Chapter 7

Role of Real Exchange Rate in the Monetary Policy Response Function

The monetary policy framework in India has evolved in terms of instruments and operational targets over the years along the changing economic realities, albeit the objectives continued to be same with time variant weightage depending upon the extant economic situation. The preamble of the Reserve Bank of India Act, 1934 enjoins the central bank objectives ‘to regulate the issue of Bank Notes and keeping of reserves with a view to securing monetary stability in India and generally to operate the currency and credit system of the country to its advantage’. Within this broad mandate, the Reserve Bank’s monetary policy pursues the twin objectives of price stability and ensuring the availability of credit to the productive sectors in the Indian economy. The emphasis between the twin objectives has, however, varied depending on the evolving price-output situation over the years. The transition of economic policies in general and financial sector policies in particular, from a control oriented regime to a liberalised but regulated regime has been reflected in changes in the nature of monetary management (Mohan, 2004a).

Although the basic objectives of monetary policy, namely price stability and ensuring credit flow to support growth, have remained unchanged, the underlying operating environment for monetary policy has undergone a significant transformation necessitating the changes in the monetary policy response function. Besides price stability and growth, augmented financial integration and deepening subsequent to financial liberalisation imposed the financial stability as an additional objective for the monetary policy in India. In fact, the monetary policy also emphasised on fostering better linkages between various segments of the financial markets including money, Government securities and forex markets to improve the transmission mechanism since the onset of financial sector reforms. It may be noted that financial stability has become an overriding
concern for the central banks across the countries since 1990s. After economic reforms implemented since 1991, Indian economy has also become increasingly globalised with rising trade and financial flows. The increased globalisation in turn rendered monetary policy to necessarily respond to external developments because of their severe implication for the domestic economy.

Against the backdrop of all these developments during post-reform period, the monetary policy framework also evolved with a shift from single indicator approach with broad money (M3) used as intermediate target to multiple indicators approach in 1998. Under the multiple indicators approach, besides monetary aggregates, information on a range of rates of return in different financial market segments along with the movements in currency, credit, the fiscal position, merchandise trade, capital flows, the inflation rate, the exchange rate, refinancing and transactions in foreign exchange - which are available on a high frequency basis – are juxtaposed with data on output and the real sector activity for drawing policy perspectives. Exchange rate has been introduced in the multiple indicators of monetary policy framework in India reflecting the increased external openness of the economy over the years. It has been observed in the previous chapter that real exchange rate (RER) affects significantly both the trade balance and capital flows. Therefore, in this chapter, the role of RER in India's monetary policy reaction function has been investigated along with other variables.

The scheme of this chapter is as follows. The Section I discuss the implications of RER movements for real activities, while the theoretical underpinnings about the role of RER in monetary policy reaction function has been given in Section II. Evolving monetary policy framework has been discussed in Section III. The Section IV contains the empirical approach and results. The concluding observations have been furnished in Section V.
7.1. Implication of RER for Economic Activities

The real exchange rate affects the economic activities of a country through many channels. Frenkel, Roberto and Lance Taylor (2006) mention that exchange rate scales the national price system to that of the world and influences key macro price ratios such as those between tradable and non-tradable goods, capital goods and labour, and even exports and imports (e.g., via the costs of intermediate inputs and capital goods,).

(i) Resource allocation: In a small open economy wherein traded goods prices are given by the world economy, the real exchange rate appreciation through movements in nominal exchange rate or in prices or in both improves the internal terms of trade in favour of non-traded goods triggering allocation of resources in favour of non-traded goods. On the contrary, real exchange rate depreciation will lead to internal terms of trade in favour of traded goods in a small open economy eventually shifting more allocation of resources towards traded goods. Through its effects on the aforementioned price ratios, the exchange rate can significantly influence resource allocation, especially if it stays stable in real terms for an extended period of time.

In a developing economy, where there is domestic demand constraint, the higher growth could be achieved through exports or imports substitution and RER can be used as an important policy instruments to increase production in tradable sector.

In order to further elaborate the role of RER in resources allocation, the arguments given by Frenkel, Roberto and Lance Taylor (2006) have been considered. They discuss the key result of Lerner Symmetry Theorem (1936) where only the import/export price ratio is relevant to resource allocation and hence, it can be manipulated by either an import or an export tax-cum-subsidy. There is “symmetry” between the two instruments, so that “under appropriate conditions” only one need be employed. They further introduce third group of commodities, i.e., non-traded goods along with exportable and importable to the
discussion in a “Ricardo-Viner” model. In this set up, two price ratios—say importable/nontradable and exportable/non-tradable—in principle guide allocation of resources. The real exchange rate (RER or \( p \)) naturally comes into play as the relative price between the non-tradable and a price weighted aggregate of the two tradable goods. These observations lead to two important policy puzzles. The first has to do with “level playing fields.” As applied in East Asia and elsewhere, industrial policy often involved both protection of domestic industry against imports by the use of tariffs and quotas, and promotion of exports through subsidies or cheap credits.

In the case of a tariff on imports, the domestic price \( P_m \) becomes \( P_m = e(1+ t)P_m^* \) with \( e \) as the nominal exchange rate (defined as units of local currency per unit of foreign), \( t \) the tariff, and \( P_m^* \) the world price. Similarly if the internal price \( P_e \) for exports is set from abroad we have \( P_e = eP_e^*/(1- s) \) with \( P_e^* \) as the world price and \( s \) as the subsidy rate. The level playing field rests on the trade theorists’ fascination with setting the internal and external relative prices of tradable goods equal, \( P_m / P_e = P_m^* / P_e^* \). This situation can be arranged if \( t = s = 0 \) or more generally \( (1+ t) = 1/(1- s) \). In a Ricardo-Viner framework, with \( P_n \) as a price index for non-tradables, the two price ratios, i.e., \( P_e / P_n \) and \( P_m / P_n \) become a subject of interest. Positive values of \( t \) and \( s \) move domestic relative prices in favor of tradable goods. According to Woo (2005), from a mainstream perspective, this outcome can be interpreted as a justification for industrial policy. The world, however, is a bit more complicated. If the home country is exporting a differentiated product, for example, a more appropriate version is to treat the RER as the ratio of tradable to non-tradable price indexes. Real devaluation or weakening the RER means that \( p \) increases. Equation below gives a formal expression.

