm_t^s is the change in base money scaled by its lagged value, Δd_t and Δr_t are respectively the changes in net domestic assets and net foreign exchange assets scaled by lagged base money.

The change in net domestic credit is further decomposed into autonomous change and changes due to sterilisation and hence,

$$\Delta m_t^s = \Delta d_t^a + \Delta d_t^s + \Delta r_t$$

where the superscripts *a* and *s* indicate autonomous and changes due to sterilisation respectively. If we assume partial sterilisation then money supply equation is:

$$\Delta m_t^s = \Delta d_t^a + (1-\lambda)\Delta r_t, \quad \text{where } \Delta d_t^s = -\lambda.\Delta r_t \qquad (4.5.0)$$

Monetary policy aims at exchange rate, output, and price stability. The exchange rate stability is either achieved through direct intervention in the foreign exchange market and/or indirect intervention. However, it is reasonable to assume that indirect intervention and sterilisation will not be carried out together. In practice, most of the central banks are actively involved in the sterilisation process.[4] So it is assumed that autonomous changes in net domestic credit are carried out only for the purpose of price and output stability. Then, the policy reaction function is given by

$$\Delta d_t^a = \Delta p_t + \Delta y_t^P - \varphi_1(\Delta p_t - \Delta p_t^{target}) - \varphi_2(\Delta y_t - \Delta y_t^P)$$

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[4] We carried out a separate exercise on sterilisation policy of the RBI and found that RBI actively sterilises the foreign exchange intervention (see Baig *et al* (2002)).

where y_t^P is potential output and p_t^{target} is the level at which price is targeted. The negative coefficients imply that the policy aims at output and price stability around their target level.

As the target price level is fixed, the above expression reduces to,

$$\Delta d_t^a = \varphi_0 + (1-\varphi_1)\Delta p_t - \varphi_2 \Delta y_t + (1+\varphi_2)\Delta y_t^P \qquad (4.5)$$

Substituting (4.5) into (4.5.0) we get,

$$\Delta m_t^s = \varphi_0 + (1-\varphi_1)\Delta p_t - \varphi_2 \Delta y_t + (1+\varphi_2)\Delta y_t^P + (1-\lambda)\Delta r_t \qquad (4.5.1)$$

When the policy authorities accept a certain rate of inflation and output growth and react only to the deviation of output from its potential level to influence economic activities and the demand for money, then the policy reaction function can be taken as:

$$\Delta d_t^a = \Delta p_t + \Delta y_t^P - \varphi_2^{'}(\Delta y_t - \Delta y_t^P)$$

$$= \varphi_0^{'} + \Delta p_t - \varphi_2^{'} \Delta y_t + (1+\varphi_2^{'})\Delta y_t^P \qquad (4.5)^{'}$$

Now substituting the above expression in (4.5.0), we get the expression for money supply as:

$$\Delta m_t^s = \varphi_0^{'} + \Delta p_t - \varphi_2^{'} \Delta y_t + (1+\varphi_2^{'})\Delta y_t^P + (1-\lambda)\Delta r_t \qquad (4.5.2)$$

Alternatively, when the policy authorities react to the deviation of inflation from its target level to influence economic activities and the demand for money, then the policy reaction function can be taken as:

$$\Delta d_t^a = -\varphi_1^{''}(\Delta p_t - \Delta p_t^{target})$$

This policy rule may be suitable if the economy follows inflation targeting to stabilize macro economic activities and does not set any explicit real output growth target. When the inflation targeting is the practice, then the real growth has no explicit role in a monetary policy reaction function.

As the target price level is fixed, the above expression reduces to

$$\Delta d_t^a = \varphi_0'' - \varphi_1''\Delta p_t \qquad (4.5)''$$

and we get the expression for money supply function as:

$$\Delta m_t^s = \varphi_0'' - \varphi_1''\Delta p_t + (1-\lambda)\Delta r_t \qquad (4.5.3)$$

Money Market Equilibrium

It is assumed that the money market clears instantaneously. Thus the equilibrium condition is given by

$$\Delta m_t^d = \Delta m_t^s \qquad (4.6)$$

Interest Rate Relation

If financial assets are perfect substitutes and capital is perfectly mobile between countries then the uncovered interest parity can be defined as:

$$i_t = i_t^* + \{E_t(e_{t+1}) - e_t\}$$

In case there is a risk attached to a financial asset, which is country specific and differs across countries, then the assets are not perfect substitutes. Thus, the interest parity condition can be written as:

$$i_t = i_t^* + \{E_t(e_{t+1}) - e_t\} + \delta_t,$$ where δ_t is risk premium.

Financial market in India can be characterised by number of market and administrative rigidities. For instance, capital mobility is officially restricted and there are institutional impediments to the free movement of capital. While this allows domestic rate of interest to be influenced by foreign rate of interest, it does not claim equalisation, even up to a risk premium. Thus, we can write the interest rate equation as:

$$i_t = \kappa_0 + \kappa_1 i_t^* + \kappa_2\{E_t(e_{t+1}) - e_t\} + \kappa_3\delta_t \qquad (4.7)$$

Policy Response to Exchange Rate Fluctuation

When the exchange rate stability is one of the concerns of monetary policy, one way the authority tries to stabilise exchange rate is direct intervention in the foreign exchange market by selling/buying foreign exchange. Such policy reaction to exchange rate fluctuation can be written as[5]

$$\Delta r_t = -\overline{\rho_t}.\Delta e_t \qquad (4.8)$$

Under fixed exchange rate regime, there is unlimited intervention in the market to peg the exchange rate at the pre-specified level and hence, $\overline{\rho_t}$ tends to infinity. Similarly, under clean float, the authorities do not interfere in the market and hence the response coefficient becomes zero. Under managed float, wherein the authority intervenes in the market to avoid excess fluctuations, the response coefficient tends to lie in between zero and infinity. A positive $\overline{\rho_t}$ implies that the authority follows the policy of "leaning with the wind".

4.3 Derivation of Measures of EMP and IIA

The EMP and IIA measures are derived for one specification of the model. The derivations for alternative specifications are given in the appendix to the chapter. We consider here the model specification as given by equations (4.1), (4.2), (4.3), (4.4), (4.5.0), (4.5), (4.6), (4.7), and (4.8). This is reproduced below for the sake of convenience. That is,

$$y_t^s = y_t^P + \alpha\{p_t - E_{t-1}(p_t)\} \qquad (4.1)$$

$$y_t^d = \beta_0 + \beta_1\{e_t + p_t^* - p_t\} - \beta_2\{i_t - E_t(p_{t+1}) + p_t\} \qquad (4.2)$$

[5] In the presence of indirect intervention, the policy reaction function would be $\Delta d_t^f + \Delta r_t = -\overline{\rho_t}.\Delta e_t$, where Δd_t^f is the domestic credit change made for the purpose of indirect intervention.

$$m_t^d = \gamma_0 + p_t + \gamma_1.y_t - \gamma_2 i_t \qquad (4.4)$$

$$\Delta m_t^s = \Delta d_t^a + (1-\lambda)\Delta r_t \qquad (4.5.0)$$

$$i_t = \kappa_0 + \kappa_1 i_t^* + \kappa_2\{E_t(e_{t+1}) - e_t\} + \kappa_3\delta_t \qquad (4.7)$$

$$\Delta d_t^a = \varphi_0 + (1-\varphi_1)\Delta p_t - \varphi_2\Delta y_t + (1+\varphi_2)\Delta y_t^P \qquad (4.5)$$

$$\Delta r_t = -\overline{\rho_t}.\Delta e_t \qquad (4.8)$$

$$y_t^d = y_t^s \qquad (4.3)$$

$$\Delta m_t^d = \Delta m_t^s \qquad (4.6)$$

Writing equations (4.1), (4.2.1), (4.4.1), (4.3) and (4.7.3) in deviation form, and using equilibrium conditions we rewrite these equations as:

$$\Delta y_t = \Delta y_t^P + \alpha.\Delta\{p_t - E_{t-1}(p_t)\}$$

$$\Delta y_t = \beta_1\Delta\{e_t + p_t^* - p_t\} - \beta_2\Delta\{i_t - E_t(p_{t+1}) + p_t\}$$

$$\Delta p_t + \gamma_1\Delta y_t - \gamma_2\Delta i_t = \Delta d_t^a + (1-\lambda)\Delta r_t$$

$$\Delta i_t = \kappa_1\Delta i_t^* + \kappa_2\Delta\{E_t(e_{t+1}) - e_t\} + \kappa_3\Delta\delta_t$$

$$\Delta d_t^a = \varphi_0 + (1-\varphi_1)\Delta p_t - \varphi_2\Delta y_t + (1+\varphi_2)\Delta y_t^P$$

$$\Delta r_t = -\overline{\rho_t}.\Delta e_t$$

Writing the above equations in matrix form as:

$$A\,.\,Z = X$$

where, A: Coefficient matrix

Z: Matrix of endogenous variables

and, X: Matrix of exogenous variables

That is,

$$
\begin{bmatrix} 1 & -\alpha & 0 & 0 & 0 & 0 \\ 1 & (\beta_1+\beta_2) & -\beta_1 & \beta_2 & 0 & 0 \\ \gamma_1 & 1 & 0 & -\gamma_2 & -1 & -(1-\lambda) \\ 0 & 0 & \kappa_2 & 1 & 0 & 0 \\ \varphi_2 & -(1-\varphi_1) & 0 & 0 & 1 & 0 \\ 0 & 0 & \overline{\rho}_t & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} \Delta y_t \\ \Delta p_t \\ \Delta e_t \\ \Delta i_t \\ \Delta d_t^a \\ \Delta r_t \end{bmatrix}
= \begin{bmatrix} \Delta y_t^P - \alpha \Delta E_{t-1}(p_t) \\ \beta_1 \Delta p_t^* + \beta_2 \Delta E_t(p_{t+1}) \\ 0 \\ \kappa_1 \Delta i_t^* + \kappa_2 \Delta E_t(e_{t+1}) + \kappa_3 \Delta \delta_t \\ \varphi_0 + (1+\varphi_2)\Delta y_t^P \\ 0 \end{bmatrix}
$$

where

$$
A = \begin{bmatrix} 1 & -\alpha & 0 & 0 & 0 & 0 \\ 1 & (\beta_1+\beta_2) & -\beta_1 & \beta_2 & 0 & 0 \\ \gamma_1 & 1 & 0 & -\gamma_2 & -1 & -(1-\lambda) \\ 0 & 0 & \kappa_2 & 1 & 0 & 0 \\ \varphi_2 & -(1-\varphi_1) & 0 & 0 & 1 & 0 \\ 0 & 0 & \overline{\rho}_t & 0 & 0 & 1 \end{bmatrix}, \qquad Z = \begin{bmatrix} \Delta y_t \\ \Delta p_t \\ \Delta e_t \\ \Delta i_t \\ \Delta d_t^a \\ \Delta r_t \end{bmatrix}
$$

$$
\text{and,} \quad X = \begin{bmatrix} x_{1t} \\ x_{2t} \\ x_{3t} \\ x_{4t} \\ x_{5t} \\ x_{6t} \end{bmatrix} = \begin{bmatrix} \Delta y_t^P - \alpha \Delta E_{t-1}(p_t) \\ \beta_1 \Delta p_t^* + \beta_2 \Delta E_t(p_{t+1}) \\ 0 \\ \kappa_1 \Delta i_t^* + \kappa_2 \Delta E_t(e_{t+1}) + \kappa_3 \Delta \delta_t \\ \varphi_0 + (1+\varphi_2)\Delta y_t^P \\ 0 \end{bmatrix}
$$

Solving for Δe_t using Cramer's rule we get,

$\Delta e_t = \dfrac{|A^3|}{|A|}$, where $|A^3|$ is the determinant of matrix A with the third column replaced by the vector of exogenous variables, and $|A|$ is the determinant of the coefficient matrix A.

$$
\begin{aligned}
\text{Now, } |A| &= \{(\beta_1 + \beta_2\kappa_2)(\varphi_1 + \alpha\gamma_1 + \alpha\varphi_2) + \gamma_2\kappa_2(\alpha + \beta_1 + \beta_2)\} \\
&\quad + (1-\lambda)(\alpha + \beta_1 + \beta_2)\overline{\rho_t} \\
&= K + (1-\lambda)(\alpha + \beta_1 + \beta_2)\overline{\rho_t}
\end{aligned}
$$

$$\text{where } K = \{(\beta_1 + \beta_2\kappa_2)(\varphi_1 + \alpha\gamma_1 + \alpha\varphi_2) + \gamma_2\kappa_2(\alpha + \beta_1 + \beta_2)\}$$

$$
\begin{aligned}
|A^3| &= (-\beta_1\gamma_1 - \beta_2\gamma_1 + \varphi_1 - \beta_1\varphi_2 - \beta_2\varphi_2).x_{1t} \\
&\quad - (\alpha\gamma_1 + \varphi_1 + \alpha\varphi_2).x_{2t} \\
&\quad + (\alpha\beta_2\gamma_1 + \alpha\,\gamma_2 + \beta_1\gamma_2 + \beta_2\gamma_2 + \beta_2\varphi_1 + \alpha\beta_2\varphi_2).x_{4t} \\
&\quad + (\alpha + \beta_1 + \beta_2).x_{5t} \\
&= (-\beta_1\gamma_1 - \beta_2\gamma_1 + \varphi_1 - \beta_1\varphi_2 - \beta_2\varphi_2)\ \{\Delta y_t^P - \alpha\Delta E_{t-1}(p_t)\} \\
&\quad - (\alpha\gamma_1 + \varphi_1 + \alpha\varphi_2)\ \{\beta_1\Delta p_t^* + \beta_2\Delta E_t(p_{t+1})\} \\
&\quad + (\alpha\beta_2\gamma_1 + \alpha\,\gamma_2 + \beta_1\gamma_2 + \beta_2\gamma_2 + \beta_2\varphi_1 + \alpha\beta_2\varphi_2)\ \{\kappa_1\Delta i_t^* + \kappa_2\Delta E_t(e_{t+1}) + \kappa_3\Delta\delta_t\} \\
&\quad + (\alpha + \beta_1 + \beta_2)\ \{\varphi_0 + (1+\varphi_2)\Delta y_t^P\} \\
&= \varphi_0\,(\alpha + \beta_1 + \beta_2) + (\alpha + \beta_1 + \beta_2 + \varphi_1 + \alpha\varphi_2 - \beta_1\gamma_1 - \beta_2\gamma_2).\Delta y_t^P \\
&\quad - \alpha(-\beta_1\gamma_1 - \beta_2\gamma_1 + \varphi_1 - \beta_1\varphi_2 - \beta_2\varphi_2).\Delta E_{t-1}(p_t) \\
&\quad - \beta_1(\alpha\gamma_1 + \varphi_1 + \alpha\varphi_2).\Delta p_t^* \\
&\quad - \beta_2(\alpha\gamma_1 + \varphi_1 + \alpha\varphi_2).\Delta E_t(p_{t+1}) \\
&\quad + \kappa_1(\alpha\beta_2\gamma_1 + \alpha\,\gamma_2 + \beta_1\gamma_2 + \beta_2\gamma_2 + \beta_2\varphi_1 + \alpha\beta_2\varphi_2).\Delta i_t^* \\
&\quad + \kappa_2(\alpha\beta_2\gamma_1 + \alpha\,\gamma_2 + \beta_1\gamma_2 + \beta_2\gamma_2 + \beta_2\varphi_1 + \alpha\beta_2\varphi_2).\Delta E_t(e_{t+1}) \\
&\quad + \kappa_3(\alpha\beta_2\gamma_1 + \alpha\,\gamma_2 + \beta_1\gamma_2 + \beta_2\gamma_2 + \beta_2\varphi_1 + \alpha\beta_2\varphi_2).\Delta\delta_t
\end{aligned}
$$

$\equiv -EDC_t$

where *EDC* is the excess demand for domestic currency generated by changes in exogenous variables. The negative sign is needed since excess demand causes the domestic currency to appreciate and appreciation is defined as a negative change in the exchange rate.

$$\text{So, } \Delta e_t = \frac{|A^3|}{|A|} = \frac{-EDC_t}{|A|}$$

$$\Rightarrow -EDC_t = \Delta e_t.|A|$$

$$= \Delta e_t.\ \{K + (1-\lambda)(\alpha + \beta_1 + \beta_2)\overline{\rho_t}\}$$

Now, $EMP = \Delta e_t$ given that $\Delta r_t = 0$. So, $EMP = \dfrac{-EDC_t}{|A|_{at\,\overline{\rho}_t = 0}}$

$$So,\ EMP = \frac{K.\Delta e_t + (1-\lambda)(\alpha + \beta_1 + \beta_2)\overline{\rho_t}.\Delta e_t\}}{K + (1-\lambda)(\alpha + \beta_1 + \beta_2)\overline{\rho_t}\Big|_{at\,\overline{\rho}_t = 0}}$$

$$= \Delta e_t - \frac{(1-\lambda)(\alpha + \beta_1 + \beta_2)\Delta r_t}{K}$$

$$= \Delta e_t - \frac{(1-\lambda)(\alpha + \beta_1 + \beta_2)}{\{(\beta_1 + \beta_2\kappa_2)(\varphi_1 + \alpha\gamma_1 + \alpha\varphi_2) + \gamma_2\kappa_2(\alpha + \beta_1 + \beta_2)\}}.\Delta r_t$$

$$= \Delta e_t + \eta.\Delta r_t$$

$$\text{where } \eta = -\frac{(1-\lambda)(\alpha + \beta_1 + \beta_2)}{\{(\beta_1 + \beta_2\kappa_2)(\varphi_1 + \alpha\gamma_1 + \alpha\varphi_2) + \gamma_2\kappa_2(\alpha + \beta_1 + \beta_2)\}}$$

The index of intervention activity measures the intervention of the policy authorities in the exchange market. The intervention index is defined as the proportion of exchange market pressure relieved by exchange market intervention. So, when the policy authorities adopt only direct intervention,

$$IIA_t = \frac{\eta.\Delta r_t}{EMP_t} = \frac{\eta.\Delta r_t}{\Delta e_t + \eta.\Delta r_t}$$

A positive (negative) value of EMP_t implies an upward (downward) pressure on the exchange rate. In other words, there is market pressure on domestic currency to depreciate (appreciate) when EMP_t is positive (negative). High EMP_t value indicates a strong market pressure on the exchange rate to appreciate or depreciate depending on the sign.