\[
Pe^* = Pe (1- s) / e
\]

(1)
Now in the above equation, the foreign price of home exports depends on the subsidy and exchange rate. Presumably, a lower value of $P_e^*$ stimulates sales abroad. As far as exchange rate is concerned, an increase in the nominal rate $e$ would also switch incentives toward production of tradables and accordingly shift the allocation of resources towards tradable goods, without the need for extravagant values of $s$ and $t$. This simple observation is indeed a strong argument in support of the use of a depreciated RER as a developmental tool.

(ii) **Capital and Labour Intensity**: The exchange rate will affect relative prices of imported intermediates and capital goods on the one hand, and labour on the other. Moreover, the RER largely determines the economy's unit labour costs in terms of foreign currency. To explore the implications, consider the effects of sustained real appreciation on imports substitution and exports. Producers of imports substitution will face tougher foreign competition and hence, to stay in business they will have to cut cost that is often affected through shedding labour. At the same time, same logic applies to exports producing sector. With appreciating RER, home’s exports will become uncompetitive and producers would curtail the production in the wake of shrinking demand and would also strive to bring down cost of production and obvious hammer would fall on labour. On the contrary, non-tradables, which will supposedly absorb the labour displaced from the tradable sectors, would be constrained by the fact that appreciation in RER would lead to cheaper foreign imports in the form of intermediates and capital goods substituting for domestic labour. Therefore, appreciation in RER will render the producers of tradables to shred labourers in order to cut down cost and nontradables to substitute cheaper capital goods for labour and in both the sectors employment is likely to decline.

The opposite reasoning would be applicable in case of RER depreciation. RER depreciation might prove to be employment-friendly
as it would lead to higher production in tradable sector (imports substitute and export) and lower substitution of labour with capital goods in nontradable sector. In both the cases, it is important to recognise that a new set of relative prices must be expected to stay in place for a relatively long period if these effects are going to work through. Changes in employment/output ratios will not happen swiftly because they must take place via changes in the pattern of output among firms and sectors, by shifts in the production basket of each firm and sector, and adjustments in the technology and organisation of production.

(iii) **Inflation**: Although the relative price levels is one of the main ingredients in calculating the RER which also have got implication for inflation especially when its movements are driven by appreciation or depreciation in nominal exchange rate. The appreciation in RER caused by nominal exchange rate appreciation results in lowering the prices of imported goods and augments the supply of tradable goods. Finally, the above appreciation in RER will lead to decline in prices of tradable goods reflecting on overall inflation. Moreover, the nominal exchange rate appreciation also drive down the prices of imported intermediate and capital goods decreasing the cost of production, which eventually feeds into inflation. At the same time, this process would generate some wealth affect with prices of tradable goods coming down and generate additional demand for non-tradable goods resulting in rise in their prices. Therefore, net impact of RER appreciation on inflation would depend on the share of tradable goods in the consumption basket and strength of wealth affect. On the other hand, the RER depreciation through nominal exchange rate depreciation would logically generate upward impact on inflation through prices of tradable goods and downward impact through wealth affect. Again, the net impact of depreciation would be contingent upon the weight of tradable goods in consumption basket and strength of wealth affect. This phenomenon is called the pass-through of exchange rate to inflation.
Goldfajn Ilan and Sergio R.C. Werlang (2000) identify the real exchange rate as potentially affecting the pass-through to inflation. Goldfajn and Valdes, (1999) have shown that the real exchange rate (RER) overvaluation is an important determinant of future depreciations. If these depreciations simply restore the real exchange rate to its steady state, they need not generate higher inflation. In this case, the overvaluation would be corrected by a change in the relative price of tradables-non tradables, and the depreciation would not generate a general increase in prices. On the other hand, large depreciations that are not based on required adjustments in relative prices would either induce inflation or reverse itself through a future nominal appreciation (the stylised fact is that the correction of excess nominal depreciations tend to occur through higher inflation (Goldfajn and Gupta, 1998). This effect was also identified by Borensztein and De Gregorio (1999).

(iv) **External balance:** The merchandise trade and services under the current account usually tend to respond to the real exchange rate movements, directly via competitiveness effects and “substitution” responses and cause change in effective demand. Appreciation in RER make a country’s exports of goods and services costly and putting them on comparative disadvantage vis-à-vis international competitors. On the contrary, the RER appreciation would make the imports of goods and services cheaper and result in increasingly substitution of domestic tradable goods with imports. The end impact of the RER appreciation would be the deteriorating external balance of a country. In the second case, depreciation in RER leads to decline in prices of exports of goods and services international markets and rise in the prices of imports of goods and services in domestic markets. Therefore, RER depreciation would improve the external balance of a country over the period. The above references about the impact of RER appreciation/ depreciation on external balance or trade balance is quite straight forward without factoring in the exchange rate
elasticity of exports and imports. In practice, these elasticities play a crucial role in finding out net impact of exchange rate movements on trade balance. The famous Marshall-Lerner (ML) condition explains that exchange rate depreciation can improve the trade balance provided that the sum of exchange rate elasticities is more than unit. Nevertheless of import role of exchange rate elasticities, it is well settled in the literature that appreciation/depreciation in RER lead to deterioration/improvement in trade balance over the period - the famous J curve effect.

(v) Economic development: The exchange rate can be deployed in conjunction with commercial and industrial policies to enhance overall competitiveness and thereby boost productivity and growth (Roberto and Lance Taylor (2006)). The question is how a weak exchange rate (possibly in combination with other policies aimed at influencing resource allocation among traded goods) fits into the macroeconomic system. Much depends on labour market behavior in the non-traded sector. Following Rada (2005) Frenkel and Taylor (2006) assume a scenario to illustrate possible outcomes. They assumed that output in the tradable sector is driven by effective demand, responding to investment, exports, and import substitution as well as fiscal and monetary policy. The level of imports depends on economic activity and the exchange rate (along with commercial/industrial policies). A worker not utilised in tradable sectors must find employment in non-tradables, become under- or unemployed, or leave the labour force. For concreteness, it was assumed that almost all labourers not employed in tradables find something to do in non-tradable production as a means of survival. Typical activities would be providing labour services in urban areas or engaging in labour-intensive agriculture. If workers in both sectors don’t have significant savings, then their behavior does not strongly influence overall macroeconomic balance, which is driven by investment, exports, saving from profits, and changes in the magnitude of the import/output ratio via import substitution. Now
consider the outcomes of devaluation. It will have impacts all over the economy, including a loss in national purchasing power if imports initially exceed exports, redistribution of purchasing power away from low-saving workers whose real wages decrease, a decline in the real value of the money stock, and capital losses on the part of net debtors in international currency terms. Presumably exports will respond positively to RER depreciation but that may take time if “J-curve” and similar effects matter. Another positive impact on the demand for tradables will come from import substitution. One implication is that for a given level of output, the trade deficit should fall with devaluation. If devaluation forces output to contract, as often appear to be the case in developing economies, import demand will decrease and reduce the trade deficit further still. In this case, real devaluation should presumably be implemented together with expansionary fiscal and monetary policies. As discussed in detail below, exchange rate strategies must be coordinated with other policy moves.

If export demand and production of import substitutes are stimulated immediately or over time by a sustained weak RER, aggregate demand should rise and drive up economic activity and employment in the medium to long run. Further, a long-term analysis will have to take into account the evolution of labour productivity, which has been considered constant in the short to medium term.

7.2. Model Specification

In the above section, it has been established that RER has significant implication for various economic activities, which are very much there in the ambit of the monetary policy especially in the emerging market and developing economies (EMEs). It may be noted that in these economies monetary policy has to deal with multiple objectives such as price stability, growth, financial stability, etc. RER movements having implication for these objectives influence the monetary policy reaction and thus can be included
in the monetary policy reaction function. A number of empirical studies have established the role of RER in monetary policy reaction function across the countries. Dong Wei (2008) estimates a structural general equilibrium two-sector model examining different specifications for the monetary policy rule and the real exchange rate process. His results indicate that the Reserve Bank of Australia, the Bank of Canada and the Bank of England paid close attention to real exchange rate movements, while the Reserve Bank of New Zealand did not seem to explicitly incorporate exchange rate movements into their policy rule, though the indirect effect of exchange rates on interest rates exists. Malikaney Christopher and Willi Semmlerz (2007) use a dynamic Keynesian model of a small open economy (South Africa) to investigate the role of the exchange rate in the monetary policy rule. They show that if the central bank responds to real exchange rate fluctuations, it tends to enforce faster convergence of macro variables in response to shocks. Mishkin (2000) proposes that emerging market economies should smooth exchange rate fluctuations in their conduct of monetary policy. Ball (1999), Batini, Harrison and Millard (2001), Dennis (2003) and Wollmershäuser (2006) find significant evidence in favour of explicitly introducing an exchange rate term in the policy rule followed by the central bank. Within the context of an empirical model of the Australian economy, Dennis (2003) shows that there are significant gains when the central bank responds systematically to the real exchange rate. An empirical study by Mohanty and Klau (2004) also finds that many central banks in emerging market economies react systematically to exchange rate movements.

In view of above studies finding the role of RER in the monetary policy rules significant, the monetary policy response function for India could be written in the equation (2) below following augmented Taylor monetary policy rule (2001).

\[ i_t = \alpha + \beta \pi_t + \delta y_t + \theta_0 e_t + \theta_1 e_{t-1} + \epsilon_t \]  

(2)
Where } is the short term nominal interest rate set by the central bank, } is the rate of inflation, and } is the deviation of real GDP from potential GDP. The variable } is the real exchange rate (an increase in } is a real appreciation). The intercept term } appearing in equation (2) implies that the target inflation rate is not zero. The interest rate and the exchange rate are measured relative to the long run steady state values. The linear policy rules represented in equation (2) is a simplification of a more complex nonlinear class in which lags of output, inflation, and the interest rate might appear along with more lags of the exchange rate.

The policy parameters are } 0 and } 1. If } > 1, } > 0, and } 0 = } 1 = 0, then equation (2) is the monetary policy rule for the closed economy as proposed by Taylor J.B in 1993 with no reaction to the exchange rate. While in an open economy } 0 and } 1 may not be equal to zero. Taylor (2001) mentions that such a terminology would be very misleading because in reality the optimal policy for an open economy may be to set both } 0 and } 1 equal to zero, at least as an approximation. In the context of equation (2), the question about the role of the exchange in a policy rule is a question about whether the } 0 and } 1 parameters should be non-zero and if so what should be their signs and numerical values. Obstfeld and Rogoff (1995) discuss a rule of thumb wherein } 0 is less than zero and } 1 is equal to zero. Then a higher than normal real exchange rate would call on the central bank to lower the short-term interest rate, which presumably would represent a "relaxing of monetary policy." The less than zero } 0 parameter indicates that interest rates respond negatively to the RER appreciation because of its contractionary effect on aggregate demand in an open economy.

The lagged real exchange rate in equation (2) allows for slightly more complicated dynamics than simply reacting to the current real exchange rate. For example, if } 1 is positive and } 0 is negative but greater in absolute value than } 1, then the initial interest rate reaction is partially offset in the next period. The version of equation (2) studied by Ball (1999) has } 0 = -0.37.
and $\phi_1 = 0.17$. These are the policy parameter values that Ball found to be optimal using a very simple open economy model with sticky prices. Thus, an appreciation of the exchange rate of 10 percent would call for a cut in the interest rate of 3.7 percentage points, followed by a partial offset of 1.7 percentage points, implying a long run reaction of a 2 percentage point cut in the interest rate.