IIA_t has no theoretical bounds. When the policy authorities allow the exchange rate to float freely, $IIA_t = 0$ as $\Delta r_t = 0$. In the fixed exchange rate regime $\Delta e_t = 0$ and $IIA_t = 1$. But under managed float exchange rate regime IIA_t normally takes values between 0 and 1. However, the value of IIA_t may lie outside the interval [0,1].

Different combinations of EMP and IIA values have different implications.

(1) Consider $EMP_t > 0$.

(i) $IIA_t < 0 \Rightarrow \eta.\Delta r_t < 0 \Rightarrow \Delta r_t > 0$. This means that intervention is keeping exchange rate even higher than market forces would.

(ii) $IIA_t > 0 \Rightarrow \eta.\Delta r_t > 0 \Rightarrow \Delta r_t < 0$. This means that intervention prevents exchange rate from rising as much as market forces would make it. Indeed, if $IIA_t > 1$, then $\eta.\Delta r_t > EMP_t$, which implies that intervention makes the exchange rate in fact fall even though the $EMP_t > 0$.

(2) Consider $EMP_t < 0$.

(i) $IIA_t < 0 \Rightarrow \eta.\Delta r_t > 0 \Rightarrow \Delta r_t < 0$. This means intervention makes the exchange rate fall more than market forces would have done.

(ii) $IIA_t > 0 \Rightarrow \eta.\Delta r_t < 0 \Rightarrow \Delta r_t > 0$. This means intervention prevents exchange rate from falling as much as market forces would make it.

To sum up, $IIA_t < 0$ occurs when the policy authorities actively depreciate (appreciate) the domestic currency with respect to its free float value and the exogenously generated excess demand for domestic currency is negative (positive). That is, intervention magnifies the exchange rate change generated by private market forces. On the other hand, $IIA_t > 1$ when intervention makes the exchange rate move in the opposite direction to what private market forces would have led to. In this case the policy authorities actively depreciate (appreciate) the domestic currency with respect to its free float value and the exogenously generated excess demand for domestic currency is positive (negative). Thus, whether EMP is positive or negative, a negative value of IIA represents a policy of leaning with the wind, and a positive value of IIA is a policy of leaning against the wind. And a value of IIA greater than one implies that intervention is strong enough to make the exchange rate move in the opposite direction to what market forces do.

4.4 Concluding Remarks

The credibility of the measure of exchange market pressure depends upon the credibility of the model. Therefore we formulated a suitable open economy macro model for India and derived a consistent measure of exchange market pressure constructed an index of intervention activity in section 4.3. This is done for the purpose of examining the policy stance of the RBI in light of our measures of EMP and IIA.

Appendix

Solutions of η for the alternative models

Expressions for the conversion factor, η, are obtained here for different alternative model specifications mentioned in the chapter.

Model 1

Consider the model specification as equations (4.1), (4.2), (4.3), (4.4), (4.5.0), (4.5)', (4.6), (4.7), and (4.8). Writing equations (4.1), (4.2), (4.3), (4.4) and (4.7) in deviation form, and using equilibrium conditions we rewrite these equations in matrix form as: $A\,.\,Z = X$

That is,

$$\begin{bmatrix} 1 & -\alpha & 0 & 0 & 0 & 0 \\ 1 & (\beta_1+\beta_2) & -\beta_1 & \beta_2 & 0 & 0 \\ \gamma_1 & 1 & 0 & -\gamma_2 & -1 & -(1-\lambda) \\ 0 & 0 & \kappa_2 & 1 & 0 & 0 \\ \varphi_2' & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & \overline{\rho_t} & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} \Delta y_t \\ \Delta p_t \\ \Delta e_t \\ \Delta i_t \\ \Delta d_t^a \\ \Delta r_t \end{bmatrix}$$

$$= \begin{bmatrix} \Delta y_t^P - \alpha\Delta E_{t-1}(p_t) \\ \beta_1 \Delta p_t^* + \beta_2 \Delta E_t(p_{t+1}) \\ 0 \\ \kappa_1 \Delta i_t^* + \kappa_2 \Delta E_t(e_{t+1}) + \kappa_3 \Delta\delta_t \\ \varphi_0' + (1+\varphi_2')\Delta y_t^P \\ 0 \end{bmatrix}$$

$$\text{Now, } |A| = \{(\beta_1+\beta_2\kappa_2)(2+\alpha\gamma_1+\alpha\varphi_2')+\gamma_2\kappa_2(\alpha+\beta_1+\beta_2)\} + (1-\lambda)(\alpha+\beta_1+\beta_2)\overline{\rho_t}$$

$$= K + (1-\lambda)(\alpha+\beta_1+\beta_2)\overline{\rho_t}$$

where $K = \{(\beta_1+\beta_2\kappa_2)(2+\alpha\gamma_1+\alpha\varphi_2')+\gamma_2\kappa_2(\alpha+\beta_1+\beta_2)\}$

And, $\left|A^{1}\right| = (2-\beta_1\gamma_1-\beta_2\gamma_2-\beta_1\varphi_2^{'}-\beta_2\varphi_2^{'}).x_{1t} - (2+\alpha\gamma_1+\alpha\varphi_2^{'}).x_{2t}$

$$+(2\beta_2+\alpha\beta_2\gamma_1+\alpha\,\gamma_2+\beta_1\gamma_2+\beta_2\gamma_2+\alpha\beta_2\varphi_2^{'}).x_{4t}+(\alpha+\beta_1+\beta_2).x_{5t}$$

Following the same steps as in the main chapter, we derive EMP as,

$$EMP_t = \Delta e_t + \eta.\Delta r_t$$

where, $\eta = -\dfrac{(1-\lambda)(\alpha+\beta_1+\beta_2)}{\{(\beta_1+\beta_2\kappa_2)(2+\alpha\gamma_1+\alpha\varphi_2^{'})+\gamma_2\kappa_2(\alpha+\beta_1+\beta_2)\}}$

Model 2

Consider the model specification as equations (4.1), (4.2), (4.3), (4.4), (4.5.0), (4.5)'', (4.6), (4.7), and (4.8). Writing equations (4.1), (4.2), (4.3), (4.4) and (4.7) in deviation form, and using equilibrium conditions we rewrite these equations in matrix form as: $A\,.\,Z = X$

That is,

$$\begin{bmatrix} 1 & -\alpha & 0 & 0 & 0 & 0 \\ 1 & (\beta_1+\beta_2) & -\beta_1 & \beta_2 & 0 & 0 \\ \gamma_1 & 1 & 0 & -\gamma_2 & -1 & -(1-\lambda) \\ 0 & 0 & \kappa_2 & 1 & 0 & 0 \\ 0 & \varphi_1^{''} & 0 & 0 & 1 & 0 \\ 0 & 0 & \overline{\rho}_t & 0 & 0 & 1 \end{bmatrix} . \begin{bmatrix} \Delta y_t \\ \Delta p_t \\ \Delta e_t \\ \Delta i_t \\ \Delta d_t^a \\ \Delta r_t \end{bmatrix}$$

$$= \begin{bmatrix} \Delta y_t^P - \alpha\Delta E_{t-1}(p_t) \\ \beta_1\Delta p_t^* + \beta_2\Delta E_t(p_{t+1}) \\ 0 \\ \kappa_1\Delta i_t^* + \kappa_2\Delta E_t(e_{t+1}) + \kappa_3\Delta\delta_t \\ \varphi_0^{''} \\ 0 \end{bmatrix}$$

Now,

$$|A| = \{(\beta_1 + \beta_2\kappa_2)(1+\varphi_1'' + \alpha\gamma_1) + \gamma_2\kappa_2(\alpha + \beta_1 + \beta_2)\} + (1-\lambda)(\alpha + \beta_1 + \beta_2)\overline{\rho_t}$$

$$= K + (1-\lambda)(\alpha + \beta_1 + \beta_2)\overline{\rho_t}$$

where $K = \{(\beta_1 + \beta_2\kappa_2)(1+\varphi_1'' + \alpha\gamma_1) + \gamma_2\kappa_2(\alpha + \beta_1 + \beta_2)\}$

And, $|A^3| = (1+\varphi_1'' - \beta_1\gamma_1 - \beta_2\gamma_1).x_{1t} - (1+\varphi_1'' + \alpha\gamma_1).x_{2t}$

$$+ (\beta_2 + \alpha\beta_2\gamma_1 + \alpha\,\gamma_2 + \beta_1\gamma_2 + \beta_2\gamma_2 + \beta_2\varphi_1'').x_{4t} + (\alpha + \beta_1 + \beta_2).x_{5t}$$

Deriving EMP in similar fashion, we get,

$$EMP_t = \Delta e_t + \eta.\Delta r_t$$

where, $\eta = -\dfrac{(1-\lambda)(\alpha + \beta_1 + \beta_2)}{\{(\beta_1 + \beta_2\kappa_2)(1+\varphi_1'' + \alpha\gamma_1) + \gamma_2\kappa_2(\alpha + \beta_1 + \beta_2)\}}$

Model 3

Consider the model specification as equations (4.1), (4.2)', (4.2a), (4.3), (4.4), (4.5.0), (4.5), (4.6), (4.7), and (4.8). Writing equations (4.1), (4.2)', (4.2a), (4.3), (4.4) and (4.7) in deviation form, and using equilibrium conditions, we rewrite these equations in matrix form as: $A \,.\, Z = X$

That is,

$$\begin{bmatrix} 1 & -\alpha & 0 & 0 & 0 & 0 & 0 \\ 1 & \beta_2' & -\beta_1' & \beta_2' & 0 & 0 & \beta_1' \\ 0 & 1 & 0 & 0 & 0 & 0 & -(1-\omega) \\ \gamma_1 & 1 & 0 & -\gamma_2 & -1 & -(1-\lambda) & 0 \\ 0 & 0 & \kappa_2 & 1 & 0 & 0 & 0 \\ \varphi_2 & -(1-\varphi_1') & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & \overline{\rho_t} & 0 & 0 & 1 & 0 \end{bmatrix} \cdot \begin{bmatrix} \Delta y_t \\ \Delta p_t \\ \Delta e_t \\ \Delta i_t \\ \Delta d_t^a \\ \Delta r_t \\ \Delta p_t^{tr} \end{bmatrix}$$

$$= \begin{bmatrix} \Delta y_t^P - \alpha \Delta E_{t-1}(p_t) \\ \beta_2 \Delta E_t(p_{t+1}) \\ (1-\omega)\Delta p_t^{tr*} \\ 0 \\ \kappa_1 \Delta i_t^* + \kappa_2 \Delta E_t(e_{t+1}) + \kappa_3 \Delta \delta_t \\ \varphi_0 + (1+\varphi_2)\Delta y_t^P \\ 0 \end{bmatrix}$$

Now, $|A| = -(1-\omega)\{(\beta_1' + \beta_2'\kappa_2)(\varphi_1 + \alpha\gamma_1 + \alpha\varphi_2) + \gamma_2\kappa_2(\alpha + \beta_1' + \beta_2')\}$

$$-(1-\lambda)\{(1-\omega)(\alpha + \beta_2') + \beta_1'\}\overline{\rho_t}$$

$$= K - (1-\lambda)\{(1-\omega)(\alpha + \beta_2') + \beta_1'\}\overline{\rho_t}$$

where $K = -(1-\omega)\{(\beta_1' + \beta_2'\kappa_2)(\varphi_1 + \alpha\gamma_1 + \alpha\varphi_2) + \gamma_2\kappa_2(\alpha + \beta_1' + \beta_2')\}$

And, $|A^3| = \{(1-\omega)(-\varphi_1 + \beta_1'\gamma_1 + \beta_2'\varphi_2) + \beta_1'(\gamma_1 + \varphi_2)\}.x_{1t}$

$+ (1-\omega)(\varphi_1 + \alpha\gamma_1 + \alpha\varphi_2).x_{2t}$

$+ (\beta_1'\varphi_1 + \alpha\beta_1'\gamma_1 + \alpha\beta_1'\varphi_2).x_{3t}$

$- \{(1-\omega)(\alpha\,\gamma_2 + \beta_2'\gamma_2 + \beta_2'\varphi_1 + \alpha\beta_2'\gamma_1 + \alpha\beta_2'\varphi_2) - \beta_1'\gamma_1\}.x_{5t}$

$- (\alpha + \beta_1' + \beta_2' + \alpha\omega + \beta_2'\omega).x_{6t}$

Deriving EMP in similar fashion, we get,

$$EMP_t = \Delta e_t + \eta.\Delta r_t$$

where, $\eta = -\dfrac{(1-\lambda)\{(1-\omega)(\alpha + \beta_2') + \beta_1'\}}{(1-\omega)\{(\beta_1' + \beta_2'\kappa_2)(\varphi_1 + \alpha\gamma_1 + \alpha\varphi_2) + \gamma_2\kappa_2(\alpha + \beta_1' + \beta_2')\}}$

Model 4

Consider the model specification as equations (4.1), (4.2)'', (4.2a), (4.2b), (4.3), (4.4), (4.5.0), (4.5), (4.6), (4.7), and (4.8). Writing equations (4.1), (4.2), (4.2b) substituted in (4.2a), (4.3), (4.4) and (4.7) in deviation form, and using equilibrium conditions we rewrite these equations in matrix form as: $A\,.\,Z = X$

That is,

$$\begin{bmatrix} 1 & -\alpha & 0 & 0 & 0 & 0 & 0 \\ 1 & \beta_2^{''} & 0 & \beta_2^{''} & 0 & 0 & 0 \\ 0 & 1 & -(1-\omega) & 0 & 0 & 0 & -\omega \\ \gamma_1 & 1 & 0 & -\gamma_2 & -1 & -(1-\lambda) & 0 \\ 0 & 0 & \kappa_2 & 1 & 0 & 0 & 0 \\ \varphi_2 & -(1-\varphi_1) & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & \overline{\rho_t} & 0 & 0 & 1 & 0 \end{bmatrix} \cdot \begin{bmatrix} \Delta y_t \\ \Delta p_t \\ \Delta e_t \\ \Delta i_t \\ \Delta d_t^a \\ \Delta r_t \\ \Delta p_t^n \end{bmatrix}$$

$$= \begin{bmatrix} \Delta y_t^P - \alpha \Delta E_{t-1}(p_t) \\ \beta_2^{''} \Delta p_t^{tr*} + \beta_2^{''} \Delta E_t(p_{t+1}) \\ \omega \Delta p_t^n \\ 0 \\ \kappa_1 \Delta i_t^* + \kappa_2 \Delta E_t(e_{t+1}) + \kappa_3 \Delta \delta_t \\ \varphi_0 + (1+\varphi_2)\Delta y_t^P \\ 0 \end{bmatrix}$$

Now, $|A| = -\omega\{\beta_2^{''}\kappa_2(\varphi_1 + \alpha\gamma_1 + \alpha\varphi_2) + \gamma_2\kappa_2(\alpha + \beta_2^{''})\} - \omega(1-\lambda)(\alpha + +\beta_2^{''})\}\overline{\rho_t}$

$= K - \omega(1-\lambda)(\alpha + +\beta_2^{''})\}\overline{\rho_t}$

where $K = -\omega\{\beta_2^{''}\kappa_2(\varphi_1 + \alpha\gamma_1 + \alpha\varphi_2) + \gamma_2\kappa_2(\alpha + \beta_2^{''})\}$

And, $|A^3| = \omega(-\varphi_1 + \beta_2^{''}\gamma_1 + \beta_2^{''}\varphi_2)x_{1t} + \omega(\varphi_1 + \alpha\gamma_1 + \alpha\varphi_2).x_{2t}$

$-\omega(\alpha\ \gamma_2 + \beta_2^{''}\gamma_2 + \beta_2^{''}\varphi_1 + \alpha\beta_2^{''}\gamma_1 + \alpha\beta_2^{''}\varphi_2).x_{5t} - \omega(\alpha + \beta_2^{''}).x_{6t}$

Deriving EMP in similar fashion, we get,

$EMP_t = \Delta e_t + \eta.\Delta r_t$

where $\eta = -\dfrac{(1-\lambda)(\alpha + \beta_2^{''})}{\{\beta_2^{''}\kappa_2(\varphi_1 + \alpha\gamma_1 + \alpha\varphi_2) + \gamma_2\kappa_2(\alpha + \beta_2^{''})\}}$

Chapter 5

Estimation of EMP and IIA

5.1 The Model for Estimation

In this chapter, we try to obtain the measures of the exchange market pressure and construct an index of intervention activity. This involves derivation of estimable form of the equations from the structural model. For the sake of convenience, we reproduce the structural model from chapter 4 and then derive the estimable form of the equations. The model is estimated to get the required parameters for calculating the conversion factor and hence EMP and IIA.