Taylor (2001) further elaborates that the partial interest rate offset is due to the lagged impact of the appreciated exchange rate on inflation. The measured inflation rate is temporarily low because of the appreciation; however, because the decline in inflation is temporary, it is not appropriate for the central bank to ease monetary policy any additional amount because of the lower inflation that would otherwise occur using equation (2). The positive coefficient $\phi_1$ prevents this additional easing. For the Ball (1999) open economy model, such a rule leads to better performance than a rule in which both $\phi_0$ and $\phi_1$ parameters are equal to zero. Performance is measured in terms of the size of the fluctuations of real GDP around potential GDP and the size of the fluctuations of inflation around the inflation target, both meant to be an approximation to peoples’ preferences.

Taylor (1999b) estimate equation (2) monetary policy rule for the European Central Bank and find exchange rate reaction coefficients of $\phi_0 = -0.25$ and $\phi_1 = 0.15$. Thus, a 10 percent depreciation of the Euro relative to the dollar would have called for a one percentage point increase in the interest rate target for the European Central Bank. This would consist of a 2.5 percentage point increase in the short run, partially offset by a 1.5 percentage point cut in the next period.

7.3. Evolution of Monetary Policy Framework in India

With the opening up of the Indian economy and its growing global integration, monetary policy had to contend not only with price stability and growth but also to ensure orderly conditions in the financial markets. The
growing integration of financial markets, while necessary for economic efficiency, posed challenges for monetary management in terms of heightened risks of contagion. Episodes of financial volatility, often sparked off by sudden switches in capital flows in response to various shocks - such as the East Asian financial crisis, sanctions after the nuclear explosions, downgrading of credit ratings, the dot com crisis of USA, the September 11 terrorist attacks in the US and recent global financial crisis - required a swift monetary policy response. The Reserve Bank, therefore, began to emphasise the need to ensure orderly conditions in financial markets as a prime concern of monetary management. Financial stability is now being recognised as a key consideration in the conduct of monetary policy, in terms of ensuring uninterrupted financial transactions; maintenance of a level of confidence in the financial system amongst all the participants and stakeholders; and absence of excess volatility that unduly and adversely affects real economic activity (Reddy, 2004).

**Intermediate Target**

The Reserve Bank did not have a formal intermediate target till the 1980s. Bank credit - aggregate as well as sectoral - came to serve as a proximate target of monetary policy after the adoption of credit planning from 1967-68 (Jalan, 2002 and RBI, 2005). Credit targeting, in fact, wove well into the concept of development central banking. Since inflation was largely thought to be structural, selective credit controls were used, from 1956, to regulate bank advances to sensitive commodities to influence production outlays, on the one hand and to limit possibilities of speculation, on the other. A Credit Authorisation Scheme (CAS), introduced in November 1965, required commercial (and later, co-operative banks, since 1974) banks to seek the Reserve Bank’s prior approval before sanctioning large working capital limits. This additional measure of credit regulation was expected to perform the multiple objectives of keeping inflationary pressures under check and ensuring that credit was directed to genuine purposes. The elaborate process of credit regulation, however well intentioned, was not only the cause of delays in credit disbursal but also impeded efficient
resource allocation by segmenting credit markets [Marathe Committee (RBI, 1983); Chakravarty Committee (RBI, 1985)]. It was in this context that the requirement of prior authorisation in respect of credit limits exceeding a threshold level under the Credit Authorisation Scheme was replaced by a system of post-sanction scrutiny in 1988. Selective credit controls were also abolished in the 1990s.

During the early 1960s, even as the analytics of money supply continued to be governed by the expansion in credit, the Reserve Bank began to pay greater attention to the movements in monetary aggregates. This accent on monetary aggregates was supported by several empirical studies which provided evidence of a stable money demand function in the Indian economy (Vasudevan 1977 and Jadhav 1994). By the early 1980s, there appeared to be a consensus that while fluctuations in agricultural prices and oil price shocks did affect prices, continuous inflation of the kind witnessed since the early 1960s could not occur unless it was sustained by the continuous excessive monetary expansion generated by the large-scale monetisation of the fiscal deficit.

Against this backdrop, the Chakravarty Committee recommended a monetary targeting framework to target an acceptable order of inflation in line with output growth (RBI, 1985). Changes in broad money were thought to provide reasonable predictions of average changes in prices over a medium-term horizon of 4-5 years, though not necessarily on a year-to-year basis. It was, in fact, argued that in the absence of a stable money demand function, the role of monetary policy in inflation management would itself be negligible. Thus, broad money emerged as an intermediate target of monetary policy and the Reserve Bank began to formally set monetary targets in order to rein in inflation. As the process of money creation is simultaneously a process of credit creation, it was also necessary to estimate the increase in credit required by the projected increase in output. The concept of monetary targeting adopted by the Reserve Bank was a flexible one allowing for various feedback effects.
The process of financial liberalisation, which gathered momentum in the 1990s, necessitated a re-look at the efficiency of broad money as an intermediate target of monetary policy. The Reserve Bank’s Monetary and Credit Policy Statement of April 1998 noted that most studies in India show that money demand functions have so far been fairly stable. At the same time, it observed that financial innovations emerging in the economy provided some evidence that the dominant effect on the demand for money in the near future need not necessarily be real income, as in the past. Interest rates too seemed to exercise some influence on the decisions to hold money. In a similar vein, the Working Group on Money Supply: Analytics and Methodology of Compilation (Chairman: Dr. Y.V. Reddy) observed that monetary policy exclusively based on the demand function for money could lack precision (RBI, 1998a).

The Reserve Bank, therefore, formally adopted a multiple indicators approach in April 1998. In this approach, policy perspectives are obtained by juxtaposing information on various indicators. For simplicity and to facilitate greater understanding, the quarterly policy statements of the Reserve Bank continue to be set in a framework in terms of money, output and prices.

**Operating Framework**

The shifting from the monetary targeting framework to a multiple indicators approach also necessitated transformation in the operating framework of monetary policy in India with short-term interest rates emerging as instruments to signal the stance of monetary policy. In order to stabilise short-term interest rates, the Reserve Bank now modulates market liquidity to steer monetary conditions to the desired trajectory (RBI, 2005). The liquidity modulation is achieved by a mix of policy instruments including changes in reserve requirements and standing facilities and open market (including repo) operations which affect the quantum of marginal liquidity and changes in policy rates, such as the Bank Rate and reverse repo/repo rates, which impact the price of liquidity.
Originally, the Reserve Bank had conducted its monetary policy through a standard mix of open market operations and changes in the Bank Rate. The fiscal dominance during the 1970s and the 1980s, however, changed the contours of the operating framework of monetary policy. A natural corollary was that the Reserve Bank's traditional instruments, the Bank Rate and open market operations, began to lose their efficacy. Consequently, the Reserve Bank began to use increasingly changes in reserve requirements to modulate monetary conditions.

Furthermore, like most emerging market economies, India witnessed financial sector expansion during 1990s as result of financial sector reforms and external sector opening. The financial sector assumed the role of affecting the efficient allocation of resources besides conventional role of channelisation, which was also recognised by the Ninth Five Year Plan to reap the benefit of higher growth. In order to infuse a degree of efficiency in the allocation of resources by the financial system, the Reserve Bank initiated a multi-pronged strategy of institutional reforms to rekindle the process of price discovery in the financial markets (Reddy, 2002).

First, the Reserve Bank deregulated interest rates, beginning with the removal of restrictions on the inter-bank market as early as in 1989. Subsequently, a phased deregulation of lending rates in the credit markets was affected and presently, banks are free to fix their lending rates on all classes of loans except small loans below Rs. 2 lakh and export credit. The deregulation of deposit rates began later and banks are now free to offer interest rates on all classes of domestic deposits (except savings deposits), not only in terms of tenor but also in terms of size. Interest rates on non-resident deposits are linked to international interest rates and these are modulated from time to time, depending on the macroeconomic - including the balance of payments - scenario.

Second, the process of interest rate deregulation was supported by the development of market architecture, especially to address the problem of missing markets at the short end. In this regard, the Reserve Bank
introduced a number of money market instruments, such as commercial paper, short-term Treasury Bills and certificates of deposits following the recommendations of the Working Group on the Money Market (Chairman: Shri N. N. Vaghul). The process of replacing cash credit with term loans, phasing out of fixed rate tap Treasury Bills and the development of a repo market outside the Reserve Bank is gradually generating a vibrant set of markets at the short end of the interest rate spectrum.

Third, along with introducing new instruments, the institution of the Discount and Finance House of India as a market maker with two-way quotes in the money markets. Although the call money market was initially widened by introducing non-bank participants, they have now been phased out with the parallel development of a repo market outside the Reserve Bank. The Government securities market was made more vibrant with introduction of securities of varying maturities enabling market players to manage their assets-liability more efficiently, to make available yield curve to investors and to infuse ample liquidity.

Fourth, with a view to deepening inter-linkages, the development of markets was supported by withdrawal of balance sheet restrictions which had tied financial intermediaries to their primary segments of the financial markets. Banks now operate across all the segments of the financial markets, including equity and foreign exchange markets, albeit with prudential limits on their exposures.

The deregulated credit markets and augmented interlinkages in financial markets required a comprehensive recast of the operating procedures of monetary policy. Accordingly, the Reserve Bank had to shift from direct to indirect instruments of monetary policy in consonance with the increasing market orientation of the economy (Reddy, 1999, 2001 and 2002 and Kanagasabhapathy, 2001). This required development of an array of monetary policy instruments, which could effectively modulate monetary conditions in alignment with the rejuvenated process of price discovery. Besides, shift in monetary policy transmission channels necessitated policy
impulses, which would travel through both quantum and rate channels. Finally, the episodes of volatility in the foreign exchange markets emphasised the need for swift policy reactions balancing the domestic and external sources of monetisation in order to maintain orderly conditions in the financial markets. Even within the set of indirect instruments, the preference is for relatively more market-based instruments such as open market operations. As the Reserve Bank’s Internal Working Group on Instruments for Sterilisation noted, the use of CRR as an instrument of sterilisation, under extreme conditions of excess liquidity and when other options are exhausted should not be ruled out altogether by a prudent monetary authority ready to meet all eventualities (RBI, 2004).

The Reserve Bank is now able to influence short-term interest rates by modulating the liquidity in the system through repo operations under the Liquidity Adjustment Facility, reinforced by interest rate signals (RBI, 2000; Sengupta, Bhattacharyya, Sahoo and Sanyal, 2000; Dua, Raje and Sahoo, 2003). The Reserve Bank has been largely able to enforce the interest rate corridor defined by the reverse repo rate, the price at which it absorbs liquidity and the repo rate/Bank Rate, the price at which it injects liquidity. India has been receiving large capital inflows over the last many years; sterilisation of these inflows, which involve higher opportunity cost in terms of lower returns on international assets vis-à-vis domestic assets, was undertaken through open market operations (OMO). Higher opportunity cost coupled with limited stock of Government securities with Reserve Bank necessitated to look for some alternate arrangement for sterilisation of these capital inflows. The Reserve Bank, therefore, signed in March 2004 a Memorandum of Understanding (MoU) with the Government of India for issuance of Treasury Bills and dated Government Securities under the Market Stabilisation Scheme (MSS), in addition to normal Government borrowings. The new instrument empowered the Reserve Bank to absorb liquidity on a more enduring but still temporary basis while leaving LAF for daily liquidity management and using conventional OMO on more enduring basis. The MSS has provided the Reserve Bank flexibility not only to absorb
but also inject liquidity in times of need by way of unwinding. Therefore, short-term instruments are generally preferred for MSS operations.