The basic model:

$$y_t^s = y_t^P + \alpha\{p_t - E_{t-1}(p_t)\} + u_t^{ys} \tag{4.1}$$

$$y_t^d = \beta_0 + \beta_1\{e_t + p_t^* - p_t\} - \beta_2\{i_t - E_t(p_{t+1}) + p_t\} + u_t^{yd} \tag{4.2}$$

$$m_t^d = \gamma_0 + p_t + \gamma_1 y_t - \gamma_2 i_t + u_t^{md} \tag{4.4}$$

$$\Delta m_t^s = \Delta d_t^a + (1-\lambda)\Delta r_t \tag{4.5.0}$$

$$i_t = \kappa_0 + \kappa_1 i_t^* + \kappa_2\{E_t(e_{t+1}) - e_t\} + \kappa_3\delta_t + u_t^i \tag{4.7}$$

$$\Delta d_t^a = \varphi_0 - (1-\varphi_1)\Delta p_t - \varphi_2\Delta y_t + (1+\varphi_2)\Delta y_t^P + u_t^{ms} \tag{4.5}$$

$$\Delta r_t = -\overline{\rho_t}.\Delta e_t \tag{4.8}$$

$$y_t^d = y_t^s \tag{4.3}$$

$$\Delta m_t^d = \Delta m_t^s \tag{4.6}$$

where u_t^{ys}, u_t^{yd}, u_t^{md}, u_t^{ms} and u_t^i are the stochastic disturbance terms in the respective equations.

From the above model, we derive the following equations through appropriate substitutions and transformations.

$$\{y_t - y_t^P\} = \alpha.\{p_t - E_{t-1}(p_t)\} + u_t^{ys} \tag{5.1}$$

$$y_t = \beta_0 + \beta_1\{e_t + p_t^* - p_t\} - \beta_2\{i_t - E_t(p_{t+1}) + p_t\} + u_t^{yd} \quad (5.2)$$

$$\{m_t^d - p_t\} = \gamma_0 + \gamma_1 y_t - \gamma_2 i_t + u_t^{md} \quad (5.3)$$

$$\{\Delta m_t^s - \Delta r_t - \Delta p_t - \Delta y_t^P\} = \varphi_0 - \varphi_1 \Delta p_t - \varphi_2(\Delta y_t - \Delta y_t^P) - \lambda \Delta r_t + u_t^{ms} \quad (5.4)$$

$$i_t = \kappa_0 + \kappa_1 i_t^* + \kappa_2\{E_t(e_{t+1}) - e_t\} + \kappa_3 \delta_t + u_t^i \quad (5.5)$$

$$\Delta r_t = -\overline{\rho_t}.\Delta e_t \quad (5.6)$$

$$\Delta m_t^d = \Delta m_t^s \quad (5.7)$$

Equations (5.1) through (5.5) are estimable equations and the relations in equations (5.6) and (5.7) are used in the estimation process to take account of simultaneity in the systems. There are seven endogenous variables, i.e., Δp_t, Δy_t, Δm_t^d, Δm_t^s, Δr_t, Δi_t, and Δe_t, and seven exogenous variables, i.e., $\{p_t - E_{t-1}(p_t)\}$, $\{e_t + p_t^* - p_t\}$, $\{i_t - E_t(p_{t+1}) + p_t\}$, $(\Delta y_t - \Delta y_t^P)$, i_t^*, $\{E_t(e_{t+1}) - e_t\}$, and δ_t in the system.

5.2 Description of the Data

We have collected monthly time series data from 1993:01 to 2002:03; and annual time series data from 1973-74 to 2001-02. We require data on income, price, money stock, reserve money, net domestic assets, net foreign exchange assets, nominal interest rate, real interest rate, real exchange rate, expected prices, potential output, nominal exchange rate, real exchange rate, expected exchange rate depreciation, US price, US interest rate and risk premium.

We have used index of industrial production (Y_t) as a proxy for income due to non-availability of monthly time series on income; wholesale price index (P_t) for price with base year 1993-94; reserve money ($M0_t$); narrow money ($M1_t$); broad money ($M3_t$); net domestic assets of the RBI (D_t); net foreign exchange assets of the RBI (R_t); rupee-dollar exchange rate (E_t);[1] call money rate (i_t) for domestic interest rate; US federal fund rate and libor rate (i_t^*); and monthly average of imports (IMP_t).

[1] Exchange rate is defined as units of domestic currency per unit of foreign currency. In the study we have used Rs/$ rate.

For the sample period 1973-74 to 2001-02, we have collected annual time series on all the variables mentioned above. However, gross domestic product at 1993-94 prices is used for income.[2]

Potential output level (Y_t^P) is estimated by using Hodrick-Presscott (HP) filter method.[3] Risk premium (δ_t) is measured by the foreign exchange reserves with the central bank scaled by the relevant year's average imports. The expected price and exchange rate need to be generated for estimation. The expected variables were obtained as the predicted values from OLS regression in which the current variable is regressed upon the lags of all the endogenous variables in the model. The appropriate lag length is determined by Schwarz (1978) and Akaike (1974,1976) criteria. The lag length for generating E_{t-1} (p_t) turned out to be 3, and 2 for E_{t-1} (e_t) for the annual series; and 1 for both in the monthly series. The expected prices and exchange rates are close to the actual (see fig 5.1 and 5.2 given below) indicating that the methods for generating expectations provides good fit.

[2] As data on the GDP at constant market price for the later one year is not available we have used the growth rate of GDP at factor cost of that year to obtain it.

[3] Potential output is estimated by **Hodrick-Prescott (HP) filter** method. This is a smoothing method that is widely used among macroeconomists to obtain a smooth estimate of the long-term trend component of a series. Technically, the HP filter decomposes a time series y_t into an additive cyclical component y_t^c and a growth component y_t^g (the smooth series) and then compute the smooth series, y_t^g by minimising the variance of y_t around y_t^g, subject to a penalty that constrains the second difference y_t^g. That is, the HP filter chooses y_t^g to minimise:

$$\sum_{t=1}^{T}(y_t - y_t^g)^2 + \lambda \sum_{t=2}^{T-1}[(y_{t+1}^g - y_t^g) - (y_t^g - y_{t-1}^g)]^2$$

The penalty parameter λ, controls the smoothness of the series by penalising the variability in the $y_t^g(\sigma)$. The larger the value of the λ, the smoother is the growth component. As $\lambda \rightarrow \infty$, the growth component corresponds to a linear time trend. For annual data Hodrick and Prescott propose setting λ = 100 and λ = 14400 for monthly data.

Fig 5.1: Movements in LWPI and LWPIE

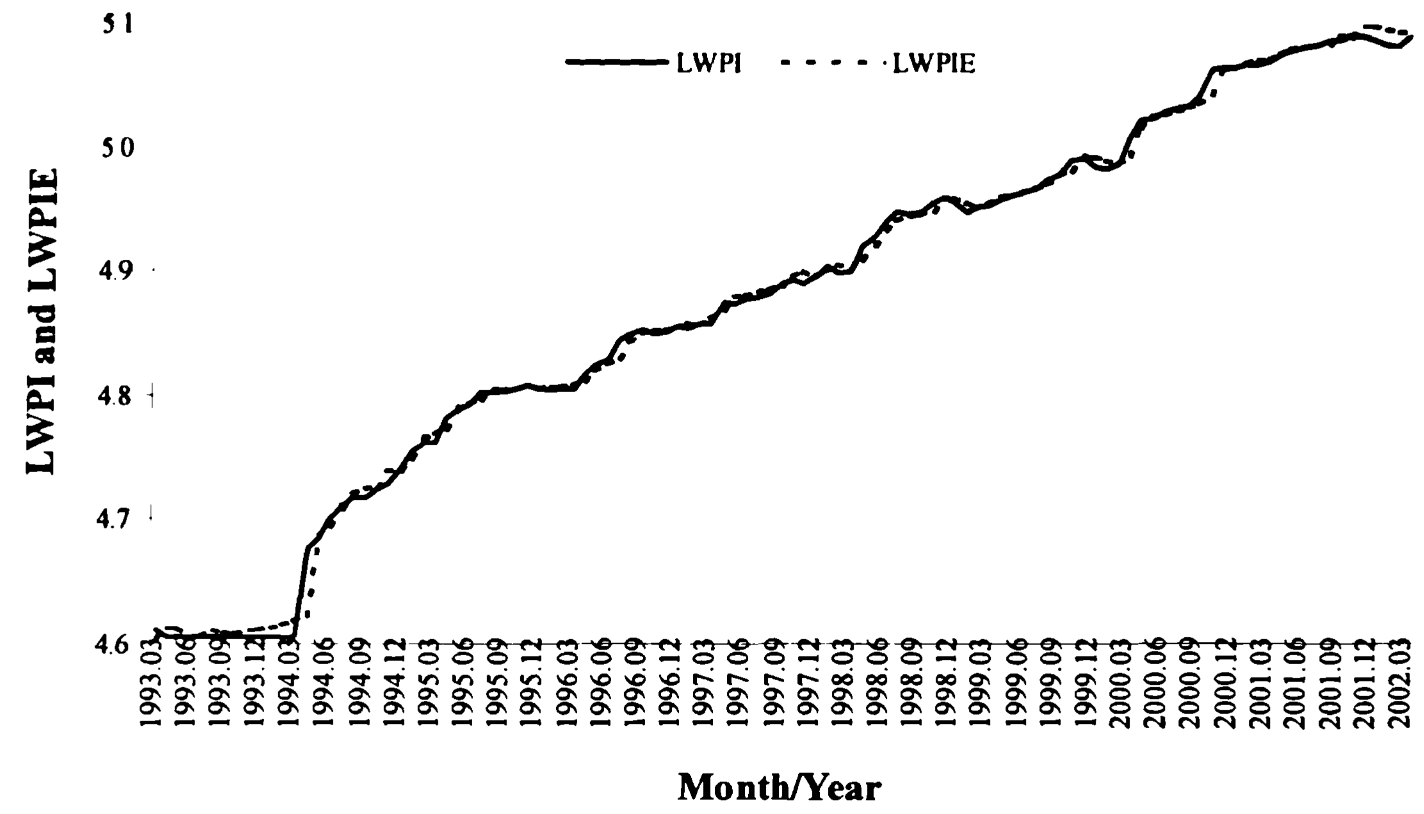
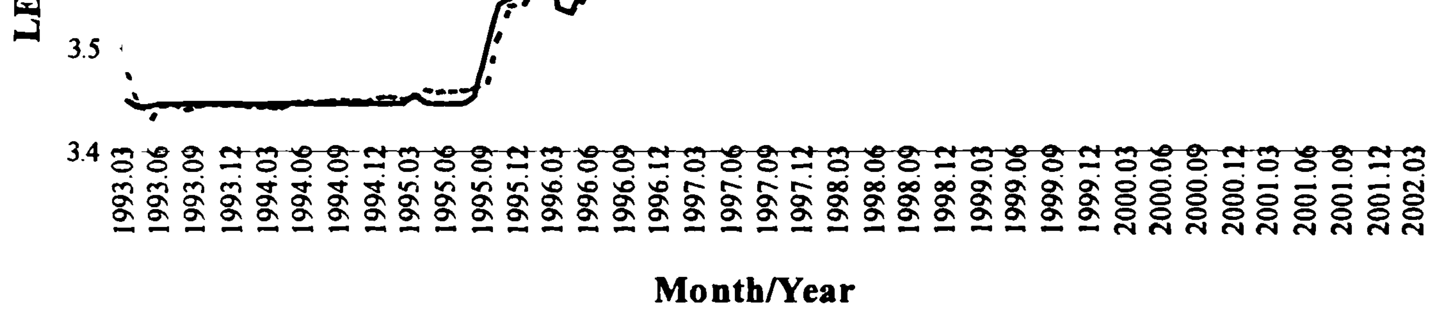


Fig 5.2: Movements in LEXR and LEXRE



In the above figures, LWPI and LEXR represent logarithms of the wholesale price index and exchange rate respectively; and, LWPIE and LEXRE represent expectations of the respective variables.

5.3 Empirical Results

We have carried out the estimation of the model, using monthly time series data over the period 1993:04 to 2002:03 and annual time series data over the period 1975-76 to 2001-02. We are discussing only monthly exercise here, as our major focus is to study the exchange rate behaviour during the market determined exchange rate regime. The annual results are presented in the appendix.[4]

The stationarity properties of the variables as they appear in the regressions, are checked using ADF and PP test[5] and the results are presented below in Table 5.1. The result shows that some variables are stationary in the level and some are stationary in the first difference. The estimation is carried out on stationary variables only.

In our model some of the endogenous variables appear on right hand side of the some of the equations. This means that there may be correlation between the endogenous variables and the disturbance term. This violates one of the classical linear regression model assumptions and hence OLS estimates would be biased. To overcome the simultaneity problem, we checked the identification problem of the model by order condition. This turns out to be an over-identified model. We use 2SLS method to estimate the model.

The preliminary estimation of money demand function is done using two alternative monetary aggregates, viz., M_1 and M_3. Looking at the statistical properties finally we retain M_3 for our study. As interest rates are highly fluctuating, we have smoothened out both the domestic and foreign interest rate for the estimation of interest rate function. For foreign interest rate we considered both federal fund rate and libor rate. As plot of both the series (not presented in the

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[4] The study with annual time series data was carried out basically because monthly data limited us to using IIP as proxy for output/income. This was felt to be unsatisfactory, so we also examined annual series with GDP to see whether the relevant equations gave better results. However, the aims of the study clearly require high frequency data. A year is too long a period to study the effects of intervention.

[5] We go by PP test at 1% level of significance. PP test is an advantage over ADF as it is a non-parametric test.

thesis) gives the same pattern and the correlation between them seems to be strong, we used only federal fund rate.