7.4. Empirical Approach & Results

Approach

The Augmented Dickey Fuller (ADF) and Phillips-Perron unit root tests have been used to test the properties of time series used in the present chapter. First, ADF test has been applied to test the stationarity of variables. This test investigates the presence of unit root in time series data. Fuller (1976) provided cumulative distribution of the ADF statistics by showing that if the calculate-ratio (value) of the coefficient is less than critical value from Fuller table, then x is said to be stationary. However, this test is not reliable for small sample data set due to its size and power properties (Dejong et al, 1992 & Harris, 2003). Therefore, the findings of ADF test have been corroborated with PP unit root test, which differ from ADF test mainly in how they deal with serial correlation and heteroskedasticity in errors. Bothe ADF and PP unit root tests are for the null hypothesis that a time series $y_t$ is I(1).

After testing for unit root, next step is to estimate the short-run and long-run dynamics with appropriate econometric techniques. In the present study, since time series data has been used, which is generally plagued with problem of unit root, cointegration technique has been used in place of simple OLS. The time series viz., short-term interest rate (callr), inflation based on wholesale price index (p), output gap(y), and RER are not integrated of same order. Therefore, ARDL cointegration approach has been used instead of Engle and Granger (1987), Johansen (1988) and Johansen and Juselius (1991). The conditional VECM in the ADRL framework for the present study could be specified as under:

$$
\Delta \tilde{r}_t = c_0 + \Theta_1 \tilde{r}_{t-1} + \Theta_2 p_{t-1} + \Theta_3 y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta \tilde{r}_{t-i} + \\
\sum_{j=1}^{p} \varphi_j \Delta p_{t-j} + \sum_{k=1}^{q} \theta_k \Delta y_{t-k} + \sum_{l=1}^{q} \mu \Delta r_{t-l} + \epsilon_t
$$

(3)
The first step in the ARDL bounds testing approach is to estimate equation (3) by ordinary least squares (OLS) in order to test for the existence of a long-run relationship among the variables by conducting an F-test for the joint significance of the coefficients of the lagged levels of the variables, i.e., $H_0: \phi_1 = \phi_2 = \phi_3 = 0$ against the alternative $H_A: \phi_1 \neq \phi_2 \neq \phi_3 \neq 0$.

Two asymptotic critical values bounds provide a test for cointegration when the independent variables are $I(d)$ (where $0 < d \leq 1$): a lower value assuming the regressors are $I(0)$ and an upper value assuming purely $I(1)$ regressors. If the F-statistic is above the upper critical value, the null hypothesis of no long-run relationship can be rejected irrespective of the orders of integration for the time series. Conversely, if the test statistic falls below the lower critical value the null hypothesis cannot be rejected. Finally, if the statistic falls between the lower and upper critical values, the result is inconclusive.

In the second step, once cointegration is established the conditional ARDL $(p_1, q_1, q_2, q_3, q_4)$ long-run model for $r_{et}$ can be estimated as:

$$ir_t = c_0 + \sum_{i=1}^{p} \phi_1 i r_{t-1} + \sum_{i=0}^{q_1} \phi_2 y_{t-1} + \sum_{i=0}^{q_2} \phi_3 y_{t-1} + \sum_{i=0}^{q_3} \phi_4 y_{t-1} + \epsilon_t$$

This involves selecting the orders of ARDL $(p, q_1, q_2, q_3, q_4)$ model in the six variables using Schwarz Bayesian Criterion. Finally, the short-term dynamic parameters by estimating an error model associated with the long-run estimates can be estimated in the following specification:

$$\Delta ir_t = a_0 + \sum_{i=1}^{p} \phi_i \Delta ir_{t-1} + \sum_{j=1}^{q} \delta_j \Delta p_{t-j} + \sum_{k=1}^{q} \delta_k \Delta y_{t-k} + \sum_{l=1}^{q} \mu \Delta r_{er{t-l}} + \delta \text{ecm}_{t-1} + \epsilon_t$$

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Where \( \varphi, \delta, \mu, \) and \( \delta \) are the short-term dynamic coefficients of the model's convergence to the equilibrium and \( \delta \) is the speed of adjustment.

**Results**

First, unit root properties of the variables were tested using unit root tests viz., Augmented Dickey Fuller (ADF), and Phillips Perron (PP). The results have been reported in Table 7.1. Both ADF and PP tests reject null hypothesis of unit root in IR at 1 per cent level of significance indicating that IR is I(0) means integrated of zero order. Null hypothesis of unit root is accepted in case of RER in the level but rejected in the first difference by ADF and PP tests, which confirms that RER is I(1). In case of \( \pi \), the null hypothesis of unit root has been rejected by ADF test in level, while accepted in level but rejected in the first difference by PP test. ADF test accepts the null hypothesis of unit root in level as well as first difference, whereas PP test accepts the null hypothesis in level but reject the null hypothesis in the first difference.

<table>
<thead>
<tr>
<th>Variables</th>
<th>ADF Test</th>
<th>Phillips-Perron Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>1st Difference</td>
</tr>
<tr>
<td>( \text{ir} )</td>
<td>-4.5404***</td>
<td>-26.2753***</td>
</tr>
<tr>
<td>( \text{RER} )</td>
<td>-1.7919</td>
<td>-5.1717***</td>
</tr>
<tr>
<td>( \pi )</td>
<td>-5.9680***</td>
<td>-6.2904***</td>
</tr>
<tr>
<td>( y )</td>
<td>-1.9760</td>
<td>-1.7858</td>
</tr>
</tbody>
</table>

**Exact critical values**

- 1 % level: -3.58, -3.58, -3.58, -3.58
- 5% level: -2.92, -2.92, -2.92, -2.92
- 10% level: -2.60, -2.60, -2.60, -2.60

Note: ***, **, and * denotes statistical significance at 1%, 5%, and 10% levels, respectively.
The results of ADF test and PP test are diametrically opposite in the case of Y in which former test indicates the unit root problem both in level and first difference, while latter shows the unit root problem in level but not in first difference. Similarly, in case of P, ADF test indicates no unit root problem in level, but PP test shows unit root problem in the level. The contradictory results of both the tests corroborates the reason explained in the empirical approach Section that at times ADF test tend to reject/accept the null hypothesis while actual position being opposite in the small sample.