Table 5.1: Stationarity Test Results (1993:04 to 2002:03)

Phillips-Perron (PP) Test				
Variables	**Level**		**First difference**	
	No Trend	**Trend**	**No Trend**	**Trend**
y_t	-0.97	-6.04*	-16.08*	-16.00*
p_t	-1.18	-1.71	-9.29*	-9.31*
e_t	0.34	-3.60**	-10.21*	-10.27*
i_t	-5.73*	-5.77*	-17.03*	-16.94*
i_t^*	-0.76	0.02	-5.28*	-5.96*
r_t	-	-	-10.48*	-10.40*
δ_t	-2.51	-3.85**	-17.15*	-17.07*
$\{y_t - y_t^P\}$	-6.57*	-6.53*	-16.15*	-16.09*
$\{m_t^d - p_t\}$	-0.06	-2.44	-11.03*	-10.97*
$\{m_t^s - r_t - p_t - y_t^P\}$	-	-	-12.35*	-12.29*
$\{m_t^s - r_t\}$	-	-	-12.66*	-12.73*
$\{e_t + p_t^* - p_t\}$	-1.55	-2.93	-10.28*	-10.34*
$\{p_t - E_{t-1}(p_t)\}$	-3.00**	-2.91	-22.98*	-22.97*
$\{E_t(e_{t+1}) - e_t\}$	-3.70*	-3.57**	-12.71*	-12.74*
$\{i_t - E_t(p_{t+1}) + p_t\}$	-5.57*	-5.59*	-16.62*	-16.52*

Contd.

Table 5.1: Stationarity Test Results (1993:04 to 2002:03)

Augmented Dicky-Fuller (ADF) Test				
Variables	Level		First difference	
	No Trend	Trend	No Trend	Trend
y_t	-0.93	-4.39*	-5.41*	-5.39*
p_t	-1.55	-1.95	-4.62*	-4.82*
e_t	-0.11	-2.84	-4.63*	-4.65*
i_t	-2.80***	-2.81	-5.65*	-5.62*
i_t^*	-2.64***	-2.13	-2.51	-2.98
r_t	-	-	-3.74*	-3.64*
δ_t	-1.30	-2.29	-4.74*	-4.71*
$\{y_t - y_t^P\}$	-6.01*	-6.02*	-5.45*	-5.43*
$\{m_t^d - p_t\}$	0.68	-1.99	-5.85*	-5.89*
$\{m_t^s - r_t - p_t - y_t^P\}$	-	-	-4.98*	-4.95*
$\{m_t^s - r_t\}$	-	-	-5.39*	-5.57*
$\{e_t + p_t^* - p_t\}$	-1.53	-2.96	-4.52*	-4.60*
$\{p_t - E_{t-1}(p_t)\}$	-2.47	-2.24	-7.51*	-4.53*
$\{E_t(e_{t+1}) - e_t\}$	-3.40**	-3.31***	-4.83*	-4.87*
$\{i_t - E_t(p_{t+1}) + p_t\}$	-2.66**	-2.67	-5.67*	-5.64*

*: The required critical values at 1%, 5% and 10% level of significance are respectively –3.49, -2.88 and –2.58 for without trend, and –4.04, -3.45 and –3.15 for with trend. In both the ADF and PP test we used the lag length 4. This optimal lag length is suggested by Newey -West test.

In the preliminary estimation of the equations, serial correlation is found. In order to allow for autoregressive moving average process, 2SLS estimation was undertaken under the alternative assumption that the error followed an autoregressive moving average process of order n, with n taking on the values of 1 through 12, successively. The Ljung-Box Q-statistics is calculated in each case to check for the serial correlation problem; also, Breusch-Godfrey Lagrange multiplier (LM) test for serial correlation for the error term. The Lagrange multiplier test for autoregressive conditional heteroscedasticity (ARCH LM) of the error term is done. The WHITE test for heteroscedasticity of the error term using squares and cross-products of the regressors is done to check the heteroscedasticity problem. The standard errors of parameter estimates are corrected for heteroscedasticity and serial correlation in the error term by the Newey-West test procedure. Schwarz (1978) and Akaike (1974, 1976) criteria are used to decide the model specification. Seasonality problem is taken care of by using seasonal dummies. Only significant seasonal dummies are retained in the final estimations but not reported in the results presented. Dummy variable is used for the different periods in 1997 to capture the impact of policy changes on our model. Finally January 1997 as a break point is retained in the final estimation as it improves the result. This is denoted as *Dum97* in the equations. The final 2SLS results are presented below.

$$\{y_t - y_t^P\} = \underset{(1.38)}{0.25}\{p_t - E_{t-1}(p_t)\} \qquad (5.1)'$$

n=107, $\bar{R}^2 = 0.63$

Q(9)=5.79 (0.67), Q(18)=10.16 (0.89), Q(27)=18.40 (0.86), Q(36)=20.07 (0.98)

$$\Delta y_t = \underset{(3.22)^*}{0.01} + \underset{(0.04)}{0.008}\Delta\{e_t + p_t^* - p_t\} - \underset{(-1.15)}{0.035}\{i_t - E_t(p_{t+1}) + p_t\} - \underset{(-3.33)^*}{0.006}Dum97 \qquad (5.2)'$$

n=107, $\bar{R}^2 = 0.75$

Q(9)=2.60 (0.10), Q(18)=5.48 (0.85), Q(27)=9.08 (0.97), Q(36)=11.25 (0.99)

$$\{\Delta m_t^d - \Delta p_t\} = \underset{(7.68)^*}{0.012} + \underset{(3.05)^*}{0.079}\Delta y_t - \underset{(-1.69)^{***}}{0.028}.i_t \qquad (5.3)'$$

n=107, $\bar{R}^2 = 0.23$

Q(9)=0.96 (0.61), Q(18)=4.47 (0.95), Q(27)=9.18 (0.98), Q(36)=14.74 (0.98)

$$\{\Delta m_t^s - \Delta r_t - \Delta p_t - \Delta y_t^p\} = -0.002 - 1.001\Delta p_t - 0.084(\Delta y_t - \Delta y_t^p) - 0.731\Delta r_t \quad (5.4)'$$

$$(-0.69) \quad (-2.97)^{*} \quad (-0.91) \quad (-1.94)^{**}$$

$$n=107,\ D\text{-}W=2.05,\ \bar{R}^2 = 0.20$$

$$i_t = 0.046 + 0.692 i_t^* + 6.67\{E_t(e_{t+1}) - e_t\} + 0.008\Delta\delta_t + 0.007 Dum97 \quad (5.5)'$$

$$(2.12)^{**} \quad (2.78)^{*} \quad (9.30)^{*} \quad (1.00) \quad (1.39)$$

$$n=107,\ \bar{R}^2 = 0.89$$

Q(15)= 5.05 (0.95), Q(18)=11.06 (0.74), Q(27)=30.58 (0.16), Q(36)=41.33 (0.16)

The t - statistics are given in the parenthesis along with the estimated equations. The values in the parenthesis for Q - statistics with different lag lengths are the level of significance. The level of significance of the coefficients is indicated by the asterisks. * 1% level of significance, ** 5% level of significance, and *** 10% level of significance.

As seen from the above estimated equations, the signs of the parameters are consistent with the theoretical expectation except the coefficient of risk premium, but some of the coefficients are not statistically significant.

The estimate of output supply equation shows that the coefficient of expected price changes is very small. This indicates that output supply is always close to its potential level.

The result of output demand function shows that real interest rate explains more variations in output demand than the real exchange rate. This is not unexpected, as the economy was not completely open during the study period.

The result of money demand function is quite satisfactory in terms of the statistical significance of the coefficients. However, the income elasticity is very low as compared to other studies. One reason for this could be that the relationship is estimated in the first difference. Also, use of the index of industrial production may be a poor proxy for income.

The money supply equation appears to show that policy authorities are more concerned about price stability. The sterilisation coefficient is -0.73, which is statistically different from zero but not from -1. This indicates that RBI is actively involved in the sterilisation process. The result is quite in line with the other studies in the Indian context.[6]

From the result of interest rate equations, it is clear that the interest rate is mostly explained by expected exchange rate depreciation. It should be noted that since δ_t is in fact a measure of credibility, the expected sign should be negative. However, we get a positive sign, but the coefficient is very small and not significantly different from zero.

Using the required coefficients, the conversion factor (η) obtained is –0.2583.[7] Using this η, EMP and IIA are calculated and presented in columns 2 and 3 of Table 5.2. We also calculate EMP and IIA according to the Girton-Roper measure, which comes from simple monetary model where the conversion factor is –1. These are presented in the columns 4 and 5 of Table 5.2. Our EMP and IIA measures are graphically shown in Fig 5.3 and Fig 5.4. For the sake of comparison, our EMP and Girton-Roper EMP (EMPgr) measures are shown in Fig 5.5, and our IIA and Girton-Roper IIA (IIAgr) measures are shown in Fig 5.6.

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[6] See Baig *et al* (2002).

[7] It is to be noted that by ignoring insignificant coefficients the value of the conversion factor only changes in the second decimal.

Table 5.2: Exchange Market Pressure and Index of Intervention Activity

YR/MON	EMP	IIA	EMPgr	IIAgr
Apr-93	-0.011468	0.402987	-0.024738	0.723242
May-93	0.003076	0.81525	0.010278	0.944701
Jun-93	0.002805	0.107865	0.003674	0.31884
Jul-93	-0.004017	0.711347	-0.012224	0.90513
Aug-93	-0.003302	1.02027	-0.012977	1.005158
Sep-93	-0.001162	0.98079	-0.004433	0.994966
Oct-93	-0.002174	0.989735	-0.008351	0.997328
Nov-93	-0.002236	0.992873	-0.008613	0.998149
Dec-93	-0.00865	0.999263	-0.033469	0.99981
Jan-94	-0.005532	1.000576	-0.021425	1.000149
Feb-94	-0.011773	0.998646	-0.045532	0.99965
Mar-94	-0.018699	1.004603	-0.072639	1.001185
Apr-94	-0.006373	0.991997	-0.024526	0.997921
May-94	-0.002795	0.993157	-0.010766	0.998223
Jun-94	-0.003477	1	-0.013462	1
Jul-94	-0.006703	1.000951	-0.025967	1.000246
Aug-94	-0.001688	1.035881	-0.006709	1.009028
Sep-94	-0.006687	0.99428	-0.02578	0.998516
Oct-94	-0.004595	1	-0.017788	1
Nov-94	-0.000191	4.263951	-0.002534	1.246451
Dec-94	0.002791	1.03424	0.011081	1.008625
Jan-95	-0.001368	0.671523	-0.004006	0.887825
Feb-95	3.46E-05	-2.689864	-0.000232	1.548772
Mar-95	-0.000281	32.19805	-0.026224	1.333827
Apr-95	-0.00618	-0.234538	-0.002018	-2.780767
May-95	0.000774	0.782132	0.002513	0.932878
Jun-95	0.002189	1.244383	0.010009	1.053438
Jul-95	-0.001703	0.573378	-0.004506	0.838794
Aug-95	0.006405	-0.001362	0.00638	-0.005295
Sep-95	0.050594	0.009464	0.051969	0.035671
Oct-95	0.034355	-0.146057	0.019946	-0.973917
Nov-95	0.006786	0.135159	0.00942	0.376964
Dec-95	0.006207	0	0.006207	0
Jan-96	0.022636	0.023617	0.024171	0.085627
Feb-96	0.02433	-0.018092	0.023066	-0.073879
Mar-96	-0.062451	-0.010627	-0.060545	-0.042438

(Contd.)

Table 5.2: Exchange Market Pressure and Index of Intervention Activity (Contd.)

YR/MON	EMP	IIA	EMPgr	IIAgr
Apr-96	-0.005885	0.234966	-0.009856	0.54318
May-96	0.023038	0.032923	0.025216	0.11645
Jun-96	-0.002822	0.694168	-0.008446	0.897827
Jul-96	0.011328	-0.314294	0.001105	-12.47772
Aug-96	0.003766	-0.420714	-0.000784	7.828217
Sep-96	-0.001624	1.567425	-0.008931	1.103153
Oct-96	-0.005029	0.509657	-0.012389	0.800954
Nov-96	0.000175	-14.19823	-0.006958	1.382155
Dec-96	0.002677	-0.042974	0.002346	-0.189794
Jan-97	0.000274	-2.533179	-0.001719	1.563152
Feb-97	0.001843	0.708085	0.005589	0.903761
Mar-97	-0.014341	0.962103	-0.053961	0.989928
Apr-97	-0.00248	0.372326	-0.005132	0.696647
May-97	-0.004958	1.003379	-0.019243	1.000871
Jun-97	-0.004918	0.971613	-0.01864	0.99251
Jul-97	-0.004533	0.554187	-0.011748	0.82796
Aug-97	0.000145	-34.23781	-0.01409	1.362109
Sep-97	0.017433	0.188444	0.026866	0.473396
Oct-97	-0.008263	0.314418	-0.015723	0.639707
Nov-97	0.028598	0.03862	0.031769	0.134592
Dec-97	0.053358	0.028542	0.057731	0.10213
Jan-98	0.002634	-0.714476	-0.00277	2.63036
Feb-98	-0.012699	-0.020408	-0.011955	-0.083927
Mar-98	0.005983	-1.616783	-0.021793	1.718395
Apr-98	0.003595	-0.099974	0.002563	-0.542895
May-98	0.020117	-0.009483	0.01957	-0.037741
Jun-98	0.043765	0.021094	0.046415	0.077
Jul-98	0.006964	0.092158	0.008807	0.282128
Aug-98	0.002907	-0.985988	-0.005323	2.084509
Sep-98	-0.013009	0.577075	-0.034567	0.840829
Oct-98	-0.006059	0.269121	-0.010742	0.58772
Nov-98	0.001164	0.042876	0.001308	0.147797
Dec-98	0.002924	-0.385019	-0.000309	14.11942
Jan-99	-0.00429	0.742933	-0.013441	0.917957
Feb-99	-0.002388	0.600845	-0.006509	0.853538
Mar-99	-0.007971	0.950062	-0.029716	0.986605

(Contd.)

Table 5.2: Exchange Market Pressure and Index of Intervention Activity (Contd.)

YR/MON	EMP	IIA	EMPgr	IIAgr
Apr-99	0.00529	-0.226503	0.001849	-2.508262
May-99	-0.002712	1.398536	-0.013602	1.079455
Jun-99	0.007924	-0.070312	0.006324	-0.341074
Jul-99	0.002126	-0.627116	-0.001703	3.03201
Aug-99	0.005331	0.245672	0.009091	0.557692
Sep-99	0.001816	0.044218	0.002047	0.151903
Oct-99	-0.002043	0.036687	-0.002258	0.128496
Nov-99	-0.005137	0.764656	-0.016417	0.926356
Dec-99	-0.002186	1.928708	-0.014294	1.142043
Jan-00	0.001395	-0.070635	0.001112	-0.34304
Feb-00	-0.001774	1.822702	-0.011058	1.131974
Mar-00	-0.010922	0.942461	-0.04048	0.984475
Apr-00	0.000411	-1.935559	-0.001873	1.64406
May-00	0.010019	0.216062	0.016235	0.516211
Jun-00	0.016267	0.020506	0.017225	0.074975
Jul-00	0.003587	0.442252	0.008142	0.754286
Aug-00	0.019239	-0.035716	0.017266	-0.154076
Sep-00	0.004781	0.048426	0.005446	0.164593
Oct-00	0.011251	0.120741	0.015152	0.347102
Nov-00	-0.001643	6.678392	-0.033151	1.281432
Dec-00	-0.012763	0.95091	-0.047614	0.986841
Jan-01	-0.007246	0.391465	-0.015392	0.713507
Feb-01	-0.004445	0.868481	-0.015529	0.962356
Mar-01	-0.000117	19.97273	-0.006855	1.325148
Apr-01	0.000884	-2.946788	-0.006598	1.528946
May-01	0.002286	-0.276535	0.000471	-5.198579
Jun-01	-0.000994	2.790398	-0.008961	1.198656
Jul-01	0.001603	-0.795989	-0.002061	2.396944
Aug-01	-0.005222	0.947994	-0.019437	0.986028
Sep-01	0.008737	-0.245224	0.002585	-3.208996
Oct-01	0.006497	-0.312501	0.000667	-11.78437
Nov-01	-0.007083	0.970613	-0.026822	0.99224
Dec-01	-0.008067	0.715848	-0.02465	0.907004
Jan-02	0.003813	-1.288393	-0.010292	1.847685
Feb-02	0.001504	-4.068834	-0.016068	1.474453

Fig 5.3: Movement in Exchange Market Pressure (EMP)