On the basis of the results of these unit root tests, it can be inferred that IR and Y are stationary in the level and therefore integrated of zero order I(0), while RER and P are stationary in their first difference means they are integrated of 1st order I(1).

In the light of differing order of integration among the data series, cointegration among the variables has been tested with newly developed auto regressive distributed lag (ARDL) model (Pesaran and Shin, 1995, 1998; Pesaran et al., 1996; Pesaran et al., 2001) has been used.

In order to test the presence of long-run relationship between IR, P, Y and RER, equation (3) was estimated normalizing on IR. I used a general-to-specific modeling approach guided by the short data span and SCB respectively to select a maximum lag order of 4 for the conditional ARDL-VECM because of quarterly frequency. Firstly, I estimate an OLS regression for the first differences part of equation and then test for joint significance of the parameters of the lagged level variables. The joint null hypothesis of the coefficients being equal to zero means no long-run relationship has been tested with F-statistics. The presence of cointegration between the variables is accepted if F-statistics reject the null at 99 per cent critical bound values generated by Narayan (2005) for small sample. The calculated F statistics presented in Table 2 is 3.5199 and is higher than the upper bound at 1% level of significance. Thus, null hypothesis of no cointegration is rejected,
implying that there exists a long-run relationship among the variables IR, P, Y and RER, when the regression is normalized on IR (Table 7.2).

<table>
<thead>
<tr>
<th>Dependent Variable (Intercept and no trend)</th>
<th>SBC Lag</th>
<th>F-Statistics</th>
<th>Probability</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>(F_{err}(IR \mid P, Y \text{ and } RER))</td>
<td>1</td>
<td>3.5199***</td>
<td>0.018</td>
<td>Cointegration</td>
</tr>
</tbody>
</table>

**Critical Values**

<table>
<thead>
<tr>
<th>T</th>
<th>90% Level</th>
<th>95% Level</th>
<th>99% Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I(0) Lower Bound</td>
<td>I(1) Upper Bound</td>
<td>I(0) Lower Bound</td>
</tr>
<tr>
<td>45</td>
<td>4.270</td>
<td>5.412</td>
<td>3.078</td>
</tr>
<tr>
<td>50</td>
<td>4.188</td>
<td>5.328</td>
<td>3.048</td>
</tr>
</tbody>
</table>

***Significant at 1 per cent level.

After finding that there exists a long-run cointegration relationship between dependent variable IR and independent variables P, Y and RER, the long-run relationship was estimated using the specification given in equation (4). The maximum lag was selected 4 and the appropriate lag length of the variables was chosen based on SBC. Table 7.3 contains the result of long-run relationship. The estimated coefficients of Y and RER are positive and significant at 1 per cent level of significance and imply that increase in output gap and depreciation in RER lead to rise in the short-term interest rate (IR) (Table 7.3). The estimated causal relationship between IR and Y and RER has been found in line with theoretical and empirical literature. The coefficient of Y shows that one unit increase in output gap would result in one unit rise in the short-term interest rate, while coefficient of RER reflects one unit increase in RER (depreciation) would cause 0.45 unit rise in short-term interest rate.
Table 7.3: Estimated Long-run Coefficients using ARDL Model

ARDL(1,0,0,0,0,0) selected based on SCB. Dependent variable IR_t.

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>-0.1207</td>
<td>0.1935</td>
<td>-0.6239</td>
<td>0.537</td>
</tr>
<tr>
<td>Y_t</td>
<td>1.0045*</td>
<td>0.3435</td>
<td>2.9245</td>
<td>0.006</td>
</tr>
<tr>
<td>RER_t</td>
<td>0.4509*</td>
<td>0.1783</td>
<td>2.5294</td>
<td>0.016</td>
</tr>
<tr>
<td>C</td>
<td>-14.4791***</td>
<td>8.4021</td>
<td>-1.7233</td>
<td>0.093</td>
</tr>
</tbody>
</table>

Note: *, **, and *** denote statistical significance at 1%, 5%, and 10% level, respectively.

On the other hand, the coefficient of P is negative, which is contrary to the theory, but insignificant. This shows that movements in inflation do not have significant impact on short-term interest rate (IR). In view of negative and insignificant, a zero restriction has been imposed on coefficient of inflation and tested with Wald-Test. Wald Statistic at 0.38919 (0.533) do not reject the zero restriction. The estimated relationship short-term interest rate possibly could be explained by the supply inelasticity in the Indian economy, meaning thereby that inflation is largely supply side phenomenon. Further, the estimated long-run relation implies that monetary policy (short-term interest rate) is more responsive to output (growth).

Chart 7.1: Actual versus Fitted Values of IR
Further, it has been explored whether actual IR is far away from the IR fitted by the above independent variables (P, Y and RER). It could be seen from Chart 7.1 that actual IR largely follows the fitted IR implying that there has not been any major deviations in the actual IR from its long-run path fitted by the above independent variables wherein Y and RER have been found impacting IR at very high level of significance.

Further, short-run dynamics from error correction were estimated within the ARDL framework given in equation (5). It could be seen in Table 7.4 that signs of short-run dynamic impact are largely consistent with long-run coefficients.