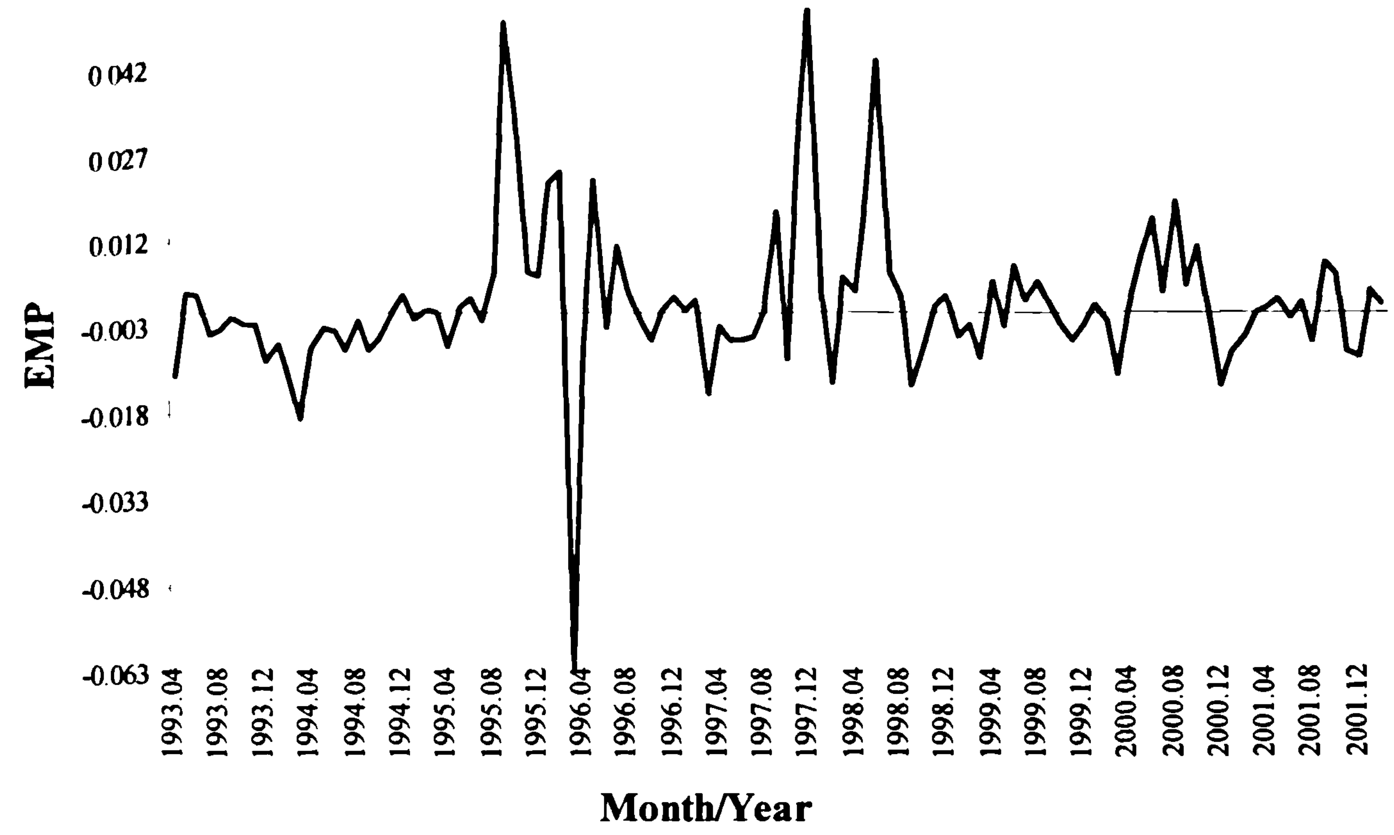


Fig 5.4: Movement in Index of Intervention Activity (IIA)

Fig 5.5: Movements in EMP and EMPgr

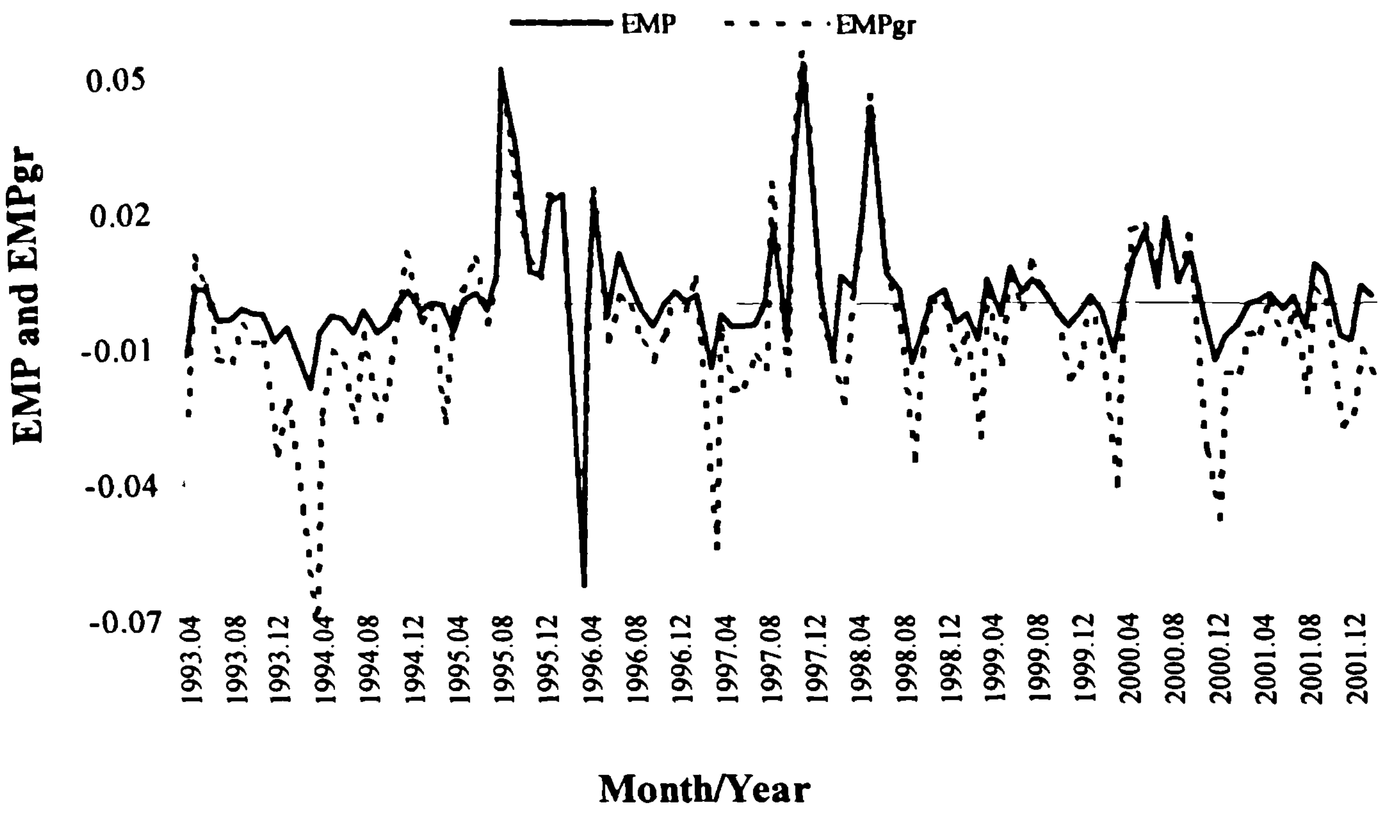
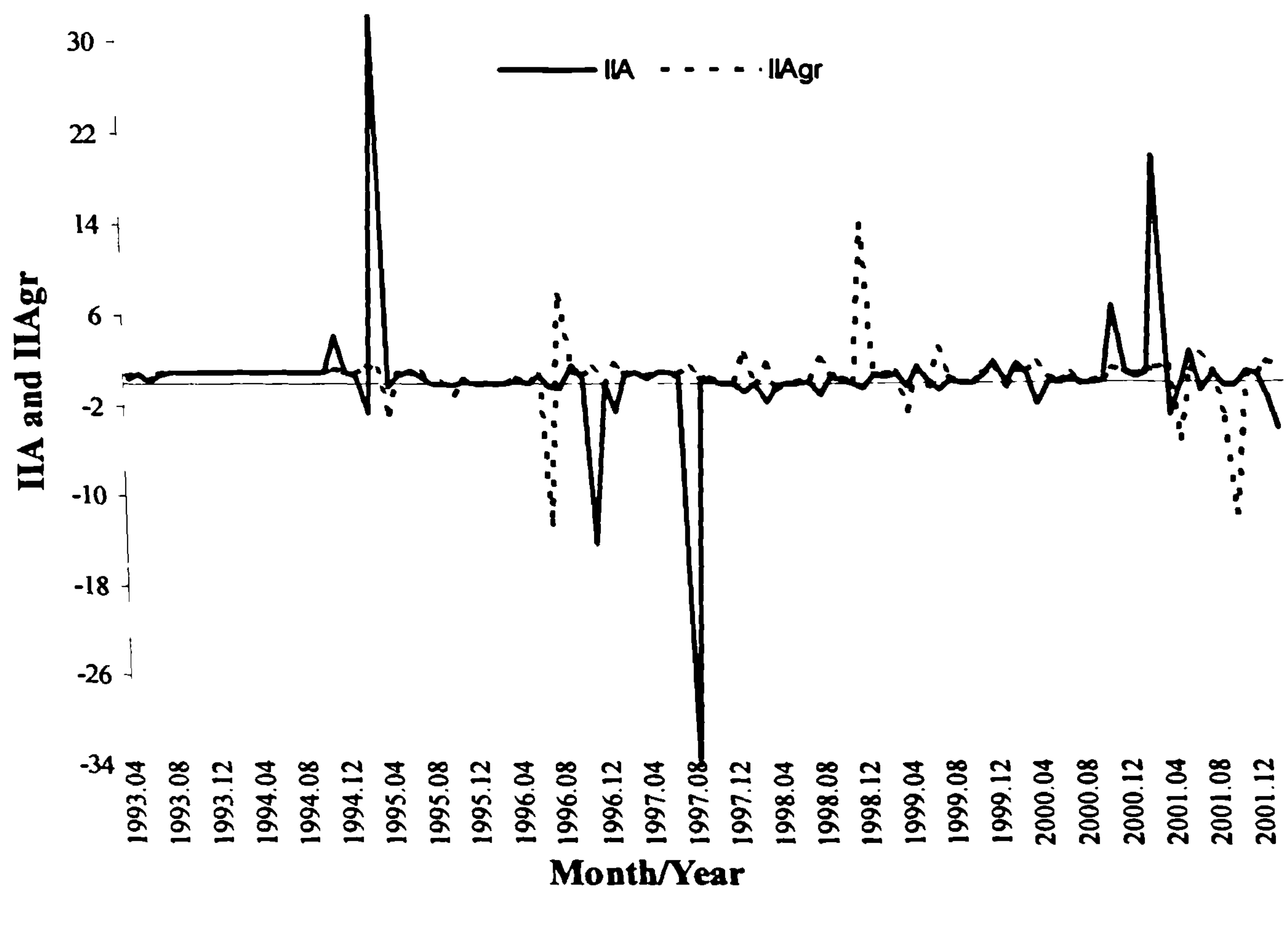


Fig 5.6: Movements in IIA and IIAgr



5.4 Discussions of EMP and IIA

The first thing to note about our empirical findings is that the value of the conversion factor is quite small. This indicates that large percentage changes in reserves represent relatively small percentage changes in exchange rate. The implication is that direct intervention would be a relatively ineffective intervention policy in the sense that large volumes of sales/purchases would need to be undertaken to make a noticeable difference to the exchange rate.

Our empirical findings also show that in the market determined exchange rate regime, there was pressure on exchange rate to depreciate some times and appreciate some times. Over the study period, in 54 months there was market pressure on exchange rate to appreciate (indicated by negative EMP values), and in remaining 53 months EMP values are positive indicating market pressure on exchange rate to depreciate (see column 2, Table 1; and Fig 5.3). The negative EMP values range from a low of 0.019 per cent (November 1994) to a high of 6.24 per cent (March 1996). The positive EMP values vary between 0.0034 per cent (February 1995) to 5.33 per cent (December 1997).

IIA values are mostly positive. Over the study period, IIA takes negative values for 32 months indicating that during these months RBI policy was 'leaning with the wind' and rest of the 75 months policy was leaning against the wind indicated by positive IIA (see column 3, Table 1; and Fig 5.4). This means RBI mostly counteracts the market forces.

It is found that negative IIA is mostly associated with positive EMP (except three months: April 1995, March 1996, and February 1998). This indicates periods when the RBI has actively intervened to make the exchange rate depreciate even more than market forces would have done. However, market pressure on exchange rate to appreciate (indicated by negative EMP values) has mainly been countered (indicated by positive IIA values) by intervention. Indeed, there have been times when IIA has been greater than one (all associated with negative EMP values). This indicates periods when intervention actually resulted in exchange rate depreciation despite market pressure for an appreciation.

We may also compare our measures with the measures using the Girton-Roper formula. From Girton-Roper measures, in 69 months there was market pressure on exchange rate to appreciate (indicated by negative EMP values), and in remaining 24 months EMP values are positive indicating market pressure on exchange rate to depreciate (see column 4, Table 1; and Fig 5.5). In some months they are opposite in sign to ours. The negative EMP values range from a low of 0.02 per cent (February 1995) to a high of 7.26 per cent (March 1994). The positive EMP values vary between 0.047 per cent (May 2001) to 5.77 per cent (December 1997).

The IIA values corresponding to the Girton-Roper measure are also mostly positive. Over the study period, IIA takes negative values for 17 months indicating that during these months RBI policy was 'leaning with the wind' and rest of the 90 months policy was leaning against the wind indicated by positive IIA (see column 5, Table 1; and Fig 5.6). Very often the IIA values are greater than one. This means RBI mostly counteracts the market forces, quite often resulting in a movement in the opposite direction. Girton-Roper measure also shows that negative IIA is associated with positive EMP except February 1998. In the months when EMPgr has a different sign from ours, the IIAgr is also of an opposite sign. However, the interpretation in both cases is that of RBI intervention leading to a depreciation of exchange rate compared to market forces.

Therefore, the Girton-Roper measure yields broadly the same qualitative results (i.e., in the same direction) as ours, as far as intervention is concerned. Both measures show a preference for depreciation. But the Girton-Roper EMP measure shows a market pressure on the rupee to appreciate more often than ours. Also, it magnifies both the exchange market pressure and the level of intervention.

The Girton-Roper measures of EMP and IIA come from a simple monetary model where the conversion factor is -1, i.e., almost four times higher than that yielded by our model. Hence inclusion of product market, monetary policy reaction function, and interest parity in inexact form plays important role on the values of conversion factor and hence EMP and IIA. Especially the expected exchange rate changes and sterilisation of foreign exchange intervention had a very significant impact on the value of the conversion factor. The larger the conversion factor, the more the dominance of the central bank's foreign exchange intervention on the measure of EMP. This explains why Girton-Roper measure typically yields much higher absolute values of EMP than ours. In practice, the volatility of foreign exchange interventions is typically much greater than that of exchange rates.[8] Thus a higher conversion factor has the implication that foreign exchange intervention determine the EMP measure almost completely and may result in a high estimate of EMP. Also, the intervention index will always be close to one. This would seem to suggest that intervention always relieves almost all the pressure in the exchange market, implying that monetary authorities do not allow exchange rates to float at all. It is difficult to believe that this would be true in all cases, calling into question the credibility of the Girton-Roper measure.

[8] See Eichengreen, Rose and Wyplosz (1996)

Appendix

Annual Study

Table A 5: Stationarity Test Results (1975-76 to 2001-02)

Phillips-Perron (PP) Test				
Variables	**Level**		**First difference**	
	No Trend	**Trend**	**No Trend**	**Trend**
y_t	0.98	-1.88	-6.58^{*}	-6.88^{*}
p_t	-0.17	-2.74	-4.73^{*}	-4.62^{*}
e_t	0.38	-2.03	-3.35^{**}	-3.36^{***}
i_t	-3.87	-3.80	-8.32^{*}	-8.10^{*}
i_t^*	-2.01	-2.35	-4.20^{*}	-4.12^{**}
r_t	-	-	-3.21^{**}	3.25^{***}
δ_t	-1.19	-1.63	-3.61^{**}	-3.57^{***}
$\{y_t - y_t^P\}$	-4.15^{*}	-4.08^{**}	-7.07^{*}	-6.91^{*}
$\{m_t^d - p_t\}$	-0.83	-3.05	-4.96^{*}	-4.86^{*}
$\{m_t^s - r_t - p_t - y_t^P\}$	-	-	-3.34^{**}	-4.69^{*}
$\{m_t^s - r_t\}$	-	-	-2.63^{***}	-3.56^{***}
$\{e_t + p_t^* - p_t\}$	-0.66	-2.18	-3.88^{*}	-3.81^{**}
$\{p_t - E_{t-1}(p_t)\}$	-4.26^{*}	-3.95^{**}	-6.76^{*}	-6.71^{*}
$\{E_t(e_{t+1}) - e_t\}$	-2.56	-2.54	-6.04^{*}	-5.88^{*}
$\{i_t - E_t(p_{t+1}) + p_t\}$	-3.27^{**}	-3.26^{***}	-4.74^{*}	-4.63^{*}

Contd.