<table>
<thead>
<tr>
<th>Table 7.4: Error Correction Representation for the Selected ARDL Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARDL(1,0,0,0,0,0) selected based on SC. Dependent variable ΔIRt.</td>
</tr>
<tr>
<td>Regressor</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>dPt</td>
</tr>
<tr>
<td>dYt</td>
</tr>
<tr>
<td>dYl</td>
</tr>
<tr>
<td>dRERt</td>
</tr>
<tr>
<td>Dct</td>
</tr>
<tr>
<td>Ecm(-1)</td>
</tr>
</tbody>
</table>

Ecm = IR + 0.12073*P -1.0045*Y -0.4508*RER+ 14.4791*C
R-Squared = 0.5356
R-Bar-Squared = 0.4582
DW-statistic = 2.1322
F-Stat = 8.3026 (0.000)

Note: *, **, and *** denote statistical significance at 1%, 5%, and 10% level, respectively

The error correction term is negative and significant at 1% significant level implying that there is convergence to long-run equilibrium path. The coefficient of the ECM is very high at -0.63 implying a fairly high speed of
adjustment to disequilibrium after a shock. Approximately 63 per cent of the deviation in IR from the long-run equilibrium level is corrected in next quarter.

Further, movements in actual change in short-term interest rate (IR) and change in short-term interest rate (IR) fitted by P, Y and RER have been examined to see whether fitted values drifts away from the actual values in the short-run. The actual change in IR has been seen largely following the fitted change in IR except for drifting away at few occasions, which implies that estimated ARDL cointegration model is quite stable even in terms of short-run dynamics (Chart 7.2).

The causality running from P, Y and RER to IR has also been tested with Pair-wise Granger Causality Tests. The results have been given in Table 7.5. As per the results, P does not Granger cause IR, while Y and RER have been found Granger causing IR at 5 per cent and 10 per cent level of significance, respectively. Interestingly, Granger Causality Tests indicate bi-directional causality among IR and RER.
### Table 7.5: Pair-wise Granger Causality Tests

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Obs</th>
<th>F-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>P does not Granger Cause IR</td>
<td>47</td>
<td>0.14086</td>
<td>0.8690</td>
</tr>
<tr>
<td>IR does not Granger Cause P</td>
<td></td>
<td>0.47754</td>
<td>0.6236</td>
</tr>
<tr>
<td>Y does not Granger Cause IR</td>
<td>45</td>
<td>3.06268</td>
<td>0.0579</td>
</tr>
<tr>
<td>IR does not Granger Cause Y</td>
<td>Y</td>
<td>1.16103</td>
<td>0.3235</td>
</tr>
<tr>
<td>RER does not Granger Cause IR</td>
<td>47</td>
<td>2.32408</td>
<td>0.1103</td>
</tr>
<tr>
<td>IR does not Granger Cause RER</td>
<td></td>
<td>3.13404</td>
<td>0.0539</td>
</tr>
</tbody>
</table>

### 7.5. Concluding Observations

Although the monetary policy framework in India has evolved in terms of instruments and operational targets over the years, the objectives continued to be same the price stability and growth. Besides these two objectives, financial stability has become an overriding concern for the monetary policy in India like in other large number of developed and emerging market economies. The monetary policy framework shifted from single indicator approach (broad money (M3) as intermediate target) to multiple indicators approach in 1998. Under the multiple indicator approach, besides monetary aggregates, information on range of rates of return in different financial market segments along with the movements in currency, credit, the fiscal position, merchandise trade, capital flows, the inflation rate, the exchange rate, refinancing and transactions in foreign exchange – which are available on a high frequency basis – are juxtaposed with data on output and the real sector activity for drawing policy perspectives. In view of exchange rate gaining prominence, the role of RER has been tested in the monetary policy reaction function in India.
Since the time series included in the model were not of the same order of integration, cointegration among the variables has been tested with newly developed auto regressive distributed lag (ARDL) model. The bound-tests find the F statistics at 3.5199, which is higher than the upper bound at 1 per cent level of significance and imply that there exists a long-run cointegrated relationship among the variables IR, P, Y and RER, when the regression is normalized on IR. The results of long-run relationship indicate the coefficients of Y and RER positive and significant at 1 per cent level of significance implying that increase in output gap and depreciation in RER lead to rise in the short-term interest rate (IR). The estimated causal relationship between IR and Y and RER has been found in line with theoretical and empirical literature. The coefficient of Y shows that one unit increase in output gap would result in one unit rise in the short-term interest rate, while coefficient of RER reflects one unit increase in RER (depreciation) would cause 0.45 unit rise in short-term interest rate. On the other hand, the coefficient of P is negative, which is contrary to the theory, but insignificant. This shows that movements in inflation do not have significant impact on short-term interest rate (IR). The Wald Statistic also confirms the zero restriction on the coefficient of P. The long-run model has been found working quite well as the cumulative sum of recursive residuals and square of recursive residuals establishes the stability of long-run coefficients. Further, actual IR has been found largely following the fitted IR implying no major deviations in the actual IR from its fitted long-run path. The signs of short-run dynamic impact are largely consistent with long-run coefficients and error correction term is negative and significant at 1% significant level implying that there is convergence to long-run equilibrium path. The coefficient of the ECM is very high at -0.63 implying a fairly high speed of adjustment to disequilibrium after a shock. The actual change in IR has been seen largely following the fitted change in IR except for drifting away at few occasions, which implies that estimated ARDL cointegration model quite stable even in terms of short-run dynamics. Finally, the Granger Causality Tests also establish that P does not Granger cause IR, while Y
and RER have been found Granger causing IR at 5 per cent and 10 per cent level of significant, respectively.

In sum, RER along with Y (output gap) has been found exerting significant positive influence on the short-term interest rate (IR), while the impact of inflation, although negative, remains statistically insignificant. The causal relationship short-term interest rate and inflation in the model quire surprising and intriguing and this possibly could be explained by the supply inelasticity in the Indian economy, meaning thereby that inflation is largely a supply side phenomenon.