Table A 5: Stationarity Test Results (1975-76 to 2001-02)

Augmented Dicky-Fuller (ADF) Test				
Variables	**Level**		**First difference**	
	No Trend	**Trend**	**No Trend**	**Trend**
y_t	1.06	-1.58	-4.75^{*}	-5.13^{*}
p_t	-0.09	-3.71	-5.02^{*}	-4.87^{*}
e_t	0.07	-2.26	-3.04^{**}	-3.09
i_t	-3.43	-3.40	-6.87^{*}	-6.76^{*}
i_t^*	-2.18	-2.71	-4.51^{*}	-4.44^{*}
r_t	-	-	-3.10^{**}	-3.19
δ_t	-1.48	-1.98	-3.61^{**}	-3.60^{**}
$\{y_t - y_t^P\}$	-3.76^{*}	-3.69^{**}	-5.25^{*}	-5.13^{*}
$\{m_t^d - p_t\}$	-1.05	-4.92	-5.37^{*}	-5.18^{*}
$\{m_t^s - r_t - p_t - y_t^P\}$	-	-	-1.66	-3.00
$\{m_t^s - r_t\}$	-	-	-1.49	-2.64
$\{e_t + p_t^* - p_t\}$	-0.63	-2.91	-4.27^{*}	-4.27^{**}
$\{p_t - E_{t-1}(p_t)\}$	-3.29^{**}	-3.19	-4.98^{*}	-5.14^{*}
$\{E_t(e_{t+1}) - e_t\}$	-3.46^{**}	-3.28^{***}	-4.86^{*}	-4.75^{*}
$\{i_t - E_t(p_{t+1}) + p_t\}$	-4.44^{*}	-4.80^{*}	-4.98^{*}	-4.85^{*}

*: The required critical values at 1%, 5% and 10% level of significance are respectively –3.69, -2.97 and -2.62 for without trend, and –4.33, -3.58, -3.22 for with trend. In ADF and PP test we used the lag length 1 and 2 respectively. This optimal lag length is suggested by Newey -West test.

Results of Annual Study

$$\{y_t - y_t^P\} = -0.18\{p_t - E_{t-1}(p_t)\} - 0.003 Dum91 \qquad (A\ 5.1)$$

(1.38) (−1.24)

n=25, $\bar{R}^2 = 0.62$, Q(4)=4.43 (0.10), Q(8)=6.51 (0.36), Q(12)=16.01 (0.09)

$$\Delta y_t = 0.05 + 0.05\Delta\{e_t + p_t^* - p_t\} - 0.06\{i_t - E_t(p_{t+1}) + p_t\} \qquad (A\ 5.2)$$

(4.32)* (1.07) (−0.97)

n=25, $\bar{R}^2 = 0.42$, Q(4)=2.13 (0.34), Q(8)=8.91 (0.17), Q(12)=12.46 (0.25)

$$\{\Delta m_t^d - \Delta p_t\} = 0.09 + 1.07\Delta y_t - 0.64 i_t + 0.006 Dum91 \qquad (A\ 5.3)$$

(11.07)* (7.03)* (−5.41)* (0.78)

n=25, $\bar{R}^2 = 0.91$, Q(4)=2.77 (0.25), Q(8)=8.01 (0.23), Q(12)=11.82 (0.29)

$$\{\Delta m_t^s - \Delta r_t - \Delta p_t - \Delta y_t^P\} = -0.02 - 0.30\Delta p_t + 1.02(\Delta y_t - \Delta y_t^P) - 0.68\Delta r_t \qquad (A\ 5.4)$$

(0.49) (−0.64) (2.06)** (−2.90)*

n=25, $\bar{R}^2 = 0.31$, Q(4)=1.87 (0.59), Q(8)=5.46 (0.60), Q(12)=12.46 (0.34)

$$i_t = 0.03 + 0.26 i_t^* + 0.10\Delta\{E_t(e_{t+1}) - e_t\} - 0.13\Delta\delta_t + 0.13 Dum91 \qquad (A\ 5.5)$$

(1.30) (1.76)*** (1.80)*** (−5.69)* (8.38)*

n=25, $\bar{R}^2 = 0.40$, Q(4)=1.39 (0.23), Q(8)=3.73 (0.58), Q(12)=11.46 (0.24)

The t- statistics are given in the parenthesis along with the estimated equations. The values in the parenthesis for Q- statistics with different lag lengths are the level of significance. The level of significance of the coefficients is indicated by the asterisks. * 1% level of significance, ** 5% level of significance, and *** 10% level of significance.

Chapter 6

Discussion of Results and its Implications

6.1 Introduction

This chapter studies the implications of the EMP and IIA measures obtained earlier, examining them in the light of actual happenings in the economy, and the RBI's claims. It examines what would have been the exchange rate in the absence of the RBI's direct intervention. In addition, it examines the policy stance of the RBI, given our measure of the degree of RBI's intervention in the foreign exchange market.

To begin with we have calculated the imputed exchange rate, i.e., the exchange rate that would have existed if the RBI had not intervened in the market. This is presented in Table 6, along with the actual, (i.e., the observed) exchange rate, given the intervention. This enables us to directly see the effect of intervention on exchange rate at each point of time. In Table 6, we also reproduced the EMP and IIA values calculated in the previous chapter, and the change in the stock of net foreign exchange assets (i.e., the direct intervention in the foreign exchange market), in each month. We have also plotted the actual and the imputed movements in exchange rate in Fig 6.2. In Fig 6.1, we have plotted the EMP and IIA obtained for each month.

6.2 Some Precautionary Statements

It is necessary to make some disclaimers regarding conclusions that can be drawn from our EMP and IIA values. We have calculated the conversion factor from a specific model of the economy, so it has the same drawbacks as the model. The first point to note is that the model we used takes into account expectation formation and risk premium. So, η reflects the signaling effect of policy (acting through expectation formation) and the risk premium. However, the model of the economy is assumed to be stable, and expectations are presumed to be rational and based on this stable model. This assumption of stability may not valid for periods of acute financial shocks and speculative attacks. In these situations the expectations would be formed on entirely different considerations. So the conversion factor we have obtained may not serve to correctly measure the signaling effects of reserve changes and other policies on the exchange market pressure.

Secondly, the model ignores indirect intervention in the exchange market. We had defended this on the grounds that the RBI is seen to sterilise foreign exchange intervention, and sterilisation will not coexist with indirect intervention. While this may be true on average, there could still be particular points of time when indirect intervention takes place, and sterilisation does not. The model does not allow for this as the domestic credit policy reaction function has only price and output stability as arguments, and not exchange rate. This means that the value of η obtained only serves to measure the exchange market pressure after a part of it has been relieved by indirect intervention. To the extent that indirect intervention is often used to forestall expected speculative attacks, the model will not serve to measure the actual EMP during crises for this reason as well as the one mentioned earlier. However, it is empirically difficult to consider indirect intervention in the model due to non-availability of data on the extent of domestic credit creation specifically for the purpose of indirect intervention in the foreign exchange market.

6.3 Discussion of Results

In this section we look at the happenings in the foreign exchange market between March 1993 and January 2002. We discuss this alongside the RBI's statements.

During March 1993 to March 1995 there was a net capital inflow into the country, which had put pressure on rupee to appreciate, and the RBI had deliberately resorted to net purchase of foreign exchange with an intention to prevent rupee appreciation so as to avoid erosion of export competitiveness.[1] This is borne out by the values of EMP and IIA. EMP is negative right through this period, and IIA is positive, and in fact, is on an average more than unity during these

[1]For details regarding the RBI's view of market conditions and its actions referred to through this chapter, see the Annual Reports from 1993-94 to 2001-02.

months. This means that RBI not only prevented appreciation, but also actually led to depreciation. This helped to stabilise the exchange rate around Rs. 31.37 per dollar. In the absence of intervention, exchange rate would have appreciated as the imputed values reflect (see Table 6).

In December 1994 there was market pressure on exchange rate to depreciate, but RBI reacted by selling reserves to counter this. The positive IIA indicates that RBI is reacting to exchange rate depreciation. But depreciation was allowed in January and February 1995, when there was a mild pressure on exchange rate to depreciate. RBI intervened in the market through net purchases to bring the exchange rate back to 31.37.

In March 1995, there was a larger net purchase of foreign exchange resulting in depreciation of rupee against US dollar by Rs. 0.28, which would have otherwise appreciated by Rs. 0.01. In April 1995 the pressure to appreciate increased. This was met by a sale of reserves through April, May and June, which resulted in an even higher level of appreciation over these months than the market would have led to. The negative IIA value in April reflects the fact of reserve depletion when EMP was itself negative. In July 1994, the exchange rate was brought back to 31.37, and the RBI claims that normalcy was restored in exchange market.

The pressure to appreciate was turned around by August 1995, and "a marginal depreciation of the exchange rate was allowed." The EMP and IIA values in August reflect this policy of leaning with the wind, towards greater depreciation.

The rupee came under speculative attack between September 1995 and February 1996. The RBI annual report states that during this period there was downward pressure on exchange rate. "The nominal exchange rate plunged in October 1995 as speculation lengthened the normal leads and lags in receipts and payments. Panic demand for cover and cancellations of forward contracts created persistent mismatches of supply and demand both in the spot and forward segments of the market. The monetary policy stance was eased transiently in November 1995 through reduction in cash reserve requirements. Easy monetary policy was followed in November 1995." The downward pressure on the rupee is reflected in the high EMP values over this period, with a small respite in November and December. The RBI is seen to have largely stayed away from directly intervening in the market, though in October it appears to have aided further depreciation by net purchases. In general, the policy appears to have been to lean with the wind in aiding depreciation. This is shown by the low positive, and sometimes negative values of IIA. In fact, the "easy monetary policy" of November increased the downward pressure, and in January and February 1996 exchange market pressure flared up and the exchange rate touched a record low. This is also reflected in our high EMP values (average 2.3% in these two months).

So, in February, policy authorities took some monetary policy measures, along with intervention sales. Normalcy was restored in March 1996 in the foreign exchange market. Market pressure on rupee was to appreciate (shown in the negative EMP measure), and policy authorities leaned with the wind (negative IIA). As a result, exchange rate fell back to 34.39 in March (February it was 36.63). There was a further appreciation in April, and RBI used this to purchase reserves, which shows up in the positive IIA. At the same time, RBI took steps towards an easy monetary policy. For the first time in the market determined exchange rate regime, bank rate was reduced to 11.00 per cent in Apr 16, 1996 from its previous rate of 12.00 in October 1991. The combined effect of the monetary policy, and foreign exchange purchases of April led to a negative EMP, and the rupee depreciated in May 1996.

The RBI says that the year 1996-97 was characterised by excess supply conditions, with a contraction in the current account deficit and resurgence of capital inflows. This, it claims, enabled the RBI "to substantially purchase US dollars during the year to prevent appreciation of the rupee, essentially to protect international competitiveness. The stability of the rupee was restored by the beginning of 1996-97 and it prevailed throughout the year." There was a continuous purchase during the year 1996-97 except May 1996 and February 1997. The net purchase continued till August 1997. But what the EMP and IIA figures show is that there was both positive and negative pressure in the exchange market over this period, and the RBI leaned against the wind whenever pressure was negative, and quite often leaned with the wind when pressure was positive. In other words, almost right through the period, the rupee value was kept lower than the market would have done, and reserves have been continuously built up.

From April 1997 to August 1997, "calm prevailed in the foreign exchange market. There was excess supply conditions in the foreign exchange market. Sluggish import demand and buoyant capital inflows put pressure on rupee to appreciate." During this period, the Reserve Bank undertook large net purchases of foreign currency. A measure of market surplus is given by the net cumulative purchases of US $ 5.4 billion by the Reserve Bank during April-August 1997. Our results show that the EMP was mainly negative, and IIA was mainly positive, and sometimes greater than one. Exchange rate was kept more or less stable during this period. It appreciated a little in July, but in August 97, when EMP was positive, though very low, net purchases were very high, (showing up in a very high value of IIA), and the rupee was made to depreciate. So RBI prevented the nominal appreciation of rupee, but it says that the rupee appreciated in real terms.

The period September 1997 to mid-January 1998 was marked with acute downward exchange market pressure. This began in September 1997 and became intense in November and December 1997. The rupee weakened quite drastically between September 1997 and January 1998. The RBI points out that this happened "despite strong fundamentals", and attributes it to a spillover effect of the currency turbulence in South-East Asian markets. "In September the demand for foreign exchange increased in the spot market; inter-bank turnover rose sharply and inter-bank spot purchases (excluding sales by the Reserve Bank) exceeded inter-bank sales by a significant margin; in the forward market, excess demand conditions mounted up as importers rushed for cover and exporters cancelled forward contracts. In response to this, Reserve Bank made a large intervention sale in the forward market." This leaning against policy is reflected in our result (positive EMP and IIA values).

Excess demand conditions persisted, with considerable volatility in the foreign exchange market, till December 1997, except for a brief respite in October, when there was a resumption of capital flows. This is rightly reflected in our EMP measures (negative EMP in October but positive in other two months). There was a marginal appreciation in the rupee. The RBI immediately eased the monetary conditions. The bank rate was reduced to 9.00 per cent and SLR reduced to 25.00 percent in Oct 1997. The fairly strong intervention, direct and indirect, kept the rupee from appreciating as much as it would have. In November and December, again, EMP was positive and high, showing downward pressure. Over the quarter rupee depreciated by about 7.6 per cent. During this period, the RBI claims that "the market was driven by downside expectations created largely in the backwash of the currency turmoil in South-East Asia and political developments within the country; profit taking by FIIs on the stock exchanges in November; significant spurt in inter-bank and merchant turnover by November and December 1997; and demand (i.e. forward sales by ADs) exceeded supply (i.e. forward purchases by ADs) by a significant margin in the forward market."

In reaction, RBI directly intervened in the spot and forward segments of the exchange market. In addition RBI took several monetary measures in December 1997, such as, raising the interest rate on fixed rate repos and the cash reserve ratio (CRR) on net demand and time liabilities of scheduled commercial banks. Forward contracts were suspended with a view to containing the spurt in activities in the forward segment of the market; the interest rate on post-shipment export credit in rupees for periods beyond 90 days and up to six months was raised. This was done "to reduce volatility, curb speculative activity and ward off any threat of contagion." The EMP fell by January, reflecting the effect of the indirect measures. However, there was a fairly large purchase of reserves in January, so the exchange rate did depreciate more than the market would have made it.

A package of tight monetary measures was further introduced in January and bank rate was further increased to 11.00 per cent. Confidence was built up in the market. A modest resumption of capital flows occurred showing up in market pressure on rupee to appreciate in February 1998. Direct intervention by the RBI also followed a leaning with the wind policy, with a purchase of reserves in January. The rupee appreciated in this month. By April 1998, normalcy was prevailing in the market. Our result confirms that through this quarter, RBI was adopting leaning with the wind policy, since EMP is positive, though low, and IIA is negative.

In April 1998, RBI rolled back the monetary measures undertaken in January 1998. For instance, it reduced the bank rate to 9.00 per cent in April 1998 in two steps. In the period from May to June 1998, according to the RBI, the foreign exchange market was characterised by considerable uncertainties in India as well as abroad. "Excess demand conditions, which had got built up in May 1998, had intensified by June 1998 in both the spot and the forward segments of merchant transactions in the foreign exchange market. Rupee depreciated from Rs 39.73 per US dollar at the beginning of May 1998 to Rs.42.38 per US dollar on June 11, 1998; and, both the three-month and the six-month swap premia jumped sharply over their April 1998 level, increasing by 3-5 percentage points to about 10 per cent in June 1998." Our EMP measure shows that there was very strong pressure on rupee to depreciate (2 per cent in May and 4.3 percent in June).

In response, RBI sold reserves (its cumulative sales during May-June 1998 were US $ 2,381 million) and also announced a set of supportive monetary measures (for details, see Annual Report, 1998-99, section 1) on June 11, 1998 to stem speculative activities and restore orderly market conditions in the foreign exchange market. These measures had the required effect, reflected in reduction in EMP in July. Pressure on rupee to depreciate was low in this month (0.67 per cent). But direct intervention was to sell, keeping the rupee higher than it otherwise would have been.

The RBI states that excess demand pressures emerged in August 1998 in the spot segment of merchant as well as inter-bank transactions of the foreign exchange market following the deepening of the Russian financial turmoil and the fear of Chinese renminbi devaluation. (This is reflected in our positive EMP value. This prompted the Reserve Bank to "undertake a fresh package of monetary policy and institutional measures on August 20, 1998 in order to prevent speculative sentiments." These measures, coupled with the successful raising of US $ 4,230 million under RIBs appear to have worked, since the EMP in September is negative, and the rupee strengthened. Once again, we note that RBI purchased reserves (with net purchases amounting to US $ 1,302 million during August-September 1998), so keeping the rupee lower than it otherwise would have been. A similar situation continued into October. Normalcy continued in the market till the fourth quarter. The forward premia too declined over the course of the third quarter. Excess market supply conditions prevailed during the fourth quarter, particularly in March 1999. The RBI steadily continued to make net purchases on the market. These were significantly higher at US $ 2,755 million over the quarter; in the month of March 1999 alone, the Reserve Bank purchased US $ 1,420 million in the foreign exchange market. So the rupee was kept lower than the market would have kept it. In this period, the RBI reduced bank rate to 8 per cent. So, it appears that the RBI followed indirect intervention to keep the pressure on the rupee low, and at the same time purchased reserves. The EMP values over this period are mostly negative, reflecting the excess supply conditions in the foreign exchange market, but the IIA was positive.

The excess supply conditions visible during the fourth quarter of 1998-99 continued into the first two months of 1999-2000, but exchange market pressure was building up in May 1999 for rupee to appreciate. RBI intervened in the market by net purchases, which is also reflected in our high IIA values (1.39). The net purchase of foreign currency amounted to US $1013 million in these two months.

During June to September 1999, the RBI says the foreign exchange market exhibited volatility and excess demand conditions following the border tensions. Due to the uncertainty in the market, for instance, excess demand rose from US $ 95 million during July 1999 to US $ 775 million during August 1999 in the spot segment and from US $ 1,109 million to US $ 1,689 million in the forward segment of merchant transactions. The forward premia firmed up in August 1999 with the onset of excess demand conditions in the foreign exchange market. This excess demand conditions put pressure on exchange rate to depreciate, which is reflected, in our positive EMP values. The Reserve Bank "reiterated its policy to maintain orderly conditions in the foreign exchange market." In order to wipe out the excess demand conditions in the market over the period June-September 1999, RBI indicated its readiness to meet fully/partly foreign exchange requirements. This seems to have kept the pressure on the rupee down, since our EMP value is quite low, though positive, for August, and becomes negative in September. The RBI followed this up by also making a net sale of dollars. This is reflected in our result, which shows negative IIA, of a fairly high magnitude for August.

During November 1999 to March 2000, again excess supply conditions prevailed in the market due to recovery in exports coupled with sustained portfolio inflows. RBI went for a huge net purchase of foreign exchange to the tune of US $3.5 billion during this period, which is higher than the net purchases for the year as a whole (US $3.2 billion). The forward premia eased with the return of excess supply conditions in the foreign exchange market. The excess supply conditions would have put pressure on rupee to appreciate. This is reflected in our negative EMP values during this period. RBI policy in this period was to build up reserves at the cost of allowing marginal depreciation of rupee. This policy is rightly shown in our empirical results. Rupee depreciated marginally during this period.

During the first quarter of 2000-01, demand pressures prevailed in the foreign exchange market, reflecting the higher oil import payments and reduced capital inflows. RBI had reduced bank rate to 7 per cent in April 2000, as part of its domestic monetary policy. The exchange rate depreciated between April and May. RBI says the market was characterised by considerable uncertainty. This was reflected in the widening of excess demand in the spot as well as forward segments of the merchant transactions during May 2000. This shows up in the high EMP figure for May. In order to reduce the uncertainty in the foreign exchange market, the Reserve Bank undertook certain policy actions on May 25, 2000 (for detail see Annual Report, 1999-00) in addition to large net sales of reserves during May and

June 2000. In response to these measures, the pressure in July fell (the EMP value is low). Towards the end of July, again there was pressure and the exchange rate of the rupee moved to Rs. 45.02 per US dollar on July 21, 2000. The Reserve Bank took again certain tight monetary policy measures on July 21, 2000, such as, increasing bank rate by 1 percentage point from 7 per cent to 8 per cent, increasing CRR by 0.5 percentage point from 8 per cent to 8.5 per cent, and reducing the limits available to banks for refinance facilities including the collateralised lending facility (CLF) to the extent of 50 per cent. The EMP measure in August is high, but had come down in September. But there is a rise again in October, which was met by sales of reserves. Our EMP measure shows that during the period April-October 2000 there was market pressure on exchange rate to depreciate. During this period IIA values are negative but small indicating that RBI adopted leaning against wind policy in terms of direct intervention, but not strongly. It seems to have relied more on indirect intervention to reduce pressure. The EMP measures do not catch this indirect intervention.

The orderly conditions witnessed in the foreign exchange market since November 2000 continued to the rest of the financial year. Our result shows that during this period there was mild market pressure on exchange rate to appreciate, but RBI intervened and led to marginal depreciation. It continued to purchase to build up reserves. This leaning against policy is reflected in our result. In March 2001, intervention was so high (IIA value is 19.97) that exchange rate moved in the opposite direction to what market forces would have led to.

For the financial year 2000-01 as a whole, the exchange rate averaged Rs.45.68 per US dollar recording a depreciation of about 5.1 per cent over the average of Rs.43.33 per US dollar during the previous year. The rupee strengthened against other major currencies reflecting the movements of the US dollar *vis-à-vis* other major international currencies.

The exchange rate of the Indian rupee *vis-à-vis* the US dollar moved within a range of Rs. 46.56 - Rs. 48.85 per US dollar during 2001-02. On the basis of monthly averages, the exchange rate depreciated by 4.3 per cent from March 2001 to March 2002. But the real effective exchange rate was broadly stable during the year. The exchange rate remained broadly stable against the other major international currencies during April-August 2001. Reflecting the nervous sentiments ruling financial markets in the wake of the September 11 events, the rupee depreciated against major international currencies including the US dollar. Following September 11 events, the premia in the forward market hardened to 5.5-5.6 per cent across all maturities and increased further to 6.3-6.4 per cent in December 2001. The bank rate was reduced to 6.5 per cent in October 2001. We see that the EMP turns negative, although low, in November. The forward premia averaged between 5.9-6.9 per cent during March 2002. However, during the period September-March 2001, RBI policy has been to accumulate reserves even at the cost of marginal rupee depreciation. During November-December 2001 there was market pressure on rupee to appreciate (EMP is negative) but RBI intervened in the market through buying reserves to absorb excess supply.

6.4 Summary and Implications of the Study

An examination of our EMP and IIA values shows that they are in line with the RBI's claims. RBI's major concern in the foreign exchange market has been to ensure the orderly conditions in the market in the market determined exchange rate regime. We find that it did do this. Whenever there is 'lumpy' demand or supply in the market, RBI intervenes in the market to bring down the excess pressure. The EMP values show that there was a pressure whenever the RBI says there was excess demand, even though the exchange rate may not have appreciated much then. In general, direct intervention has been used to smooth out fluctuations. The exchange rate has largely followed the market, with a smoothing out of volatile fluctuations. This is seen from figure 6.2, which shows actual exchange rate and imputed exchange rate moving together. But the preference seems to have been to let the rupee depreciate slightly, while appreciation has been countered.

However, in periods of crisis, (for example, the first major speculative attack in the post unification period during September 1995 to February 1996, the East Asian currency crisis, the border tension, and the aftermath of the September

11 attack on the WTO), while the EMP values are high, they do not appear high enough to classify the period as a 'crisis'. But we must be careful in interpreting this, because, first, the EMP values measure what is left as market pressure after indirect intervention has taken place. The imputed exchange rates in Table 6 and Fig 6.2 show what the exchange rate would have been in the absence of direct intervention, but after indirect intervention has taken place. Second, our values are monthly averages. Typically, speculative attacks would show up on specific days, and the RBI would move in quickly to counteract this. At this broad level, our findings do capture the RBI's intervention policy.

During crises, we find that the RBI has taken steps in the money market as soon as it senses the attacks. In fact, it seems to have relied mainly on this kind of indirect intervention, with direct intervention being used to soak up the remaining pressure. This is perhaps not surprising, since, as we found, the change in reserves required to bring about a unit change in exchange rate is very large (i.e., the conversion factor η is small). There have even been times when the indirect intervention has itself brought about stability and direct intervention appears to have gone in the opposite direction.

Quite often there have been purchases of reserves even at the cost of mild depreciation of the rupee. While it takes protective steps in crises, and it aggressively prevents appreciation through both direct and indirect intervention, in periods of a downward pressure (even when this has been brought about through its own indirect intervention policies), it purchases reserves. It appears therefore that building up of reserves is an important objective of the RBI.

There have also been times when monetary policy appears to have been in a direction opposite to the requirements of the exchange market. This serves to point out the conflict between internal and external balance. In fact, the estimate of our monetary policy reaction function shows that price stability is a major concern. So, in such situations, when monetary policy has been undertaken for internal balance, the consequent exchange market pressure has been relieved through purchases (i.e., through direct intervention). We also find that sterilization takes place, since the sterilization coefficient has a high value. This suggests that the RBI may be caught in a situation of the 'impossible trinity'. However, even sterilized intervention could have an effect through signaling and through reducing risk perceptions. These effects, in normal periods, are reflected in η. It is interesting to note that the RBI also talks of "confidence building measures". The building of adequate reserves may serve to ensure confidence in the market, and keep it "orderly" and "calibrated".

Table 6: EMP, IIA, EXR (O), EXR (I) and ΔNFA

YR/MON	EMP	IIA	EXR (O)	EXR (I)	ΔNFA
Apr-93	-0.011468	0.402987	31.3105	31.1641	1982
May-93	0.003076	0.81525	31.3283	31.4068	-1190
Jun-93	0.002805	0.107865	31.4068	31.4162	-140
Jul-93	-0.004017	0.711347	31.3704	31.2806	1254
Aug-93	-0.003302	1.02027	31.3725	31.2668	1592
Sep-93	-0.001162	0.98079	31.3718	31.3360	544
Oct-93	-0.002174	0.989735	31.3711	31.3036	1010
Nov-93	-0.002236	0.992873	31.3706	31.3010	1059
Dec-93	-0.00865	0.999263	31.3704	31.0992	4232
Jan-94	-0.005532	1.000576	31.3705	31.1969	2717
Feb-94	-0.011773	0.998646	31.3700	31.0012	5949
Mar-94	-0.018699	1.004603	31.3727	30.7834	9766
Apr-94	-0.006373	0.991997	31.3711	31.1728	3394
May-94	-0.002795	0.993157	31.3705	31.2834	1523
Jun-94	-0.003477	1	31.3705	31.2614	1940
Jul-94	-0.006703	1.000951	31.3707	31.1602	3835
Aug-94	-0.001688	1.035881	31.3726	31.3177	1017
Sep-94	-0.006687	0.99428	31.3714	31.1628	3887
Oct-94	-0.004595	1	31.3714	31.2272	2606
Nov-94	-0.000191	4.263951	31.3910	31.3654	488
Dec-94	0.002791	1.03424	31.3880	31.4786	-1743
Jan-95	-0.001368	0.671523	31.3739	31.3451	549
Feb-95	3.46E-05	-2.689864	31.3779	31.3750	57
Mar-95	-0.000281	32.19805	31.6538	31.3691	5745
Apr-95	-0.00618	-0.234538	31.4132	31.4582	-950
May-95	0.000774	0.782132	31.4185	31.4375	-410
Jun-95	0.002189	1.244383	31.4017	31.4873	-1849
Jul-95	-0.001703	0.573378	31.3789	31.3482	674
Aug-95	0.006405	-0.001362	31.5808	31.5799	6
Sep-95	0.050594	0.009464	33.2038	33.1786	-328
Oct-95	0.034355	-0.146057	34.5372	34.3445	3393
Nov-95	0.006786	0.135159	34.7405	34.7716	-634
Dec-95	0.006207	0	34.9568	34.9561	0
Jan-96	0.022636	0.023617	35.7380	35.7481	-360
Feb-96	0.02433	-0.018092	36.6343	36.6075	300
Mar-96	-0.062451	-0.010627	34.3936	34.3465	-470

(Contd.)

Table 6: EMP, IIA, EXR (O), EXR (I) and ΔNFA (Contd.)

YR/MON	EMP	IIA	EXR (O)	EXR (I)	ΔNFA
Apr-96	-0.005885	0.234966	34.2391	34.1912	1041
May-96	0.023038	0.032923	35.0105	35.0279	-570
Jun-96	-0.002822	0.694168	34.9803	34.9117	1461
Jul-96	0.011328	-0.314294	35.5050	35.3766	2660
Aug-96	0.003766	-0.420714	35.6955	35.6387	1151
Sep-96	-0.001624	1.567425	35.7284	35.6375	1816
Oct-96	-0.005029	0.509657	35.6404	35.5487	1827
Nov-96	0.000175	-14.19823	35.7353	35.6466	1823
Dec-96	0.002677	-0.042974	35.8352	35.8310	85
Jan-97	0.000274	-2.533179	35.8699	35.8450	511
Feb-97	0.001843	0.708085	35.8892	35.9360	-927
Mar-97	-0.014341	0.962103	35.8697	35.3745	9847
Apr-97	-0.00248	0.372326	35.8139	35.7807	715
May-97	-0.004958	1.003379	35.8145	35.6363	3866
Jun-97	-0.004918	0.971613	35.8095	35.6384	3857
Jul-97	-0.004533	0.554187	35.7372	35.6472	2031
Aug-97	0.000145	-34.23781	35.9200	35.7424	3959
Sep-97	0.017433	0.188444	36.4318	36.5462	-2573
Oct-97	-0.008263	0.314418	36.2260	36.1308	2037
Nov-97	0.028598	0.03862	37.2358	37.2620	-887
Dec-97	0.053358	0.028542	39.2168	39.2226	-1217
Jan-98	0.002634	-0.714476	39.3943	39.3201	1543
Feb-98	-0.012699	-0.020408	38.8871	38.8940	-215
Mar-98	0.005983	-1.616783	39.5007	39.1198	7957
Apr-98	0.003595	-0.099974	39.6572	39.6427	315
May-98	0.020117	-0.009483	40.4708	40.4550	160
Jun-98	0.043765	0.021094	42.2423	42.2420	-810
Jul-98	0.006964	0.092158	42.5102	42.5365	-571
Aug-98	0.002907	-0.985988	42.7563	42.6338	2494
Sep-98	-0.013009	0.577075	42.5217	42.2001	6463
Oct-98	-0.006059	0.269121	42.3338	42.2641	1421
Nov-98	0.001164	0.042876	42.3810	42.3831	-46
Dec-98	0.002924	-0.385019	42.5530	42.5049	1055
Jan-99	-0.00429	0.742933	42.5061	42.3704	2935
Feb-99	-0.002388	0.600845	42.4656	42.4046	1357
Mar-99	-0.007971	0.950062	42.4487	42.1271	7291

(Contd.)

Table 6: EMP, IIA, EXR (O), EXR (I) and ΔNFA (Contd.)

YR/MON	EMP	IIA	EXR (O)	EXR (I)	ΔNFA
Apr-99	0.00529	-0.226503	42.7250	42.6733	1203
May-99	-0.002712	1.398536	42.7712	42.6091	3816
Jun-99	0.007924	-0.070312	43.1355	43.1101	564
Jul-99	0.002126	-0.627116	43.2850	43.2272	1338
Aug-99	0.005331	0.245672	43.4594	43.5158	-1298
Sep-99	0.001816	0.044218	43.5349	43.5383	-79
Oct-99	-0.002043	0.036687	43.4493	43.4460	74
Nov-99	-0.005137	0.764656	43.3968	43.2261	4043
Dec-99	-0.002186	1.928708	43.4850	43.3019	4292
Jan-00	0.001395	-0.070635	43.5500	43.5457	101
Feb-00	-0.001774	1.822702	43.6136	43.4727	3265
Mar-00	-0.010922	0.942461	43.5862	43.1373	10607
Apr-00	0.000411	-1.935559	43.6388	43.6041	863
May-00	0.010019	0.216062	43.9829	44.0760	-2324
Jun-00	0.016267	0.020506	44.6893	44.6984	-362
Jul-00	0.003587	0.442252	44.7788	44.8496	-1686
Aug-00	0.019239	-0.035716	45.6800	45.6403	716
Sep-00	0.004781	0.048426	45.8883	45.8984	-244
Oct-00	0.011251	0.120741	46.3445	46.4046	-1428
Nov-00	-0.001643	6.678392	46.7789	46.2684	12180
Dec-00	-0.012763	0.95091	46.7496	46.1819	13442
Jan-01	-0.007246	0.391465	46.5439	46.4109	3138
Feb-01	-0.004445	0.868481	46.5167	46.3370	4334
Mar-01	-0.000117	19.97273	46.6205	46.5113	2666
Apr-01	0.000884	-2.946788	46.7835	46.6617	3060
May-01	0.002286	-0.276535	46.9202	46.8904	745
Jun-01	-0.000994	2.790398	47.0038	46.8736	3382
Jul-01	0.001603	-0.795989	47.1393	47.0791	1551
Aug-01	-0.005222	0.947994	47.1265	46.8931	5874
Sep-01	0.008737	-0.245224	47.6420	47.5382	2557
Oct-01	0.006497	-0.312501	48.0500	47.9515	2376
Nov-01	-0.007083	0.970613	48.0400	47.7097	8268
Dec-01	-0.008067	0.715848	47.9300	47.6525	7123
Jan-02	0.003813	-1.288393	48.3500	48.1128	5981
Feb-02	0.001504	-4.068834	48.7200	48.4227	7520

Note: (1) EXR (O) is the observed exchange rate of rupees per US dollar. (2) EXR (I) is the imputed exchange rate, calculated as: EXR_t (I) = [1 + EMP_t]. EXR_{t-1} (O). (3) ΔNFA is the changes in net foreign exchange assets in crores of rupees.

Fig 6.1: Movements in EMP and IIA

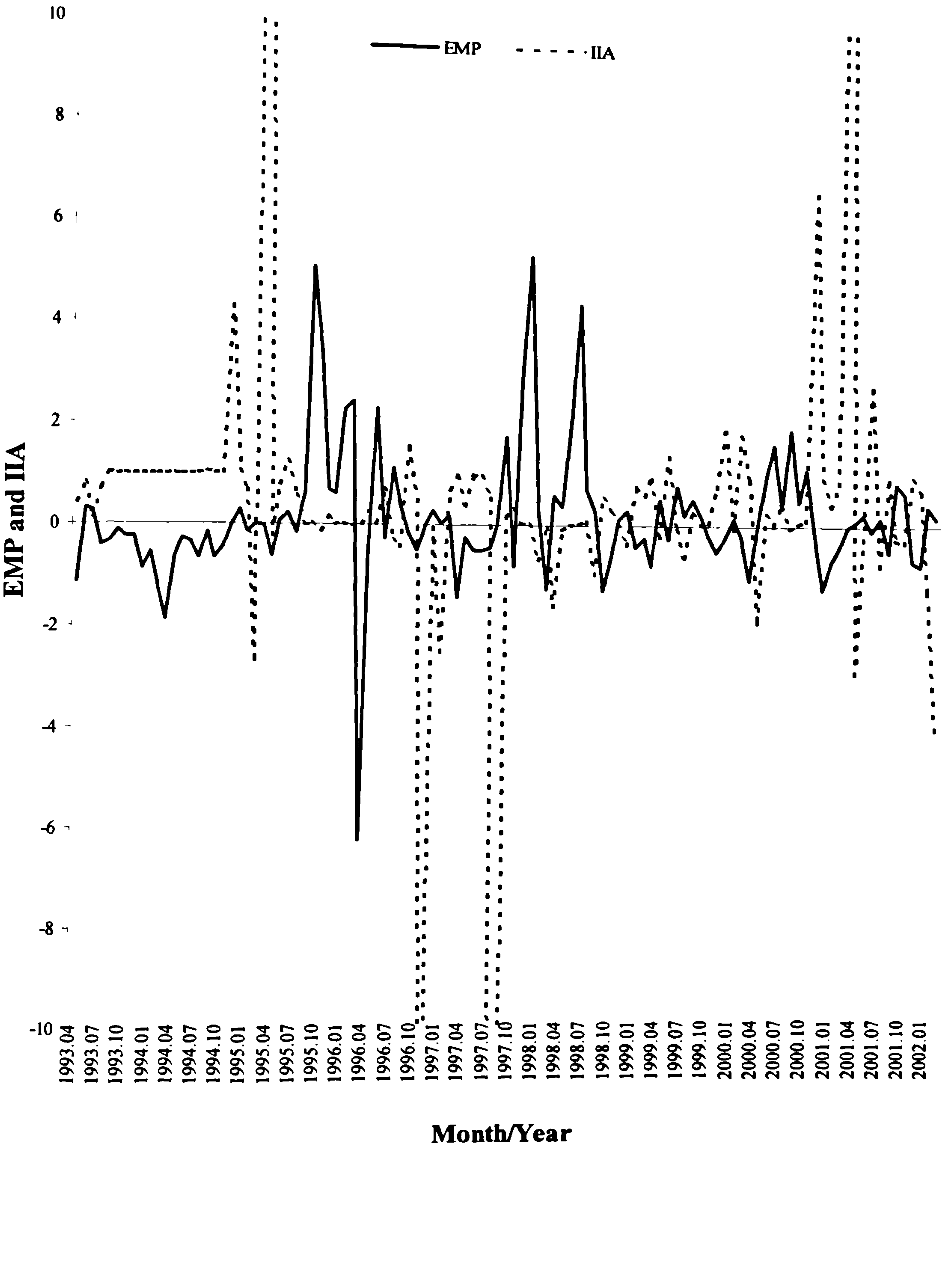
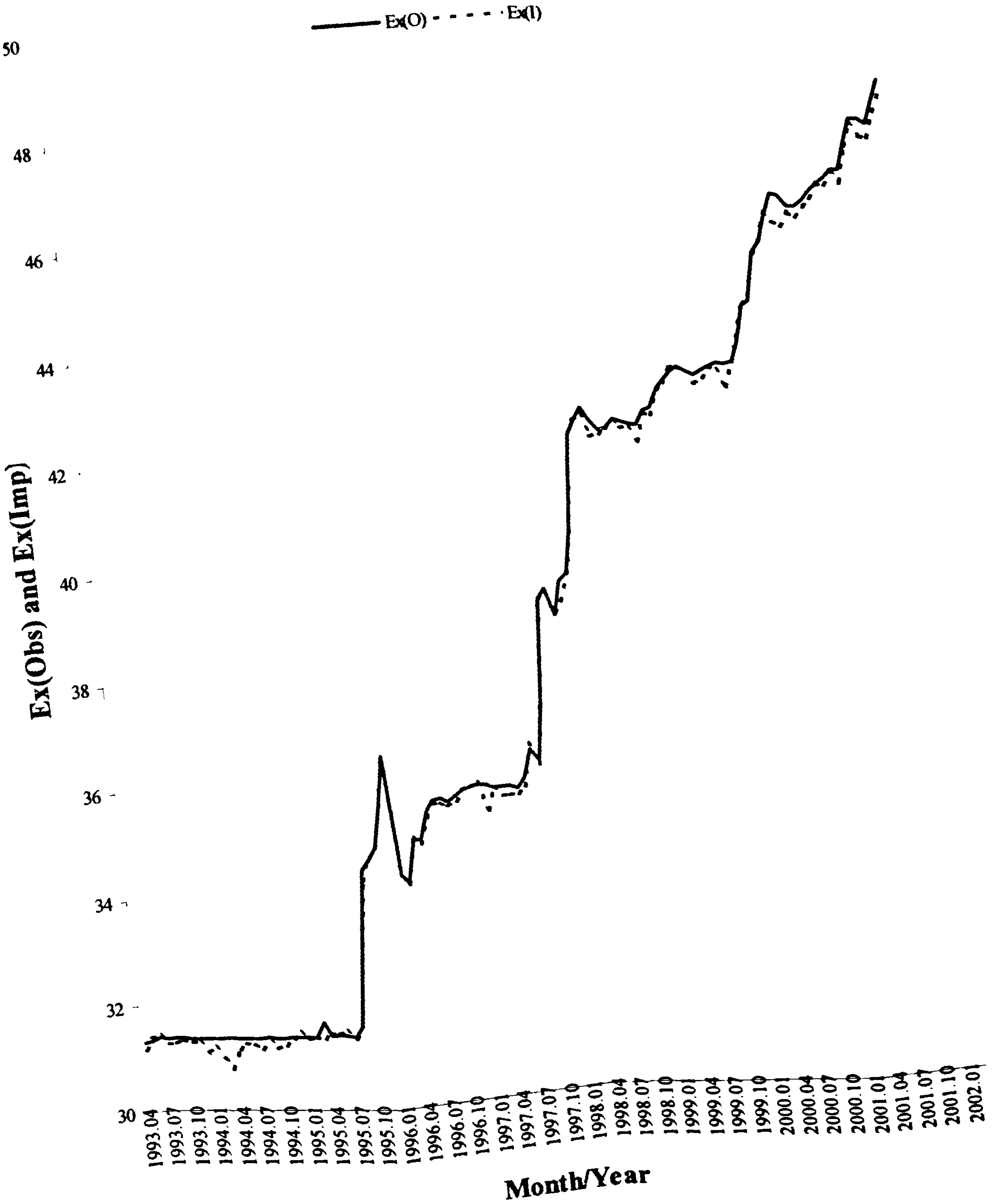


Fig 6.2: Movements in Observed and Imputed Exchange Rate (Rs/$)



Chapter 7

Summary, Limitations and Scope for Further Research

7.1 Summary

The primary aim of the thesis was to find a suitable measure of the exchange market pressure under the managed float system of exchange rates in India. In order to do so, the methodology suggested by Weymark (1995, 1998) was used.

The idea behind the measure is that the excess demand for domestic currency (which is the exchange market pressure) is removed by changes in the exchange rate and the money supply. The latter depends upon the monetary policy followed for internal as well as external stabilisation. The exchange market pressure can in principle be measured quantitatively by a statistic formed by combining observed changes in exchange rate and changes in money supply that are explicitly aimed at intervening in the foreign exchange market, including both direct and indirect intervention. In order to arrive at such a measure, changes in money supply have to be converted into equivalent changes in exchange rate. This conversion factor naturally depends upon the structure of the economy, since the effects of the changes in money supply are felt on the exchange rate after they have worked through the other markets in the economy.

With this purpose, a suitable short-run macroeconomic model of the Indian economy was formulated, following a preliminary look at the behaviour of some of the fundamental macroeconomic variables and their inter-relationships. The model has explicitly taken into consideration, both the product and asset markets. It is assumed that output price is determined in the product market, giving up the assumption of purchasing power parity. A Lucas supply function for output was specified. A standard small open economy demand for output function was taken, with real exchange rate and real interest rate as its arguments. The assets considered were money, domestic and foreign bonds. Since capital is only imperfectly mobile across the Indian border, domestic and foreign bonds are not perfect substitutes, because of differing risk characteristics. So the interest parity condition was taken in an inexact form and only up to a risk premium. The money supply was assumed to be under the control of the Reserve Bank of India, with a constant money multiplier. The monetary policy rule of the RBI was set up under the assumption that the foreign exchange policy takes the form of direct intervention only, and that it is sterilised. Domestic credit changes, other than those meant to sterilise foreign exchange reserve inflow, were assumed to be aimed at price and output stabilisation. The model also assumed that expectations are rationally formed.

An expression for the conversion factor was worked out from the model. This expression depends upon the parameters of the model. So the model was estimated. The estimate of our monetary policy reaction function shows that price stability has been a major concern of the policy authority. We also find that sterilization takes place, since the sterilization coefficient has a high value.

The value of the conversion factor was calculated from the estimated parameters. On the basis of observed changes in exchange rate and official reserves, this was used to calculate the monthly exchange market pressure and a related index of intervention activity of the RBI between March 1993 and March 2002. These figures were then used to analyse the RBI's intervention policies over this period.

The results indicate that the conversion factor has a low value, viz. -0.2583. This suggests that direct intervention in the foreign exchange market can only be of limited effectiveness to manage exchange rates. Analysis of the actual situation and RBI's interventions suggests that over this period RBI did manage the exchange rate volatility, while allowing it to broadly follow the market. RBI seemed to have a preference for keeping the rupee mildly depreciating, while aggressively controlling appreciation. However, in crisis periods, it intervened strongly to protect the rupee. But it relied on both indirect and direct intervention at such times, with direct intervention being mainly used to relieve the residual pressure after indirect intervention. It also emerged that building up reserves appeared to be an important objective of the RBI, especially in the later years. The overall objective of RBI in the foreign exchange market has been to ensure confidence in the market, and keep it "orderly" and "calibrated", is reflected from our results.

7.2 Limitations of the Study

The EMP and IIA measures we have derived are specific to the structural model used. As such the measures are only as credible as the underlying model. The model we used is a fairly standard open economy model, commonly used in the literature. However the model has certain limitations in the Indian context.

The first concerns the specification of the product market. Given the structural milieu of the Indian economy and its rigidities, it is difficult to defend the Lucas supply curve and the market clearing assumption. An alternative may be to use a Keynesian specification or a Mundell-Fleming type of model, where output is demand determined, and which allows for unemployment.

When we deal with money market equilibrium, it is assumed that money multiplier is constant. This is done to simplify the estimation process, particularly of the reaction function of monetary policy. However, during the sample period 1993 to 2002 there has been steady reduction in CRR and market oriented financial sector reforms have contributed to financial innovation, bringing changes in the proximate determinants (currency to deposit ratio, and reserve to deposit ratio) of money multiplier. The changes in money multiplier could strengthen or dampen the effect of money market and foreign exchange intervention on money market liquidity or the exchange rate and thereby on the measure of EMP. In the extreme case, it could even change the sign of the EMP measure. For example, even if the RBI was selling reserves to alleviate the downward pressure on the rupee, if the money multiplier were to increase sufficiently, money market liquidity might increase and exert further downward pressure. In addition, the growing fiscal deficit in India has contributed to the endogeneity of money supply process. Hence, it may be untenable to assume that money supply is a policy determined variable.

We have also specified a monetary policy reaction function that incorporates only price and output stability. In other words, we have assumed that monetary policy to attain exchange rate stability consists only of direct intervention in the foreign exchange market. If indirect intervention also takes place, it should be incorporated into the policy reaction function. Ignoring it would result in biased estimates of parameters of policy reaction function, which would in turn result in erroneous measure of exchange market pressure. In this context, the role of sterilisation and indirect intervention needs to be closely examined.

The monetary policy reaction function has been defined to show that policy reacts to deviation of actual output from its potential level. Estimation of potential level of output for a developing country like India is misleading, because the method involved in deriving the potential output takes into account the information available in the actual output, which is always far below the natural rate. Therefore, output stabilisation policy might be the right one at the trough of the cycle, but it will be the wrong policy at the peak of the cycle.

Further limitations come from the data. In the estimation process, we have used index of industrial production as a proxy for income due to non-availability of monthly time series on income. As the industrial output constitutes only around 25 per cent of our GDP, using this as a scale variable in the demand for money function tends to underestimate the income elasticity or overestimate the interest elasticity of demand for function. For instance, in the present study, the income elasticity turns out to be 0.08 in the demand for M3 money stock, whereas empirical studies using GDP as scale variable reports elasticity around 1.5 for M3 money demand. This will inflate the errors in the measure of the EMP. The results from the supply and demand for output will suffer for the same reasons.

Finally it should be mentioned that the model itself is valid for a stable economy, where there are no shocks in the financial market. So the conversion factor, and hence the EMP measures obtained may not capture the pressure in the exchange market when the economy is subject to shocks like a speculative attack or any other financial crisis.

7.3 Scope for Further Research

Since the EMP and IIA measures are model dependent, it would be interesting to see how sensitive they are to changes in the underlying model. This could be done by deriving and calculating EMP and IIA for different model specifications and carrying out a sensitivity analysis. Further, if the potential use of these measures in applications is identified, then the relative performance of the alternative measures may be evaluated.

Within the present model itself, a forecasting exercise can be carried out. This will provide potential information to the policy makers in advance.

The structural model framed in this study assumes parameter constancy hence, constant conversion factor. One can reformulate the model where parameters are time varying. The econometric methods such as time varying parameter estimation or Kalman Filter estimation can be used to derive the time varying conversion factor which would capture the dynamic changes in the financial markets.

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